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Mapping *Nature*'s scientist: The posthumous demarcation of Rosalind Franklin's crystallographic data

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ABSTRACT

Nature, the journal that in 1953 published James Watson and Francis Crick's double-helix model of DNA, also published numerous pieces about crystallographer Rosalind Franklin. Franklin's coverage, however, was published largely after her death in 1958 and dealt with the fact that, without her knowledge, Franklin's colleague Maurice Wilkins gave Watson her crystallographic images of DNA and thereby supplied him with the key data upon which his model was built. In this analysis of the 68 *Nature* pieces on Franklin and DNA published in the years following her death, we argue that the amalgamation of this coverage performed sophisticated and sustained boundary-work that outlined the realm of science and the scientist as just outside the bounds of Franklin's life and career. Three mechanisms of intra-scientific demarcation are revealed as operating across these publications, including: (1) the defiance of generic expectation, (2) performances of scientific epideictic, and (3) argument from dissociation. We explicate how these mechanisms supported a mapping of science writ large that employed Franklin in the role of what Thomas Gieryn labels a "contrast-case." This analysis offers a theoretical infrastructure for studying how technical communities create and sustain their borders via cartographic legacies of socializing rhetorics.

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When crystallographer Rosalind Franklin died of ovarian cancer on April 16, 1958, at the age of 37, she did not know that James Watson and Francis Crick's model of DNA's double helix was based on their having gained illicit access to her own scientific data, specifically her X-ray diffraction image "Photo 51."[1] Nor did she know that they – along with her lab partner, Maurice Wilkins, the individual who leaked her data – would go on to be awarded the 1962 Nobel Prize in Physiology or Medicine for their molecular modeling.[2] She also did not know that, in the years following Watson, Crick, and Wilkins' win, *Nature* – the prestigious scientific journal that initially attributed the double-helix model to Watson and Crick – would publish numerous feature articles, commentaries, reviews, and opinion pieces memorializing her career and discussing why she did not receive credit for producing the data upon which Watson and Crick's model was based.

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What Franklin *did* know when she died was that, despite orchestrating what was described in her *Nature* obituary as "the most beautiful X-ray photographs of any substance ever taken,"[3] she had been banished by department head John Randall from working in the King's College London Medical Research Council (MRC) Unit and informed she was never to study DNA again. She knew that after two years of working diligently and unrelentingly at Kings where, as a woman, she was prohibited from dining in the senior common room or entering the pub where male colleagues met to discuss findings, she had been deemed a vector for drama (a euphemistic charge that had much to do with her status as female, unmarried, and Jewish) and barred from the community of scholarship that her contributions had helped to transform.[4] She also knew that, despite all of this, she had used what turned out to be the last years of her life to begin anew and make breakthroughs in virology and the study of tobacco mosaic virus at Birkbeck College London, thereby establishing definitively her scientific acumen, intellectual fortitude, and collegiality.[5]

Today, the viability of Franklin's scientific aptitude and the centrality of her contribution to the discovery of DNA's double helix is not in question: her skills as a crystallographer and chemist have been recognized repeatedly as second-to-none, and there is widespread scientific consensus that "Photo 51" provided the crucial empirical evidence upon which the helical model was built.[6] Questions remain, however, about why Franklin was (and is) discussed so extensively among those in the scientific community, the very individuals who repeatedly banned and blocked and removed her from their circles. In this essay, we contend that *Nature*'s posthumous publications about Franklin performed sophisticated boundary-work that demarcated the scientist through what Thomas F. Gieryn labels the "contrast-case" of Rosalind Franklin's life and career.[7] The rhetorical appeals and strategies in these texts secured the terrain of a longitudinal cultural cartography of science wherein the "interpretative grounds for extending or denying epistemic authority" was mapped out,[8] not via traditional research articles but rather through *Nature*'s "extra-disciplinary discourse" wherein authors take on the role of teacher or advocate and audience members are situated as non-disciplinary readers within the overarching scientific community.[9]

In the following analysis of the 68 *Nature* publications discussing Franklin and DNA from 1958 until 2015,[10] we illustrate how these textual fragments constituted a sustained attempt to reconcile the theft of Franklin's data with the scientific community's celebration of the discovery of DNA's double helix. More specifically, we find that this amalgamation of texts – which includes pieces that set out explicitly to defend Franklin's legacy by amending the scientific record to include her contributions and expand the boundaries of science – nonetheless reiterated existing boundaries about who is, or can be, a scientist. This reiteration transpired in no small part because Franklin and her work were situated across these texts as just outside, and therefore marking, the borders of elite science.

Our analysis demonstrates that the cartography of science which was "edged and filed"[11] around Franklin's demarcation was communicated via three strategic mechanisms involving the defiance of generic expectation, performances of scientific epideictic, and argument from dissociation. In the following pages, we situate these mechanisms within the broader study of the demarcation of science and contribute to an ongoing effort to explicate how scientific boundary-work unfolds, considering – all the while – the social and material implications of this cartographic process for those who continually are

bounded outside scientific limits. The theoretical goal in this work is to join Colleen Derkatch in "isolating and describing the specific mechanics of the negotiation of borders" in science and medicine,[12] as well as to answer the call for scholarship that focuses not just on the analysis of key scientific publications but also on "responses to research articles from disciplinary readers."[13] All of the texts analyzed in this essay respond in some way to Watson and Crick's renowned and rhetorically rich 1953 *Nature* article,[14] and they therefore provide an increasingly comprehensive account of the cultural cartography outlining and maintaining the history of genetic science specifically and the late-twentieth-century community of scientists more generally. We proceed by, first, reviewing scholarship on scientific boundary-work and socializing rhetorics; second, outlining the circumstances under which Watson and Crick's article on DNA's structure was published in 1953; and, third, mapping the central rhetorical means through which Franklin was demarcated as a contrast case in *Nature* coverage after her death. We conclude by explicating a theory of intra-scientific boundary-work that highlights how internal socializing rhetorics constitute and uphold the borders and liminalities of technical communities over time.

Intra-scientific boundary-work and socializing rhetorics

To date, research on scientific boundary-work, what Gieryn defines as the process of demarcating science from "non-scientific intellectual or technical activities"[15] to establish professional authority and legitimacy, has focused largely on demarcation within the contexts of public scientific advocacy and regulatory controversies.[16] Scholars have also explored the functions of intra-scientific boundary-work that transpires among scientists within the technical sphere, primarily in the context of peer-reviewed scientific research and publication, to distinguish practices and fields within science as more-or-less scientific.[17] What has been less explored is boundary-work as it unfolds in what Thomas Lessl identifies as professional "socializing rhetorics" that are situated within the broader "society of scientists" to facilitate identity formation and delineate in-group characteristics.[18] These texts exist at the margins of technical scientific rhetoric and public or mainstream conversations about the cultural role science plays in society, and they perform a powerful gatekeeping function in that they constitute science both internally and as it tends to be perceived and operationalized externally. *Nature*'s publications memorializing and otherwise narrativizing Rosalind Franklin's role in the discovery of DNA's molecular structure offer a clear example of this specific mode of boundary-work. In this respect, an exploration of the rhetorical mechanisms driving these specific publications has the potential to generate much-needed infrastructure for the broader study of how socializing rhetorics of science map their communities.

Research on the rhetorical mechanisms of boundary-work in general includes insights that are particularly applicable to the study of intra-scientific socializing rhetorics. For instance, Gieryn reports that all demarcation narratives, regardless of context, exist across three "genres" aimed at *expulsing* rivals from the scientific realm (or to the margins of that realm); *expanding* the scientific realm to include the previously excluded; and *protecting the autonomy* of recognized scientific realms.[19] In intra-scientific contexts, the first two of these genres tend to unfold, in the words of Charles Alan Taylor, when a "community of scientists marshals its rhetorical resources in praise or criticism of its members" and "simultaneously reconstructs itself. Its rhetorical pronouncements define

for itself, and largely for us, what it means to 'do science.'"[20] Scholars have illustrated how this definitional task concerning what is and is not scientific is ongoing and evolving. Borders are established, initially, in response to historically situated exigencies (e.g., Rosalind Franklin's untimely death in 1958; publication of James Watson's memoir, *The Double Helix*, in 1968),[21] but these exigencies necessarily change over time and require reframing and renegotiation. In this respect, all scientific boundary-work involves a steady stream of "cultural cartographers" who employ a range of strategies to "episodically establish, sustain, enlarge, police, breach, and sometimes erase in the defense, pursuit, or denial of epistemic authority" the territories and borders of the scientific realm.[22]

Beyond scholarship on boundary-work writ large, research on boundary-work in the technical sphere of science has also generated valuable (and transferable) insights into the mechanisms of scientific demarcation. Swedlow, for instance, isolates two types of appeals commonly employed among scientists to differentiate between the scientific and the non-scientific and/or between different gradations of scientific quality. These include "pollution claims," which assure an audience of scientists that rivals are deluded, lying, or driven by motives that do not align with scientific values (e.g., religious or economic considerations), and "purity claims," which contend that the subject of inquiry is clean of unscientific influences.[23] These claims have been shown to transpire both in the technical sphere of doing and reporting scientific research – "rhetorics of science" – and in the professional sphere wherein members of the broader society of scientists communicate socializing messages that constitute "rhetorics about science."[24]

Across these intra-scientific milieus, scholars have noted a "self-concealment aspect" in that the role of demarcation in these rhetorics tends to be obscured. Derkatch explains that "something about the rhetoric of boundary-work covers its own tracks,"[25] and this may be particularly the case in the context of socialization wherein discourse often adopts a narrative format that speaks to seemingly unrelated issues but, all the while, communicates messages about in-group norms and expectations via an "indirect measure of attack."[26] This veiling quality means that intra-scientific boundary-work is a medium through which bias can be, and frequently is, articulated and sustained. For example, Gieryn recognizes but does not interrogate the "deeply gendered" nature of scientific boundary-work, a phenomenon tied to the broader history of science wherein scientific endeavors have been equated with objectivity and masculinity, and nature (i.e., the object of study) with subjectivity and femininity.[27] Indeed, in a range of instances scholars have demonstrated that socializing rhetorics of science have associated science with individuals and groups who represent "normative" demographic qualities such as male, White, heterosexual, Protestant, and middle-to-upper class, thereby marking as non-scientific those who fall outside these bounds.[28]

Lessl highlights the urgency and value in exposing biases communicated through intra-scientific boundary-work by demonstrating that, although any one example of boundary-work emerges in light of a specific historical moment and location, narrative demarcation and the socializing rhetorics it supports are not thereby constrained and often have a "broader scope of influence."[29] What this means in the case of *Nature*'s postmortem depictions of Franklin and DNA, for instance, is that to employ the narrative of her life and career as a territory outside of – or at the margins of – science in 1958 is also to create a foundation for making sense of science and its margins in years thereafter. These "rhetorical costs of demarcation," as Lessl calls them, are especially pronounced because, even

as maps are redrawn, there remains what Gieryn describes as a "cartographic legacy" with "accumulated residues of previous instances of boundary-work, as when a creased and dog-eared map gets unfolded rather than drawn fresh."[30] The aim of the subsequent analysis, then, is to identify the cartographic legacy constituted by *Nature's* socializing rhetorics and thereby explicate mechanisms of this particular brand of intra-scientific boundary-work.

Mapping the society of genetic scientists

The process of discursively "mapping out" *Nature*'s cultural cartography of the scientist from 1958 to 2015 requires, first, a synopsis of the admittedly contested exigencies leading to the publication of Watson and Crick's article in 1953.[31] An outline of the case has Franklin arriving at King's College at the beginning of 1951. Hired by Randall, Franklin was told she would head the department of X-ray crystallography, though Maurice Wilkins was under the impression that the new hire would be not his boss but his employee. Franklin soon assumed the role of advisor to Wilkins's student, Raymond Gosling, and was given oversight of a high-quality sample of DNA procured by Wilkins.[32] By all accounts, she was single-minded in her devotion to taking and analyzing crystallography photographs of this sample, demanding of herself the procurement of irrefutable evidence to support her published work. When the ostensibly juvenile and impetuous Watson – working in the neighboring Cavendish Laboratory – insisted that she show him her data, she said no. Later, without Franklin's knowledge, Watson visited Wilkins who pulled Franklin's data out of a drawer and handed it over for Watson's inspection. One of these photographs – Photo 51 – offered an especially clear picture of the helical form of DNA. With characteristic vibrato and perhaps a bit of innuendo, Watson later recalled, "The instant I saw the picture my mouth fell open and my pulse began to race."[33] This data, along with an internal report by Franklin and Gosling that was passed to Watson by another King's laboratory member, was the evidence that Watson and Crick used to propose their double-helix model in *Nature*.[34]

Although Bruno Latour has reported, simply, that Watson "had a hard time obtaining" the data from Franklin,[35] many others have characterized Watson's actions as ethically problematic at best and criminal at worst.[36] That *Nature*'s editors, at the time, were not always in the habit of putting submitted articles through external peer review made it possible for Watson and Crick to garner credit for the model without also revealing the data upon which the model depended.[37] Instead, *Nature* published two follow-up articles in the same issue, one headed by Wilkins and one by Franklin.[38] Franklin's article, which included Photo 51, was positioned in the issue as simply a replication and corroboration of Watson and Crick's original findings. In the 68 *Nature* publications about Franklin and DNA following her death – which spanned 57 years and included 22 reviews, 12 commentaries, nine feature articles, eight short reports, eight letters-to-the-editor, five editorials, and four obituaries – the details of this scenario were narrativized so that Franklin herself was positioned as the boundary between elite science and the non-scientific. In the subsequent analysis, we contend that the creation and long-term maintenance of this particular map of the society of early genetic scientists depended on three rhetorical mechanisms related to the defiance of generic expectation, performances of scientific epideictic, and argument from dissociation.

Defiance of generic expectation: Witches, heroines, and feminist icons

In contrast to the technical research articles featured in *Nature*'s pages during the latter half of the twentieth-century, the 68 publications discussing Franklin and DNA from 1958 to 2015 defied the norms of "masculine" technical science reporting related to objectivity, passive voice, and "shunning the personal."[39] Instead, these pieces were almost uniformly presented via a dramatic frame that favored first-person accounts, active voice, and personal expression. Several publications opened with vivid prologues designed to mirror that of a novel or play. A 2003 feature article by science historian Robert Olby began with an invitation for readers to situate themselves historically and consider Franklin's experiences through a nostalgic lens, "To recall the year 1953 is to visit – and for some of us to revisit – another world, when *Nature* did not use the abbreviation DNA for deoxyribonucleic acid."[40] Similarly, a 1974 review article by *Nature*'s Biology Editor, Peter Newmark, immediately situated its readers

> back in the balmy days of the early 1950s, before the national press was heavy with doom and the scientific press with molecular biology, small groups of scientists in London, Cambridge and California were working away on the academic problem of the structure of DNA.[41]

This stark shift in perspective from formal research article, largely forensic in nature,[42] to first-person, embodied drama, more epideictic than anything else, signaled a corresponding shift in communicative purpose; these pieces foregrounded not the transference of technical knowledge so much as the social construction of community norms, professional ideals, and a shared history. Danielle Endres and colleagues find that the use of a dramatic rhetorical framing – one that defies generic expectations – is a common backdrop for the "internal boundary-work that happens within a transdisciplinary scientific community after a breach in the community's rhetorical norms."[43] In this case, the use of Franklin's data without her knowledge, particularly in the wake of her early death and the widespread celebration of the double-helix model, seemed to catalyze and support the proliferation of a distinct mode of scientific rhetoric that socialized through the dramatization of science as an activity and a profession.

That the genre had shifted toward the dramatic in these pieces was further highlighted by their repeated characterizations of referenced scientists as "protagonists," "characters," and "players," with Franklin upheld as a "heroine" and her early death described as a "special tragedy."[44] A commentary from 2010 by Cold Spring Harbor Laboratory directors, Alexander Gann and Jan Witkowski, offered a "Cast List" for "The search for the structure of DNA," complete with sensational entries pitting characters against each other (e.g., Randall was said to have "set up the disastrous misunderstanding with Wilkins who believed from Randall that Franklin and he would be working together on DNA").[45] Authors drew repeated, self-conscious attention to the "stories" told in the pieces at hand and in science more generally, adding "spice" and rampaging up a "plot thickened."[46] In defiance of the expectation that members of the scientific community obscure their own agency in technical contexts,[47] authors emphasized the choices made in composing these specific publications and related works and thereby signaled the demarcative aims of their rhetoric. A 2003 letter-to-the-editor by Marta Paterlini, a member of the Laboratory of Human Neurogenetics, encouraged readers to visualize the "floods of ink, electronic and actual" that "have been spent on celebrating the

fiftieth anniversary of the discovery of DNA's structure, recollecting facts and testimonies from the protagonists."[48] Likewise, in a review essay from 2012 by editor and science biographer Richard Holmes, the piece was drawn to a close with the meta-analytic observation that "science is always a story. A detective story, perhaps; a mystery story; a love story; even, on occasion, a ghost story … But always a story of human lives."[49]

The story told in each of these cases revolved around Franklin and the ways in which she navigated the worlds of academic chemistry and the physical sciences in the 1940s and early 1950s. What emerged from these tales was an overarching "scientific folklore" that socialized readers by casting Franklin in one of two ways,[50] both of which drew from tropes of traditional gender roles and heterosexual romance. In one casting, Franklin was introduced as "Rosy" or, in some cases, "Rosie," a name that she had never used for herself.[51] Watson first wrote about Rosy in 1968s *The Double Helix*, describing a jealous, prudish, annoyingly upper-class shrew who refused to cooperate or work with a team and had the potential for violence.[52] Wilkins's 2004 obituary by biochemist and King's College Professor Walter Gratzer offers a clear example of this type of characterization, explaining that "Wilkins's laborious progress towards the structure of DNA was rudely disturbed by the arrival at King's of Rosalind Franklin," who "cruelly elbowed" him "out of his cherished project" and "intimidated" him away from the model building that may have put him ahead of Watson and Crick in the race for discovery.[53] Here and elsewhere, Franklin was said to have obstructed and therefore polluted the work of genuine scientists like Wilkins, those dedicated not to the glory of recognition and attribution but to the greater good of scientific progress. A similar picture emerged of Franklin in a 1983 keynote address given by Watson that was covered by *Nature* to mark the 30th anniversary of the original Watson and Crick publication. Watson noted that, although Franklin "was a very intelligent woman" she "wasn't a diplomatic person" and had never been dedicated to the DNA project in the way that he, Crick, and Wilkins had been. This last point was designed to call into question the scientific purity of Franklin's intentions and, as Jordynn Jack explains, blame her for her "own lack of progress."[54] It was made by highlighting her lack of affiliation with scientific in-groups (e.g., "I don't think she'd ever spent any length of time with people who thought DNA was important") and her supposed disloyalty to the cause (e.g., "But she was really prepared to give up working on DNA, and she wouldn't have agreed to give up if she'd thought it was important. So that was why she didn't get the answer.").

With but a few exceptions, *Nature*'s postmortem coverage of Franklin enlisted the Rosy portrayal only when there was a degree of separation from the source. For instance, Gann and Witkowski's 2010 commentary featured newly unearthed correspondence between Wilkins and Crick. In one quoted letter, Wilkins wrote concerning Franklin's impending departure from the King's Lab, "'I hope the smoke of witchcraft will soon be getting out of our eyes.'" Of this "'witchcraft' line," the commentary's authors perpetuated – rather than critiqued – the trope, noting only that such a comment was "likely to find its place in the canon of well-known allusions to [Franklin]."[55] Along those same lines, a 2005 book review by developmental biologist Lewis Wolpert underscored Watson's supposed skill as a writer by quoting from a passage wherein Watson described Franklin:

> 'Though her features were strong, she was not unattractive and might even have been quite stunning had she taken even a mild interest in clothes. This she did not. There was never

> lipstick to contrast with her straight black hair, while at the age of thirty-one her dresses showed all the imagination of English bluestocking adolescents.' Would that other scientists could write as well as that.[56]

One cannot help but speculate if Wolpert's final comment in this passage was sarcastic, though nothing from the review as a whole suggested as much. Readers were directed to the extract to admire Watson's ability to turn a phrase, but they would also inevitably consider the writing's content and its depiction of Franklin as apparently disinclined to partake in expected feminine niceties and therefore as out-of-place with her male colleagues. At the same time, Franklin's sex – foregrounded in this passage by way of Watson's critique of her gender performance – was upheld as evidence that she was (no matter her dress or behavior) inherently incongruous in the world of professional science. Though *Nature* employed these lines not necessarily to highlight this particular depiction of Franklin, the legend of Rosy the Witch – neither scientist nor proper woman – was nevertheless communicated and upheld therein.

In contrast to the witch trope, a second casting that emerged from these publications depicted Franklin as a wronged heroine and feminist icon. Although many of the pieces that characterized Franklin in this way seemed to be trying to champion her inclusion in the historical record of genetic science, they worked largely against this goal by downplaying discussion of Franklin's actual scientific work and reducing her to an abstract political symbol. For instance, journalist and Franklin biographer, Brenda Maddox, authored several *Nature* publications about Franklin including a 2003 feature article titled, "The Double Helix and the 'Wronged Heroine.'" Maddox quoted heavily from Watson's *The Double Helix* to pit her depiction of Franklin against his and prove that Franklin had truly been mistreated by the male scientists with whom she worked. Watson – Maddox noted – admitted that "'Rosy, of course, did not directly give us her data,'" and that, later, Watson and Wilkins concluded, "'Clearly Rosy had to go or be put in her place.'"[57] While these quotations provided evidence that Watson stole from – and was impertinent when discussing – Franklin, they did not function in the Maddox article to situate Franklin as a scientist in her own right. Maddox labeled what emerged from the release of Watson's book and other archival materials of the time the "legend of Franklin" and the "Franklin myth,"[58] thereby calling attention to the narrative work she and others seemed to be doing in re-evaluating the creation of the double-helix model with Franklin's contributions at the center. As a 2013 review essay by science historian Patricia Fara explained of Maddox's commentary – particularly her biography of Franklin –

> Even Brenda Maddox, who criticizes Watson for his chauvinistic attitudes, played on gender stereotypes in choosing the subtitle *The Dark Lady of DNA* for her biography of Franklin. Is it not sufficiently fascinating that Franklin's skilled research was crucial for Watson's fame?[59]

Although this particular essay concluded by arguing that Franklin did not actually deserve more credit than she received (thus contributing additional fodder for the overarching demarcation of Franklin as outside elite scientific bounds), Fara's "second-order boundary-work" was nonetheless sound in that a heroine framing of Franklin – dark lady or no – did little to counter the contention that she was nothing more than an "impostor 'scientist'" lacking the proficiencies and aptitude to discover the helical structure of DNA in her own right.[60]

Around the turn into the twenty-first century, claims that Franklin was becoming a feminist icon ignited something of a backlash in *Nature*'s pages. In a 1997 review essay, Gratzer went so far as to contend that "premature death can be a shrewd career move, for Franklin became almost instantly a feminist numen," before then listing some of the historical works he saw as responsible for her false memorialization. "Watson's rather unchivalrous treatment of her in his book inflamed her admirers," he wrote, "and a regrettable biography published in 1975 made strident assertions that Franklin had been a lone woman in a den of male bigots at Kings College and that her work had been devalued and her character traduced."[61] Other authors argued that Franklin's launch as a feminist icon was merely the stuff of "myth"[62] and, correspondingly, that the employment of a fellowship in Franklin's name for women scientists in the Netherlands was "illegal" in that it facilitated "positive discrimination."[63] For these authors, Franklin's posthumous adoption by women's rights advocates (Franklin herself did not mention or align with the cause)[64] offered proof that her career had existed outside the bounds of pure, unadulterated science. They held that those attempting to revise the historical record to account for Franklin's contributions were essentially manufacturing a scientific controversy, as Leah Ceccarelli terms it,[65] in the name of feminist politics. The drama that resulted was one in which the bounds between "science and politics had been breached, impermissibly allowing activity in one sphere" (i.e., genetic science) "to intermingle with activity in another" (i.e., political ideology), "polluting it."[66] In this respect, delineating Franklin as, at best, a marginal scientist was characterized as necessary for sustaining scientific integrity and epistemic authority.

Performances of scientific epideictic: Intuition and collaboration as community values

The dramatic framing of these *Nature* pieces was coupled, in almost every case, with discursive performances of scientific epideictic. Dale E. Sullivan identifies intra-scientific rhetoric as a context wherein epideictic is employed to create and sustain scientific cultures' evolving orthodoxies.[67] This process tends to unfold through appeals to praise and blame that are related to the "notion of heresy" wherein an individual or idea is constructed as disruptive to community values.[68] In the pieces at hand, scientific epideictic was employed to praise the values and abilities of Watson, Crick, and – often – Wilkins and, inversely, to contrast those values and abilities with those of Franklin. The process of narrativizing Franklin's role in the discovery of DNA's helical structure, then, functioned as a tacit means for educating those in the scientific community about the grounds for achieving membership.

The value cited most often in these pieces as fundamental to scientific work was not that of accuracy, exactitude, or rigor, as is often the case in intra-scientific epideictic,[69] likely because Franklin so exceeded expectations on those fronts. Instead, the central value mentioned was that of intuition and the ability to jump from empirical data to a more comprehensive sense of how data fits together. A 1993 commentary from *Nature*'s Biology Editor, Nicholas Short, highlighted the contrast between Franklin and her colleagues by using intuition and a penchant for model-building as criteria: "So, unlike Franklin, Crick and James Watson elected to build models and calculate the diffraction pattern each would produce."[70] It was largely agreed – even by those championing Franklin's

cause – that, as *Nature*'s Editor John Maddox wrote in a 1993 editorial, Franklin "might have made faster progress if she had done a little model-building."[71] In 2003, Raymond Gosling – Franklin's former student who assisted her in taking "Photo 51" – divulged that an intuitive jump in reasoning "has always seemed to me to have been the quantum leap that Watson made, and shows the advantages of model-building."[72] These passages implied that, although Franklin may have been well-trained, hard-working, and technically sound, without scientific intuition she was still lacking in her credentials as a legitimate scientist.

Evidence of Franklin's intuitive deficit was communicated most often in terms of Watson and Crick's apparent abundance. A 2003 commentary by chemist Watson Fuller contended that "Franklin had been adamant that the investigation should proceed by a detailed analysis of the X-ray data rather than a more intuitive approach."[73] By contrast, he noted, "crucial for the success of Watson and Crick's approach had been the use of molecular models based on knowledge of chemical bonding determined from stereochemistry and X-ray single-crystal studies of molecular components," and, furthermore,

> Crick especially had a strong commitment to model building. It is important to emphasize in view of the attention that has been given to the exploitation of King's data by the Cambridge workers, that before the discovery of the double helix, Crick encouraged Wilkins and Franklin to build models and provided them with jigs developed in Cambridge for constructing the atomic components.[74]

Franklin, it seemed, was given every opportunity to prove herself as a scientist but just did not possess either the ability or the gumption to make the leaps in logic necessary for completing the task at hand. That Wilkins was categorized as sub-par alongside Franklin in this commentary was an anomaly. The vast majority of texts positioned him, like Watson and Crick, as a consummate scientist by pointing to evidence of his advanced and intuitive cognitive reasoning, as well as his skill at working in a team.

Indeed, a second value upheld consistently throughout these texts was that of collaboration, with Franklin put forth as a negative example prone to isolation and divisiveness. Science historian Horace Freeland Judson explained in a 2006 book review that,

> When Wilkins returned and expected to collaborate with [Franklin], she shut him out. He grumbled about her to Crick and Watson, and in February 1953 he notoriously showed Watson an X-ray diagram she had obtained – which they interpreted as she had failed to do.[75]

Judson implied that Wilkins's expectation of collaboration was not only reasonable but also absolutely necessary for the achievement of scientific discovery. Franklin, he argued, failed to uphold this central scientific norm, and therefore the others had no choice but to use alternative means to obtain needed data and information. What made Franklin especially egregious from this perspective, Judson and other *Nature* authors contended, was that she had managed to procure valuable materials and results (admittedly through her own diligence and expertise) but then had neither the scientific intuition to know what to do with them nor the character and munificence to pass them to those who did. In their 2010 commentary, Gann and Witkowski turned to original correspondence between Wilkins and Crick to make this point, quoting Wilkins who fumed, "'To think that Rosie had all the 3D data for 9 months and wouldn't fit a helix to it and

there was I taking her word for it that the data was anti-helical. Christ.'"[76] Franklin, according to this portrayal, was so secretive and self-involved that she had nearly managed to derail the progress of a much larger scientific trajectory. Fuller's 2003 commentary contended that Franklin's decidedly unscientific tendency toward sequestration was what facilitated her concealment of what "was to prove, in the hands of Crick, crucial information."[77] Fuller continued by reasoning that the taking of Franklin's data was more than justified given her unprofessional behaviors. It was done, he reported, "in the spirit of the multidisciplinary approach needed for the determination of a biological macromolecule such as DNA."[78]

Several early twenty-first-century *Nature* authors offered clear and insightful explanations for Franklin's supposed shortcomings in terms of the values delineated, although they did so within larger articles that functioned to undercut Franklin's credibility and render moot her (lack of) placement in the scientific canon. Science writer Philip Ball wrote in a 2015 review article that Franklin was likely unwilling to make intuitive jumps beyond her data because "in Franklin's time, it is not surprising that a female scientist would think that she could ill afford that luxury [to fail]."[79] He went on to contend that even the "latter-day Franklin" was still debilitated by discrimination and thereby limited in her ability to succeed in science. This enlightened critique, however, followed commentary that invalidated Franklin for her failure to "trust model-building, believing that the structure must be revealed through mathematical analysis," while Watson and Crick were said to assimilate and see beyond the data, which facilitated their discovery of DNA's structure.[80] A similar characterization emerged in a 2010 review of *Photograph 51*, an Alfred P. Sloan Foundation-funded play based on Franklin's life and career. In the review, science journalist Josie Glausiusz recognized that "as a Jewish woman, Franklin was thwarted by obstacles of the time – sexism and anti-Semitism – and by her own internal limitations," before then noting that the playwright, Anna Ziegler, contended that Franklin's "toughness got her where she was, but it also meant that she guarded her ideas from outside interference. 'The play is largely about Franklin's inability to collaborate, or lack of desire to.'"[81] The recognition in this piece that Franklin faced constraints and hardships as a Jewish woman, hardships with which other scientists did not contend, could have been employed as a warrant for questioning the value of teamwork and networking in appraising scientific membership. Instead, the praise imposed on Watson, Crick, and Wilkins was upheld throughout this coverage, and Franklin's difference from those individuals – including the adversity she encountered because of her subject position and resulting "inability" or "lack of desire" to share data – was enlisted as an implicit justification for her exclusion.

Argument from dissociation: The art of crystallography

After her death, Franklin's methodological integrity as a crystallographer was universally applauded in *Nature*, but the field of crystallography itself was repeatedly called into question as superficial, artistic, and therefore unscientific. An argument emerged across these pieces that involved the linking of crystallography with art, the visual, and femininity, as well as a corresponding dissociation of Franklin and her research from the supposedly objective, cognitive, and masculine realm of science proper. The idea that Franklin's research was more art than science was communicated via copious descriptions of its

loveliness, descriptions that contrasted starkly with widely accepted technical definitions associating the field with the structural analysis of crystals via "diffraction by synchrontron radiation, optics, mathematics, symmetry, twinning (one form of crystal growth error), and the production and analysis of X-rays."[82] Franklin's 1958 obituary created a textual infrastructure for this aesthetic characterization, arguing not only that Franklin's crystallographic images were "among the most beautiful X-ray photographs of any substance ever taken" but also that she was well-known for her "beautifully executed researches."[83] These comments functioned as argumentative "techniques of separation" by encouraging readers to evaluate both the product of Franklin's work and her research process in terms of aesthetics rather than more traditional scientific criteria such as validity or precision.[84] Similarly, in a 1968 letter-to-the-editor, Franklin's former collaborator – chemist and biophysicist Aaron Klug – referred to Franklin's "beautiful X-ray photographs which were used in the subsequent analysis of both forms" of DNA,[85] and, in a 2011 commentary, Gosling wrote of the photographs that he would "always remember the moment I first saw that beautiful double diamond pattern."[86] By praising the veneer of her data first and foremost, and referencing its scientific import as an afterthought or not at all, these depictions functioned to disparage, implicitly, her intellectual contribution to the discovery of DNA's helical structure. Michelle Gibbons explains that the process of scientific discovery has long been conceptualized in terms of "internal cognitive acts" while "external acts of making visible" such as Franklin's have been neglected and negated regardless of the cognitive labor required of their creation.[87] In light of this history, terms such as "beautiful" are (and have been) only rarely employed in the technical sphere of discourse to describe scientists or scientific efforts (e.g., no other scientist's work is depicted in this way in the 68 pieces analyzed). When such terms are employed in this context, they serve as intra-scientific cues categorizing the subject matter at hand as ectopic and incongruous.

In several *Nature* pieces, this devaluation of Franklin's scientific role in light of her work's visual nature and spectacular appeal was made more explicitly. For example, in Watson's 1983 keynote address, he applauded Franklin's "very beautiful work" before referencing "her operation for ovarian cancer" and, subsequently, a National Institutes of Health grant that "we [he and his male colleagues] got her" toward the end of her life before the "Agricultural Research Council (ARC) turned her down after she'd told the head of the ARC that he was an idiot."[88] In this case, Watson lavished praise on Franklin's research for its attractiveness before then mentioning the type of female-specific cancer that ultimately killed her (the insinuation being, perhaps, that the malignance of her ovaries – long conceptualized as the foci of the female sex – proved her ill-suited for science)[89] and concluding with a nod at the supposed rescue he and his colleagues attempted for her when she was ill yet nonetheless irascible and unprofessional. His comments, along with those of more understated *Nature* authors, created the impression that both Franklin and her photographs were remarkable chiefly because they were pretty, not because they were scientifically consequential.

Descriptions of Franklin's work as beautiful and therefore disassociated from the scientific realm garnered additional persuasive force when coupled with references to crystallography as a historically "woman's science." As Maureen M. Julian explains, "The science of crystallography has been accused of being overrun with women and has been likened to 'intellectual knitting,'" before then demonstrating the trope's historical

inaccuracy because the vast majority of crystallographers have, statistically, been men.[90] Michelle Francl offers a similar deconstruction, noting that the so-called "harem effect" of crystallography, wherein women were said to be brought into the fold to work – mindlessly – with renowned male scientists, has long been tied to women's supposed penchant for patience, attention to detail, and – somewhat ironically in light of the claims made against Franklin – cooperation, not to mention the lower wages women were forced to accept.[91] *Nature* publications that appealed to this trope tended to discuss crystallography as a perfunctory, tedious investigation, less intellectually robust than other scientific disciplines. As science writer Georgina Ferry explained in a 2014 feature article entitled "Women in Crystallography,"

> One downside of crystallography's reputation as a technical discipline, and one sometimes perceived to be 'women's work,' is that for a while, other scientists (particularly chemists) saw it as a laboratory service, and not a science in its own right.[92]

In this respect, the mere reference to Franklin as a crystallographer was likely enough to cue intra-disciplinary readers into a categorization of her research as inferior, or entirely unrelated, to a scientific perspective.

That Franklin's crystallographic work was repeatedly condensed down in these pieces to a single, influential X-ray photograph, the famed Photo 51, also contributed to the sense that her research was primarily an artistic venture. Little reference was made to Franklin's publications on DNA using different data, or to her robust research programs in the study of coal and plant viruses. Of the 68 pieces in *Nature* on Franklin and DNA from 1958 to 2015, seven (10% of the sample) reprinted Photo 51, characterizing it as the linchpin of Franklin's renown. Several of these articles also featured photographs of Franklin herself staring slightly away from the camera, looking off into the distance, or bending down to peak into a microscope. Despite Watson's pronouncements concerning Franklin's lack of attention to her appearance, these photographs featured a striking young woman wearing the style of tailored dresses, make-up, and jewelry common among middle-to-upper-class women of the mid-twentieth century. Although her short haircut may have signaled some unorthodoxy in her gender performance, there can be little doubt that the placement of these close-up images was intended to highlight the spectacle – and curiosity – of Franklin's femininity and invite inspection from the male (scientific) gaze. She looked away in these images, it could be argued, so that members of the scientific community might better engage in examination of her. In this way, Franklin was situated as an object of study – a "visible woman"[93] – rather than an agent of science, relevant to the scientific world but not a member of that world.

In a *Nature* short report from 2000, the contention that Franklin was visually remarkable and therefore like her data was replaced with the insinuation that Franklin and her data were one and the same. The report featured a piece of artwork wherein a close-up of Franklin's face was juxtaposed on top of Photo 51, with the caption reading, "The striking symmetry of the X-ray crystallography of DNA prepared by Rosalind Franklin was one of the last clues that led Watson and Crick to deduce the left-handed double-helical structure of DNA" (see Figure 1).[94]

Although strategic juxtaposition has been shown in some cases to underscore the incongruity between distinct ideas,[95] in this instance juxtaposition seemed to accentuate

Figure 1. Rosalind Franklin's photograph is juxtaposed over her renowned crystallographic X-ray diffraction image, Photo 51, in a *Nature* short report published in 2000. Used by permission of King's College London Archives and the Churchill College Archives Center.

similarities. The artwork highlighted Franklin's facial symmetry by intertwining it with her celebrated X-ray diffraction image. Therein, Franklin's chin tipped down slightly so that the curve of her head aligned with the outline of Photo 51's helix. One of Franklin's eyes was positioned in the center of the helix's inner circle in a way that personified the helix and situated Franklin as what Barbara Creed identifies as the "monstrous-feminine,"[96] abject in her unwillingness to "respect borders, positions, rules" and offering only a "clue" – albeit a hypnotizing and captivating one – for Watson and Crick to uncover.[97] This depiction of Franklin drew upon the idea that woman is the embodiment of the natural world and, in this case, ripe for (photographic) capture and use by those within the scientific community's bounds.[98] Franklin existed in this characterization only as she merged with (or was trapped by) the natural world, becoming at once object of study and the point at which science can be differentiated from its philosophical pairing, nature.

Traversing Franklin's cartographic legacy

The goal in this analysis has been to begin explicating a theoretical foundation for the means by which socializing rhetorics of science create and sustain maps of their communities. Research demonstrates that intra-scientific boundary-work is predominantly implicit, constantly evolving, and maintained only through the ongoing rhetorical efforts of cultural cartographers versed in scientific norms, controversies, and ideals.[99] The amalgamation of texts analyzed in this case – 68 *Nature* publications on Franklin and DNA spanning 1958–2015 – provides a glimpse into the complex rhetorical ecology that supports such demarcation and thereby facilitates the theory-building project outlined by Derkatch on the mechanisms of scientific boundary-work.[100] More specifically, we found that the sources at hand enlisted three overarching demarcation mechanisms, which situated Franklin as at the margins of the scientific world. First, in the intra-scientific, "extra-disciplinary" context of these publications that was not-quite-technical and not-quite-lay,[101] authors highlighted the socializing function of their writings by flouting the generic expectations of the traditional scientific report and communicating a scientific drama thick with first-person, figurative language. The dramatic framing not only signaled that a breach had occurred in the scientific community's norms, as previous research has shown,[102] but also to situate the matter of Franklin's membership within the community in terms of tropes related to traditional gender roles and expectations. That Franklin was discussed only in this context while other "players" were still actively publishing their work and being featured in a range of other ways in *Nature* meant that, regardless of whether her role was evil witch or wronged heroine turned feminist icon, she alone was characterized as a dramatic protagonist and therefore forever outside the generic constraints of the scientific world. This "dance of characterization," as Lisa Keränen describes it, spoke less to the accuracy of Franklin's representation and more to "larger battles over science's epistemic authority."[103]

Theoretically, any shift away from the traditional report in a professional context such as this has the potential to function similarly, with individuals discussed only in an alternative format (e.g., drama; legal document; political cartoon) marked as something other than those who participate and are named in the accepted and anticipated genres of science (e.g., a traditional scientific report with an "IMRAD" structure – introduction, methods, results, and discussion).[104] This finding – that a shift from one genre to another within scientific discourse can act as a powerful demarcation strategy – is one that demands future study, particularly when coupled with Carolyn R. Miller and Jeanne Fahnestock's contention that genres in scientific rhetoric are defined in a number of different ways, "with some looking internally, to linguistic features and clusters of features, and others externally, to discourse communities and social interactions or recurrent rhetorical situations."[105] The continued classification of diverse genres in scientific rhetoric would, in this regard, advance efforts to identify intra-scientific generic shifts that implicitly construct certain types of individuals as inherent outsiders.

Second, the *Nature* publications analyzed for the present inquiry tended to pair genre-defiant, dramatic framings with performances of scientific epideictic. Scientific epideictic in these cases defined membership in the scientific community according to one's intuition and collaborative efforts. Franklin was narrativized as lacking on both of these fronts and her image served as a contrast-case in which exclusion from the community

was justified. Although research has implied that the scientific community writ large tends to uphold consistent values related to rigor, objectivity, and accuracy,[106] this case demonstrates not only that scientific epideictic is a forceful mechanism for intra-scientific boundary-work but also that the values enlisted therein are diverse, fluid, and wide-ranging depending on the context at hand. As Gieryn explains, "internal inconsistencies in what scientists are expected to be provide diverse ideological resources for use in boundary-work."[107] In this case, Franklin was memorialized as unwilling to depart from her empirical data, a quality historically associated with the scientific method, and she was memorialized as self-sufficient, which is, again, a quality upheld consistently as necessary for scientific discovery. For Franklin, however, these characteristics were framed in the negative as evidence of her lack of intuition and ability to collaborate. That intuition and cooperation are characteristics traditionally associated with women rather than men, and that Franklin was also de-legitimated in these texts for her feminine physical appearance and her data's aesthetic qualities, demonstrates that these criteria are based more on cultural cartographers' overarching aims and immediate yet evolving goals than on any empirical truths.

Third, in these sources Franklin's outline was also "edged and filed" via an argument from dissociation wherein her career as a crystallographer was linked to art, aesthetics, and the feminine rather than to science, objectivity, and the masculine.[108] Dissociation functioned as a boundary-work mechanism in these publications through explicit, visual juxtaposition and through relatively subtle intra-scientific cues that required historical and insider knowledge to decipher. While even lay audiences might recognize that "beautiful" as a descriptor for scientific data is atypical and therefore perhaps a sign of the subject's outsider status, one would require a relatively specialized science history education to understand that crystallography has been associated overwhelmingly with women and less sophisticated scientific contributions. The means through which ideas were disassociated from each other in the processes of intra-scientific demarcation in this case were grounded in ongoing, emerging narratives, which may be best deciphered over time across diverse sources and in light of ongoing scientific controversies and historical stasis points.

Indeed, the value in drawing from an amalgamation of texts that span multiple decades but that were all published in the same renowned scientific journal is that some assessment of the changes in boundary-work according to era can be made. Two findings stand out on this front. For one, the number of publications about Franklin and DNA – and thus the underlying boundary-work performed therein – increased conspicuously around the turn of the century. Only 15, or a little over 20%, of the pieces in this sample were published in the twentieth century, with the vast majority of the sample – 53 pieces or almost 80% – published in the twenty-first, over forty years after Franklin's death in 1958. One could argue that the further away from Franklin's life these texts were written and circulated, the more abundant and apocryphal they became, standing in for a number of other issues related to the bounds of science and where the future of science was and is headed. This reading is supported by the second longitudinal finding that emerges from this analysis, which is that post-turn-of-the-century *Nature* publications on Franklin and DNA were notably more divisive than earlier publications. Authors took clearer stances on whether they put forth a "Rosy" casting of Franklin or a wronged heroine/feminist icon casting, and the fissure between the two sides seemed to grow deeper and wider

as time went on. Despite the appearance of an overt dispute between factions, however, the underlying boundary-work accomplished by dramatic framings on either side ultimately furthered the same mapping of science with Franklin at the margins. In this respect, the drama in these publications diverted attention from the idea that Franklin was being narrativized across the board as something other than a scientist.

There are, of course, a number of rich historical and contemporary cases that offer opportunities for the continued explication of these specific mechanisms of boundary-work, as well as other as-yet-unidentified mechanisms. As Margaret W. Rossiter would note, Rosalind Franklin was hardly the first or the only woman in science to be under-recognized and coded as outside the bounds of elite science.[109] Biologist Nettie Stevens, astronomer S. Jocelyn Bell Burnell, and physicist Lise Meitner, to name just a few, have received some after-the-fact scholarly and mainstream attention for their exclusion from their scientific communities,[110] and rhetorical analysis of the specific ways in which they were demarcated within their fields would contribute tremendously both to boundary-work theorization and modern-day interventions attempting to open STEM fields to more women, minorities, and members of the working classes. One of the variables that makes the Franklin case unique is that so much of the boundary-work surrounding her story was accomplished long after she had passed away, and, if nothing else, the present research provides reason to continue considering how memorialization in science socializes and constructs the future of scientific fields. Questions also remain, though, about how the mechanisms of demarcation might differ in situations where individuals can advocate for their own inclusion in the society of scientists (as was and is the case for Bell Burnell).[111] Attention to the stories that women and other underrepresented individuals tell about their own bounding within science will help to highlight how those individuals can and do act as cultural cartographers in their own right.

To be sure, the present research does not emerge from the assumption that mechanisms of intra-disciplinary boundary-work always and inherently monopolize and exclude. As is the case for traditional geographical maps, which function constitutively via an interaction of rhetorical form and content,[112] discursive maps in and of themselves do not lean inherently in any one ideological direction. In fact, as Gieryn suggests in his work, professionalization discourses have as much potential to include and alter norms as they do to omit and uphold convention.[113] This is particularly the case because boundary-work is never complete and must be constituted and created anew continuously over time. The boundary-work identified in this analysis has long supported a broader scientific community of exclusion, one wherein women and those in a variety of traditionally marginalized subject positions are ostracized and underrepresented across the board, especially at the most elite levels of recognition. This cartographic legacy is well entrenched, though the continued study of how that entrenchment has unfolded has the potential to drive scientific socialization in entirely different and more inclusive and progressive directions.

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Notes

1. Franklin took this photo with the assistance of her graduate research assistant, Raymond Gosling, who she trained in techniques of X-ray diffraction. In fact, Gosling was the one who actually snapped "Photo 51," wrapping the DNA around a paper clip to better capture its structure. Naomi Attar, "Raymond Gosling: The Man Who Crystallized Genes," *Genome Biology* 14, no. 4 (2013): 402. Jose Cuevas and Laurence E. Heglar contend that X-ray diffraction photography is inherently a collaborative effort, dependent as much on multiple people as it is on enabling materials and conditions; "Photography and the Discovery of the Double Helix Structure of DNA," *Philosophy of Photography* 4, no. 2 (2013): 163–80. In this respect, giving anyone sole authorship of photographic data is problematic, though we join other scholars in arguing that Franklin's oversight of Gosling's training and her computational findings and directives over this particular image positioned her as the principal author of this data. It should be noted, though, that Franklin published her findings on this data along with Gosling. See Katherine Nightingale, "Behind the Picture: Photo 51," *Insight*, April 25, 2013, Accessed June 20, 2018. https://www.insight.mrc.ac.uk/2013/04/25/behind-the-picture-photo-51/.
2. Elizabeth H. Oakes, "Franklin, Rosalind Elsie," in *Encyclopedia of World Scientists* (New York: Facts on File Science Library, 2007), 248–49; Sarah Rapoport, "Rosalind Franklin: Unsung Hero of the DNA Revolution," *New York History* 84, no. 3 (2003): 315–29. Although collaborative sharing of data within a laboratory was normative at this time, such sharing was done with consent from the data's author and was decidedly not normative across different laboratories, as was the case in this situation with Franklin and Wilkins working for King's College London Medical Research Council Unit and Watson and Crick working for Cavendish Laboratory. See Mark Lawler and Tim Maughan, "From Rosalind Franklin to Barack Obama: Data Sharing Challenges and Solutions in Genomics and Personalised Medicine," *The New Bioethics* 23, no. 1 (2017): 64–73; and Robin Lloyd, "Rosalind Franklin and DNA: How Wronged was She?" *Scientific American*, November 3, 2010, Accessed May 1, 2018. https://blogs.scientificamerican.com/observations/rosalind-franklin-and-dna-how-wronged-was-she/.
3. J. D. Bernal, "Dr. Rosalind E. Franklin," *Nature* 182 (1958): 154.
4. Lynne Osman Elkin, "Rosalind Franklin and the Double Helix," *Physics Today* 56, no. 3 (2003): 42–48; Anne Piper, "Light on a Dark Lady," *Trends in Biochemical Sciences* 23, no. 4 (1998): 151–54.
5. Angela N. H. Creager and Gregory J. Morgan, "After the Double Helix: Rosalind Franklin's Research on Tobacco Mosaic Virus," *Isis* 99, no. 2 (2008): 239–272; Jenifer Glynn, "Rosalind Franklin: 50 Years On," *Notes and Records* 62, no. 2 (2008): 253–55.
6. Maureen M. Julian, "Rosalind Franklin: From Coal to DNA to Plant Viruses," *Journal of Chemical Education* 60, no. 8 (1983): 660–62; Marilyn Ogilvie and Joy Harvey, "Franklin, Rosalind Elsie (1920–1958)," in *The Biographical Dictionary of Women in Science: Pioneering Lives from Ancient Times to the Mid-20th Century*, ed. Marilyn Ogilvie, Joy Harvey, and Margaret Rossiter (New York: Routledge, 2000), 285–86; Martin J. Tobin, "April 25, 1953: Three Papers, Three Lessons," *American Journal of Respiratory and Critical Care Medicine* 167, no. 8 (2003): 1047–49.
7. Thomas F. Gieryn, "Boundary-work and the Demarcation of Science from Non-science: Strains and Interests in Professional Ideologies of Scientists," *American Sociological Review* 48, no. 6 (1983): 787.
8. Thomas F. Gieryn, *Cultural Boundaries of Science: Credibility on the Line* (Chicago, IL: University of Chicago Press, 1999), 21.
9. John Lyne and Henry F. Howe, "The Rhetoric of Expertise: E.O. Wilson and Sociobiology," *Quarterly Journal of Speech* 76, no. 2 (1990): 140.
10. The 68 pieces include 22 reviews, 12 commentaries, nine feature articles, eight short reports, eight letters-to-the-editor, five editorials, and four obituaries, all of which include the name "Rosalind Franklin" in the text and were published after Franklin's death on April 16, 1958.

The first piece in the sample is Franklin's obituary, published on July 19, 1958, and the last piece is a review of a play based on Franklin's story published on September 24, 2015.

11. Gieryn, *Cultural Boundaries of Science*, 14.
12. Colleen Derkatch, *Bounding Biomedicine: Evidence and Rhetoric in the New Science of Alternative Medicine* (Chicago, IL: University of Illinois Press, 2016), 196.
13. Danette Paul, Davida Charney, and Aimee Kendall, "Moving Beyond the Moment: Reception Studies in the Rhetoric of Science," *Journal of Business and Technical Communication* 15, no. 3 (2001): 372.
14. James D. Watson and Frances H. C. Crick, "A Structure for Deoxyribose Nucleic Acid," *Nature* 171, no. 4356 (1953): 737–38; S. Michael Halloran, "The Birth of Molecular Biology: An Essay in the Rhetorical Criticism of Scientific Discourse," *Rhetoric Review* 3, no. 1 (1984): 70–83.
15. Gieryn, "Boundary-Work and the Demarcation of Science from Non-science," 781.
16. See, for example, Derkatch, *Bounding Biomedicine*; Gieryn, *Cultural Boundaries of Science;* Lisa Keränen, "Mapping Misconduct: Demarcating Legitimate Science from 'Fraud' in the B-06 Lumpectomy Controversy," *Argumentation and Advocacy* 42, no. 2 (2005): 94–113.
17. See, for example, Alan G. Gross, Joseph E. Harmon, and Michael S. Reidy, *Communicating Science: The Scientific Article from the 17th Century to the Present* (New York: Oxford University Press, 2002); Brendon Swedlow, "Using the Boundaries of Science to Do Boundary-work Among Scientists: Pollution and Purity Claims," *Science and Public Policy* 34, no. 9 (2007): 633–643.
18. Thomas M. Lessl, "The Galileo Legend as Scientific Folklore," *Quarterly Journal of Speech* 85, no. 2 (1999): 146–47.
19. Charles Alan Taylor, *Defining Science: A Rhetoric of Demarcation* (Madison: University of Wisconsin Press, 1996), 10; Gieryn, *Cultural Boundaries of Science*, 115–16.
20. Charles Alan Taylor, "Defining the Scientific Community: A Rhetorical Perspective on Demarcation," *Communication Monographs* 58, no. 4 (1991): 415.
21. In *Cultural Boundaries of Science*, Gieryn argues that the "landmarks" that give science meaning "depend upon exigencies of the moment," x–xi; James D. Watson, *The Double Helix: A Personal Account of the Discovery of the Structure of DNA* (1968; New York: Simon & Schuster, 1996).
22. Gieryn, *Cultural Boundaries of Science*, 15, xi.
23. Swedlow, "Using the Boundaries of Science to do Boundary-work Among Scientists," 635.
24. Taylor, "Defining the Scientific Community," 407.
25. Derkatch, *Bounding Biomedicine*, 193.
26. Lessl, "The Galileo Legend as Scientific Folklore," 164.
27. Gieryn, *Cultural Boundaries of Science*, 35; Evelyn Fox Keller, *Reflections on Gender and Science* (New Haven, NJ: Yale University Press, 1985).
28. See, for example, Celeste Condit, "How Bad Science Stays that Way: Brain Sex, Demarcation, and the Status of Truth in the Rhetoric of Science," *Rhetoric Society Quarterly* 26, no. 4 (1996): 83–109; and Maria Ong, "Body Projects of Young Women of Color in Physics: Intersections of Gender, Race, and Science," *Social Problems* 52, no. 4 (2005): 593–617.
29. Thomas M. Lessl, "Scientific Demarcation and Metascience: The National Academy of Sciences on Greenhouse Warming and Evolution," in *Controversy and Confrontation: Relating Controversy Analysis with Argumentation Theory*, ed. Frans H. van Eemeren and Bart Garssen, 77–91 (Amsterdam: John Benjamins, 2008), 80.
30. Lessl, "Scientific Demarcation and Metascience," 78; Gieryn, *Cultural Boundaries of Science*, 20.
31. Gieryn, *Cultural Boundaries of Science*, 34.
32. Michael White, *Acid Tongues and Tranquil Dreamers: Tales of Bitter Rivalry that Fueled the Advancement of Science and Technology* (New York: William Morrow, 2001), 248–94.
33. Watson, *The Double Helix*, 169.
34. Watson and Crick, "A Structure for Deoxyribose Nucleic Acid," 737–38.

35. Bruno Latour, *Science in Action: How to Follow Scientists and Engineers Through Society* (Cambridge, MA: Harvard University Press, 1987), 1.
36. Brenda Maddox, *Rosalind Franklin: The Dark Lady of DNA* (New York: Harper Perennial, 2003); Anne Sayre, *Rosalind Franklin and DNA* (New York: W. W. Norton & Company, 2000).
37. Melinda Baldwin, *Making Nature: The History of a Scientific Journal* (Chicago, IL: University of Chicago Press, 2015), 2, 146; "Credibility, Peer Review, and *Nature*, 1945–1990," *Notes and Records* 69, no. 3 (2015): 337–52.
38. Maurice Wilkins, Alex R. Stokes, and Herbert R. Wilson, "Molecular Structure of Deoxypentose Nucleic Acids," *Nature* 171, no. 4356 (1953): 738–40; Rosalind E. Franklin and Raymond G. Gosling, "Molecular Configuration in Sodium Thymonucleate," *Nature* 171, no. 4356 (1953): 740–41.
39. Denise Tillery, "The Plain Style in the Seventeenth Century: Gender and the History of Scientific Discourse," *Journal of Technical Writing and Communication* 35, no. 3 (2005): 273–289; Paul Newell Campbell, "The Personae of Scientific Discourse," *Quarterly Journal of Speech* 61, no. 4 (1975): 391–405; Gross, Harmon, and Reidy, *Communicating Science*, 165; Charles Bazerman, *Shaping Written Knowledge: The Genre and Activity of the Experimental Article in Science* (Madison: University of Wisconsin Press, 1988).
40. Robert Olby, "Quiet Debut for the Double Helix," *Nature* 421, no. 6921 (2003): 402.
41. Peter Newmark, "Human Face of Watson and Crick," *Nature* 250, no. 5464 (1974): 361.
42. Jeanne Fahnestock, "Accommodating Science: The Rhetorical Life of Scientific Facts," *Written Communication* 3, no. 3 (1986): 275–96.
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44. Horace Freeland Judson, "Honest Jim: The Sequel," *Nature* 413, no. 6858 (2001): 775; Bernal, "Dr. Rosalind E. Franklin," 154.
45. Alexander Gann and Jan Witkowski, "The Lost Correspondence of Francis Crick," *Nature* 467, no. 7315 (2010): 519–24.
46. Olby, "Quiet Debut for the Double Helix," 405; Georgina Ferry, "Science Today, History Tomorrow," *Nature* 493, no. 7430 (2013): 21.
47. Martha Solomon, "The Rhetoric of Dehumanization: An Analysis of Medical Reports of the Tuskegee Syphilis Project," *Western Journal of Speech Communication* 49, no. 4 (1985): 233–47.
48. Marta Paterlini, "History and Science United to Vindicate Perutz," *Nature* 424, no. 6945 (2003): 127.
49. Richard Holmes, "The Scientist Within," *Nature* 489, no. 7417 (2012): 499.
50. Lessl, "The Galileo Legend as Scientific Folklore," 146.
51. Franklin's student Gosling recalled, "A lot of people referred to her as Rosy behind her back, but nobody called her Rosy to her face." Paula S. Apsell, *Secret of Photo 51*, Film, directed by Gary Glassman (Boston: NOVA, 2003), DVD.
52. Watson, *The Double Helix*.
53. Walter Gratzer, "Maurice Wilkins (1916–2004)," *Nature* 431, no. 7011 (2004): 922.
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