Routledge Studies in Technical Communication, Rhetoric, and Culture

# SCIENTIFIC COMMUNICATION

## PRACTICES, THEORIES, AND PEDAGOGIES

Edited by
Han Yu and Kathryn M. Northcut

ROUTLEDGE

# Scientific Communication

Yu and Northcut have blazed a new, important, timely, and practicable trail in the field of science communication.

—*Paul Dombrowski, University of Central Florida*

For faculty (and grad students) who want to initiate courses in science writing, or for those who want to enrich their approaches, Yu and Northcut's new work has much to offer. The volume offers the best current thinking to support the teaching of science writing.

—*Stephen A. Bernhardt, University of Delaware, Emeritus*

This book addresses the roles and challenges of people who communicate science, who work with scientists, and who teach STEM majors how to write. In the Practice and Theory section, chapters address themes encountered by scientists and communicators, including ethical challenges, visual displays, communication with publics, as well as changed and changing contexts and genres. The Pedagogy and Curriculum section covers topics important to instructors' everyday teaching as well as longer-term curricular development. Chapters address delivery of rhetorically informed instruction, communication from experts to the publics, writing assessment, online teaching, and communication-intensive pedagogies and curricula.

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*Edited by Han Yu and Kathryn Northcut*

# Scientific Communication

## Practices, Theories, and Pedagogies

**Edited by Han Yu and Kathryn Northcut**

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Han Yu and Kathryn Northcut

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# High stakes and great responsibility

## An introduction to scientific communication

*Han Yu and Kathryn Northcut*

Before his death in 2002, Stephen Jay Gould, one of the best-selling scientist authors of our time, reflected upon his first two books, which coincidentally appeared in the same year, 1977. The Harvard professor of zoology and geology and museum curator noted that his first "technical" book (*Ontogeny and Phylogeny*) and his first "popular" book (*Ever Since Darwin*) were featured by *The New York Times* because the idea of a scientist publishing successfully in two separate genres seemed quite surprising (Gould, 2002, pp. 1–2). However, in looking back at his own publication history, Gould apologized for having perpetuated a false distinction between scientific and non-scientific prose:

> I no longer view this conjunction of technical and "popular" as anomalous, or even as interesting or unusual.... For, beyond some obvious requirements of stylistic tuning to expected audiences—avoidance of technical jargon in popular essays as the most obvious example—I have come to believe... that the conceptual depth of technical and general writing should not differ, lest we disrespect the interest and intelligence of millions of potential readers who lack advanced technical training in science, but who remain just as fascinated as any professional, and just as well aware of the importance of science to our human and earthly existence.
>
> (Gould, 2002, p. 2)

In the eight-year tenure of Barack Obama, despite cataclysmic problems in U.S. banking and industry, recognition of the importance of science was borne out in strongly positive language and modest fiscal boosts across scientific enterprises (Hourihan, 2017). At the 2016 Democratic National Convention, Hillary Clinton's declaration, "I believe in science!" received cheers from the crowd, but not enough votes in key districts to be elected. On securing the presidency, Donald Trump immediately made decisions that reinforced his avowed dismissal of certain initiatives, including climate science, renewable energy, environmental sustainability, and public health, among others. For example, the Trump budget aims to cut $250 million in research activity sponsored

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by the National Oceanic and Atmospheric Administration (NOAA) and $900 million from the Office of Science in the Department of Energy (Achenbach, 2017). Science, it seems, fell out of political favor with the pendulum swing of partisan politics.

For scientists and citizens whom Gould identified as "well aware," 2017 thus dawns with serious concern for "our human and earthly existence." As the world looks on, the institutions Americans took for granted, like the Environmental Protection Agency (EPA) and the National Institutes of Health (NIH), face debilitating budget cuts. Federally affiliated websites are monitored and purged of climate change related content, social media posts, and blog entries (Davenport, 2017). And appointments to positions of national science leadership seem antithetical to the purposes of their organizations—like the appointment of Scott Pruitt, a fossil fuel industry advocate, as the head of EPA.

Our colleagues in science are deeply concerned, and some of their life-long research pursuits are at stake. For the time being, those of us in the interdisciplinary (and relatively unknown) field of technical communication might seem spared. However, that's really not the case: even though the fallout does not appear to directly target us, we are all connected, and anything that affects science inevitably affects us. A brief look at our investment and involvement in science should make that evident.

## Our Current Involvement in Science

Although technical communication lacks a precise definition, it is concerned with transactions where someone needs to obtain information in order to make decisions or take action. Contexts for such transactions vary, but in research, practice, and teaching, we engage most extensively with discourses of technical fields (such as engineering and computing), scientific fields (such as biology and physics), and general business contexts (like finance or marketing).

Recent studies by our scholars, for example, examined image construction in science (Buehl, 2014; Northcut, 2011; Welhausen, 2015), the argumentation and representation of science (Kitalong, Moody, Middlebrook, & Ancheta, 2009; Whithaus, 2012), and the communication of various topics from climate change to genetics to drug therapy (Cagle & Tillery, 2015; Mogull & Balzhiser, 2015; Turner, 2005; Yu, 2017). Our journals also devoted special issues to engage with the topic (Johnson-Sheehan & Stewart, 2003a,b; Northcut, 2007).

Although few of our programs may explicitly use "science" or "scientific" in their program titles, our experience and conversations with colleagues tell us that many programs, especially those at land-grant universities, regularly offer classes with science-related titles that serve students from life sciences, agricultural sciences, and medical sciences. The general goal of these classes is to prepare students for the kinds of communication tasks expected of them in their academic programs and/or future careers.

Such classes are prevalent because nationwide, our colleagues in science recognize that communication competency determines whether their graduates are able to publish, obtain grant funding, and secure professional or academic positions. Similarly, for science students to succeed in industry, government, and nonprofits where they work in positions ranging from manufacturing, R&D, to policy making, they must communicate with management, marketing, and legislative bodies. Academic and industry scientists also need the ability to work with popular media and communicate with a broader audience about the relevance and worth of their work. Indeed, in today's political climate, the ability to invite, engage, and persuade public audiences may be the best way to preserve science.

## Opportunities We Are Missing

Despite our deep involvements and investments, our field has produced surprisingly little focused and systematic research in scientific communication the way it has in other flavors of technical and professional communication (although, for a welcome exception, see Gross & Buehl, 2016).

In important research areas such as intercultural communication (e.g., Thatcher & St. Amant, 2011; Yu & Savage, 2013), genre studies (e.g., Spinuzzi, 2003; Winsor, 2003), and new media research (e.g., Brewer, 2015; DeWinter & Moeller, 2014; Lamberti & Richards, 2011), our books focus exclusively or primarily on technical and professional discourses and contexts. Journal publications are no more encouraging. Database searches using the key words "scientific communication" and "science communication" yield enormous literature. But major publication venues are outside of our discipline and often situated in the sciences (e.g., *Nature* and *Science*), communication studies (e.g., *Journal of Science Communication* and *Public Understanding of Science*), and science education (e.g., *International Journal of Science Education* and *Journal of Research in Science Teaching*). Our scholars' research on science, for all intents and purposes, disappears in this enormous literature.

Certainly, we do benefit by drawing upon other fields and subfields. Charles Darwin's *Origin of Species* provides the classical example of how scientists persuade audiences using rhetorical strategies. Edward O. Wilson's *Consilience* (1998) helps us understand science as an evolved enterprise. Bruno Latour and Steve Woolgar's *Laboratory Life* (1979, 1986) long served as a staple for introducing our students to the culture of science. Works in the veins of discourse analysis, cultural studies, and ethnography that refer extensively to science and scientists (e.g., Baake, 2003; Fahnestock, 1999; Gross, 1990) also inform much of our research.

However, these works, valuable as they are, frequently have different concerns and focuses than what our scholars, and many in our expected readership, value. To start, most published works are interested in scientific communication as "historical phenomena—created, recognized, mobilized, and given force within the mind of each writer and reader at specific social-historical moments" (Bazerman, 2000, p. 318). As such, they are frequently focused on historical cases and classical figures such as Francis Bacon, Isaac Newton, and Charles Darwin (see, e.g., Bazerman, 2000; Fahnestock, 1999; Gross, 1990; Gross, Harmon, & Reidy, 2009). Such studies are therefore of limited use to our scholars who are interested in contemporary scientific discourses and practices.

In addition, these works are rooted in rhetorical, social, cultural, and philosophical discussions but less interested in how to enhance (in a more or less normative sense) scientific discourses. Because of this difference, they are not immediately useful to scholars who are interested in pedagogical challenges: namely, how can we teach science students to produce more effective and ethical communication. Also, how can we teach students in communication and rhetoric to be critical readers, writers, editors, and critics of scientific discourses?

## Filling the Gap

Such missed opportunities inspired this volume. When we proposed the book, we sought to address any number of challenges that we imagine will emerge when the institution of science meets the context of writing. We profoundly empathize with science communication instructors because we are two of them. We recognize that resources on this subject that we attempt to teach and theorize are very limited, while much more information is readily available concerning generic "technical writing" or "technical communication." We wanted to help prospective scientists who need to write and writers who are immersed in the world of science. We wanted to know what and how these students should be taught. And we wanted to know how writing instructors and scholars broach science. In short, we began with a strong commitment to compiling a useful book, but only a vague sense of what the volume would look like when it was done.

Between 2014 and 2017, this volume developed. Every time the authors of the 13 chapters submitted a new version, our confidence grew. Arguments evolved. Methodologies unfolded. Connections among chapters emerged. After years of refinement, each chapter has a story to tell, an argument (or several) to make, and a body of knowledge that is likely to inspire or educate.

Now, our collection can claim to effectively achieve the following objectives, winnowed down from the 24 originally listed in the call for chapter proposals:

1 Define and describe science communication and scientific communication, explicating and complicating those terms.
2 Demonstrate how the writing practices of scientists change over time, as do the constraints (both internal and external) under which they work.
3 Examine assumptions and expectations about how scientists *should* communicate and how ethical practice is (and is not) enforced in broader social contexts.
4 Provide specific, extended examples of genres in which science is heavily invested.
5 Explicate the roles and social responsibilities of scientists, science communicators, and other agents as they invent, repurpose, and deploy scientific information for different purposes to different audiences.
6 Describe courses in science communication, including descriptions of and observations about the instructors, the students, and what they do.
7 Interrogate the role of rhetoric in science communication pedagogy.

Not all chapters demonstrate every objective, but each makes a substantial contribution.

Reid explains in Chapter 1 that, despite scientists cordoning themselves off through exclusionary professionalization, non-scientists are involved in scientific endeavors for various reasons. The changing role of the citizen-scientist perhaps tells us even more about a science-infused society than it does about particular science projects. In such a society, the boundary between insiders and outsiders, experts and non-experts, is blurred. This blurred boundary is made clear in Reid's description of a biology lab and echoed in Chapter 10, as Maddalena and Reilly describe science communication service courses.

Two studies examine how science as an institution operates in the larger regulatory context of the U.S. In Chapter 2, Katz and Linvill interrogate how the federal government oversees (or demurs from regulating) the ethical activities of science. Mogull, in Chapter 3, reveals how the financial motivations of pharmaceutical companies compete with a strictly correct interpretation of research data. These bird's-eye accounts help us see scientists out of the romanticized setting of the isolated lab, but rather as actors in a heavily regulated industry operating in a litigious social environment.

Rich examples of science communication genres are highlighted in most of the chapters in the Practice and Theory section. These genres frequently reflect the changing context of science and implicate both insiders and outsiders, experts and publics. Maps of the Zika virus give us insight into how visualizations communicate health risks to publics and how that communication is bound up with people's perception of risk (Welhausen, Chapter 4). The visual trope of evolutionary biology, the tree of life, is interrogated not only for scientific accuracy, but for anthropocentric implications (Yu, Chapter 5). Trending Twitter hashtags enable us to observe public perceptions of and responsiveness to our deteriorating atmosphere (Cagle & Tillery, Chapter 6). And museum displays are evolving to engage visitors as active co-creators of scientific knowledge (Schneider-Bateman, Chapter 7).

However, knowing a bit about what scientists do, should do, or don't do is still a long way from knowing how to effectively teach students to appreciate ethical, effective practice as scientists, writers, and communicators. The second section of the book, Pedagogy and Curriculum, begins with a strong argument for taxonomizing the world of science communication. In Chapter 8, Buehl and FitzGerald take a scientific approach practiced in biology and anthropology to explain the role and function of scientific communication species, niches, and terrains across the university.

Chapters that follow then give us a peek into actual species, niches, and terrains. In Chapter 9, Gigante discusses the kind of knowledge to teach students and debunks "quick-fix" approaches to teaching scientific communication. In Maddalena and Reilly's service classes (Chapter 10), we learn how to produce unexpected research questions, dialogic literature reviews, and functional research posters. In Davis and Frost (Chapter 11), we see how a rhetorically informed scientific communication pedagogy is enacted in face-to-face and online classrooms, the latter becoming an increasingly popular fixture in our programs. Harding and Studer (Chapter 12) then guide us through a series of workshops that train unexperienced graduate lab assistants to teach science writing to undergraduate students. Finally, in Chapter 13, Carmichael and Klock give guidelines on how to integrate Wikipedia into scientific communication classes to provide an authentic authoring experience to students.

## How Does This Book Help Me to Teach Science Communication?

What helps an instructor to teach scientists to write, or to teach writers to write about science? The short answer is "a lot" and "it depends." This volume engages with that question and, however imperfectly, provides a basis for learning much of what needs to be known. No single book is sufficient, but we hope that this volume offers a necessary component in professional development sought by motivated and competent instructors.

*In order to teach science, we need to understand scientists.* A qualified science communication instructor needs at least some interaction with scientists or scientists-in-training. Scientists in different disciplines form different hypotheses and research questions, use different tools and equipment, and work with different materials and samples. However, the training of scientists does have some common themes, which defy complete explication in this essay but are part of a current national conversation: recognition of the importance of reproducible data, systematic observation, and logical reasoning upon which to build theories; assumptions that science exists for the purpose of examining and explaining the natural world as well as the built environment; and concern for ethical practice and exploration.

A qualified science communication instructor is one aware of and fascinated by these practices and themes, as Gould (2002) would recognize. She has probably taken a university science course, and visited or worked in a laboratory. He probably watches TED talks about scientific topics, or reads *Scientific American* and watches NOVA for fun.

Such fascinations will teach us some key lessons about communication, though probably very little indispensable knowledge about science. That doesn't mean that science *per se* isn't important, because it is. But no single discipline can be isolated as the one that we need to understand in order to have the academic equivalent of a science communication credential. Science is socially performed, not mechanically formulated, and scientists are people, not data. Therefore, like communicating in other contexts, we are communicating for, with, and about human activities. False attempts at objectivity (see Chapter 9) and universalism may be where we start as we try to broach science, but understanding situated science communication contexts and their unique stakeholders, audiences, purposes, conventions, and expectations is, as always, key.

Because of this, the ideal science communication instructor has undertaken research where she studied individual scientists; their motivations and concerns; their subject matters; their approaches and methods; and/or their data, findings, and communication products. This research will show us that data collection and analysis are central to the work of most scientists (Chapter 1), but at the same time, science is *not* merely about finding robust data to better answer research questions (Chapters 2 and 3). Scientists work within social, cultural, political, and economic contexts, and their work is subject to the values of those contexts. To identify "scientist" as a professional title *only* is reductive.

Instead, scientists are citizens, experts, agents, and rhetors. Many who identify as "scientist" also identify with any number of other labels: artist, poet, historian, activist, congregant, and student, to name a few. Labels aside, all scientists must continually share their research both within their communities and across broader audiences. The publication/dispersal of their work is not an optional last step; it's inherently part of doing the science and being a scientist. Scientists sometimes work alone in their communication work but frequently with a mixed group of experts: other scientists, technical communicators, science writers, journalists, graphic designers, medical illustrators, marketing/sales specialists, and publishers. Depending on the skillsets of the scientists and their colleagues, their works run the spectrum from masterful and transcendent to clumsy and misguided. Our authors, Welhausen, Yu, Cagle and Tillery, and Schneider-Bateman, show us these complex possibilities in their respective engagements with scientists' communication products.

The more time we spend around scientists, the less likely we are to generalize—as is true with most intercultural experiences. Science is not homogeneous, and its practitioners are complicated individuals with overlapping and sometimes contradictory values and beliefs. Numerous subcultures exist, even within disciplines. Like cultures, science also changes over time. The paradigms, methods, ethics, and norms of science evolve. The views toward science shared by broader social and cultural groups also change, and are also inherently complex.

To teach science communication, then, is to present how the heterogeneous group of scientists, in their respective ways, establish credibility to explain and promote their version of science. Doing so, we can then help students look beyond jargon, research methods, quantitative data, proper English, writing conventions, and move toward legitimate participation in the interdisciplinary communities where science and communication—and concomitant social change—happen.

At some points in the development of these ideas and of this book, we wondered: given the challenges, the complexity, and the difficulty in defining even the basic terms of what we do, who would *want* to teach science communication? Then we read draft after draft from our pedagogy and curriculum authors, Buehl and FitzGerald, Gigante, Maddalena and Reilly, Davis and Frost, Harding and Studer, and Carmichael and Klock, and we stopped worrying. Their attention to everything about teaching science and communication demonstrates the persistence and engagement that will propel this enterprise in productive directions without further comment by us.

## What's in a Name: Technical, Science, and Scientific?

Despite our authors doing the heavy lifting, two terms deserve some initial unpacking as they encompass, in several ways, the premise of this volume.

### *Technical Communication vs. Scientific Communication*

At this point, some readers may question *if* we need to be concerned by our field's lack of explicit research on scientific discourse. Wouldn't our studies of engineering, manufacturing, and other professional discourses transfer to the science? Although the content of these discourses differs, surely the essence of our work applies if all of them are, for the lack of an alternative descriptor, "technical" in nature. In short, how is "technical communication" and "scientific communication" so very different, if at all?

These questions surfaced, although were by no means settled, in our early attempts to define the field. Britton (1965), for one, treated the two terms synonymously and spoke of them conjunctively as "technical and scientific writing," a practice that is still common today. For him, the two concepts are one and the same because their primary characteristic "lies in the effort of the author to convey one meaning and only one meaning" (p. 114). Kelley (1976) had a similar view. Subsuming technology under science as "applied science," he defined technical writing as "Writing about subjects in the sciences in which the writer informs the reader through an objective presentation of facts" (p. 3).

Of course, there were positions to the contrary. For Zappen (1983), both scientists and technologists address a range of contexts, some "basic" and some "applied." Technical writing, then, is not simply applied scientific writing. Dobrin (1983), more pointedly, argued that technical writing and scientific writing are distinct: technical writing makes accurate, individual statements (e.g., nut A fits bolt B); scientific writing makes a universal truth claim that is provisional given certain terms (e.g., given a particular experiment setup, certain findings emerge).

Such debates and attempts to taxonomize are relics of a bygone era, in which disciplines could lay claim to territory and distinguish themselves from others by what they did and how they did it. In the current era of flattened hierarchies, interdisciplinary academic pursuits, and rapidly changing priorities, the work itself often takes precedence over how the work is defined, getting us back to the question of how people—whoever they are—write science for various audiences.

For these reasons, and the fact that our field has become more established and diversified and that no concise definition could easily describe it, debates over definitions waned. Rather, "technical communication" becomes the umbrella term, loosely defined to describe a range of technical, scientific, business, and professional communication products and processes.

As editors of this collection, we have no intention to (re)define the field or (re)define terms. Instead, we highlight some distinct characteristics of technical and scientific communication—not so much to offer dichotomous definitions but to demonstrate that the latter deserves focused attention. Without such attention, it is wishful for us to think that our understandings of, say, the financial report genre would automatically apply to understanding research reports, or that our pedagogy with engineering students would automatically apply in a class enrolled with pre-med students.

What are the differences? First and probably most obvious is the ultra-specialized nature of contemporary scientific investigation. Each discipline, sub-discipline, and research area involves extensive insider knowledge, implicit convention, and nomenclature. Together, these factors make it difficult for scientists, and communicators who work with them, to convey their work to non-scientists or even scientists from other fields.

Second, compared with technical information, scientific information is more resistant to adaptation for varying audiences, or it takes more layers of complexity in working through that adaptation (see Chapters 1, 3, 4, 5, and 7). To borrow from Dobrin (1983), this is because scientific discourses must connect with the norms and premises of a research paradigm to make truth claims. Scientific claims are contingent upon multiple elements, including previous findings, experimental design (which is in turn built upon previous work), and analytical assumptions. It is therefore less easy to determine what are essential findings, what is non-essential background, or how to disentangle the why, the what, and the how. For example, a patient trying to read literature on a treatment for heart disease will want to know more than just how to obtain or take a drug, but how we know what we know about the drug's activity, including side effects.

With technical information, it is relatively easier to separate background of why a piece of technology works from how it works, or what users can do with the technology from how the technology does it. Again, to borrow from Dobrin (1983), this is because technical writing is more situation-specific and relatively free from theoretical or methodological baggage. Leveraging this feature, a writer can choose and combine specific statements to suit a target audience's need. For example, instructional manuals usually omit the "why" and focus on "how," whereas an engineering testing report will forgo the laws of physics and focus on quantitative data of product performance.

Last, technical and scientific discourses also elicit different affective and social responses. In the realm of technology, audiences are frequently technologists who engage in technical work or consumers who purchase technologies. While there can be profound safety and ethical issues in communicating technologies to these stakeholders (see Dombrowski, 2000; Katz, 1992), in today's techno-centric world, audiences generally assume the "good" of the technology or see it as a neutral means to an end. In terms of Feenberg's critical theory of technology (1991), we are likely to either take an instrumental attitude toward technology or to valorize it.

In contract, skepticism of science is rampant. Feenberg's determinist attitude (1991) may prevail as the publics remain wary of uncomfortable and contradictory scientific claims. For any number of science disciplines, stakeholders—including members of the publics, activists, legislative bodies, and companies/laboratories with competing interests—may not agree with the inherent "good" of a piece of science, seeing it more like a runaway train where the discovery and creation process is one step ahead of policies that protect the public interest. The progression of science, whether for the betterment or detriment of humans and the planet, seems inevitable and frightening. Stem cell research, genetically modified food, climate change, and even natural evolution are a few examples where factors such as education, emotion, religion, economics, values, ethics, and politics complicate the understanding and communication of science.

In short, we repeat: the communication of science deserves our focused attention.

### *Scientific Communication vs. Science Communication*

Another pair of terms deserving explanation here is "scientific" vs. "science," as in "scientific communication" vs. "science communication." Conventionally and generally, "scientific communication" means communication that transpires between fellow scientists and specialists (as in peer-to-peer communication). It results in such products as research proposals, research articles, and conference presentations. By contrast, "science communication" means communication that transpires between scientists and non-scientists—or more precisely, accommodations and popularizations that transmit *from* scientists *to* non-scientists. Its results include newspaper and magazine reports or TV programs of science.

This conventional distinction is by no means universal or consistent. Knowingly or otherwise, researchers and teachers use them interchangeably or differently (see Chapter 8). As for our position, we think that their difference was born out of outdated rhetorical contexts and academic traditions. We maintain that in contemporary use, a demarcation between the two is not only unnecessary but indeed problematic.

First, the supposed difference between the two terms is semantically unattainable. When we use the term "scientific" to prefix "communication," we could mean that the communicated content is scientific in nature or that the act of communication is somehow scientific—whatever that means. But if we accept these premises, nothing changes when we shift from "scientific" the adjective to "science" the noun. Semantically, the "science" prefix would yield the same connotations.

Certainly, one may argue that in "science communication," the communicated content is *about* science but *not* actually scientific. This argument may be at the bottom of the conventional differentiation between "scientific communication" and "science communication." Communication between fellow scientists and experts, as the idea goes, is the *real* science, pure and precise. What is trickled downstream to the publics, however, is diluted, simplified, distorted, and ultimately *not* scientific.

But this dichotomy is difficult to maintain as it is impossible to pinpoint the place where content becomes simplified, language becomes imprecise, and knowledge becomes derived (Hilgartner, 1990; also see Chapters 3, 6 and 10). Canonically, the communication of science starts with scientists doing experiments and reporting their findings to fellow experts in peer-reviewed publications; once validated through peer reviews, those findings may then be disseminated by mainstream media to the publics. This canonical model, however, has started to crumble when economic incentives, institutional pressures, and the intention to engage the publics are driving scientists to bypass peer review and work directly with the popular press (Chubin & Hackett, 1990; Russo, 2000). In addition, through such formats as citizen science projects, social movements, and policy debates, today's publics are increasingly involved in the discussion and performance of science (Chapter 1).

More fundamentally, we will do well to recognize that the supposed demarcation between "experts" and "non-experts" is situation-dependent, politically charged, and potentially problematic. Brian Wynne's (2004) famous study of the Chernobyl Nuclear Power Plant explosion demonstrates how sheep farmers' knowledge of the local environment and farming management could have informed scientists' attempt to assess and reduce contamination. In this and other cases (see Irwin & Michael, 2003), the boundary between insiders and outsiders is blurred as science becomes a social enterprise, a cultural phenomenon, and an economic necessity.

This is not to say that formal knowledge of science is *not* relevant and important. It is, especially in today's political climate. But also important is publics' local knowledge and value stances (Holliman, Whitelegg, Scanlon, Smidt, & Thomas, 2009; Irwin & Wynne, 2004)—or, in Gould's (2002) words, their interest, intelligence, awareness, and fascination.

For these reasons, in this collection, we treat "scientific communication" and "science communication" interchangeably. We did not, however, prescribe that our authors use one term over the other because both have historical currency and may be preferred by individual scholars, instructors, and programs. Ultimately, what is important is not semantic rigidity but a consensus in the way we understand science as social discourse: created and used by people in dynamic and unstable contexts, for varying and ever-changing reasons.

## Concluding the Beginning

We who spend much of our time at universities are privileged, surrounded by researchers in a wide range of academic disciplines, working with motivated, ambitious, and capable students. If we choose to, we can place ourselves on the front lines of the fight to reduce oceanic pollution, improve efficiency of vehicles, and solve the other problems of a small, hot, crowded planet. Those of us who—however awkwardly—straddle various disciplines of humanities and science are in the enviable position to encourage students to pursue critical questions of their disciplines. In one of the ironies of the modern university, those of us credentialed in liberal arts and humanities (self-labeled "non-scientists") are extremely likely to teach students majoring in science, technology, engineering, and math (STEM).

While 2017 may not seem like an ideal historical moment to valorize science and argue for the merits of science communication, perhaps this is an ideal time for this volume to be published. We hope it will bolster those who continually strive to improve science education, technological competence, and greater access to information and education. As a species, we remain ignorant of the promises and practices of science at our peril. Or perhaps, as another icon of science has said, "[T]here is no shame in not knowing. The problem arises when irrational thought and attendant behavior fill the vacuum left by ignorance" (Tyson, 2004, p. 38). By way of closing, we resort to riffing on Neil deGrasse Tyson's infamous words: "Science communication is important whether we want it to be or not."

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# Part I

# Practice and Theory

# 1 Shifting Networks of Science

## Citizen Science and Scientific Genre Change

*Gwendolynne Reid*

This chapter reports on a study of communication related to the emerging scientific practice of citizen science, a practice with multiple definitions, but which, in simplest terms, denotes "participation by the public in a scientific project" (McKinley et al., 2015, p. 3). Many of the earliest and most widely known citizen science projects have focused on birds, such as the National Audubon Society's Christmas Bird Count and Cornell University's eBird project – a project that has produced dynamic visualizations of bird migration patterns across continents (Audubon and Cornell Lab of Ornithology, 2016). Recently, these projects have greatly diversified, with featured projects in SciStarter – a database of citizen science projects – ranging from those focused on genome and environment interactions, to those on flu symptoms, and to those on monarch butterfly counts.

The number of citizen science projects has also grown significantly in recent years. Jonathan Silvertown (2009), in his influential article on citizen science, attributes its current rise to widespread access to the Internet and mobile technologies, scientists' increasing realization of the public's interest in and availability for research (p. 467), and the fact that funding organizations routinely build in outreach as an outcome for funded research (p. 469). These factors have led to a radical climb in the number of projects labeled "citizen science," a trend documented in recent reports, such as ecologist Duncan McKinley's et al. (2015) report on citizen science contributions to environmental protection and natural resource management. Mapping the number of peer-reviewed publications per year that are indexed in the Web of Science database as relevant to "citizen science" for the last two decades, McKinley et al. show growth from near-zero results between 1995 and 2005 to an almost vertical climb past the 200-per-year mark in 2015 (p. 5). Silvertown (2009), moreover, points out that while not always labeled "citizen science," science conducted by citizens has been an integral part of its history (e.g., Benjamin Franklin and Charles Darwin).

But what does all this mean for scientific communication? Why pay attention to an emerging practice like citizen science when seeking to understand, practice, or teach scientific communication? This collection

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is in part intended to address the question of how to define scientific communication, including whether "scientific communication" is distinct from "science communication." In this chapter, I argue that, while roughly distinguishable as communication between expert scientists and communication about science with non-experts, the two are more interrelated than commonly understood and that this interrelationship is a force for mutual change and influence. The canonical model of scientific communication between experts and the public has a particular sequence and direction, a particular rhythm: internal communication within the scientific community occurs first, and transmission and popularization of scientific findings for the public occurs second (Bucchi, 1998, p. 5; Hilgartner, 1990, p. 519). While this model has been challenged and complicated (Bucchi, 1998; Hilgartner, 1990; Lewenstein, 1995; Myers, 2003), citizen science, by including communication with the public *during* a study rather than after its publication, overtly disrupts and changes the rhythm inherent in the model, a model many engaged in science and scientific communication continue to operate under. This shift in timing, while seemingly simple, both responds to and creates pressure for genre change in scientific research articles and their genre networks, changes that are especially relevant to those seeking to participate in this context or preparing others to do so. In short, the emerging writing practices related to citizen science impact traditional scientific writing practices, including those related to the research article genre and communication with the public.

Taking a case study approach (Gomm, Hammersley, & Foster, 2000), this chapter draws on my ethnographic work with the Heartbeats Project (Hine, 2015; Marcus, 1998), a citizen science project run by a biology lab actively engaged in innovating with scientific communication and embracing the blurred boundaries between expert and non-expert that citizen science encourages. The project is conceived of as a response to the limited data behind the well-known "rule" that, on average, mammals' hearts beat one billion times per lifetime and seeks additional data to test whether the original rule holds as well as to extend the analysis to other biological classes, like birds and amphibians. To participate, citizen scientists submit species heartrate data found in the scientific literature, which is then vetted by members of the project team before inclusion in the data set. The findings reported here were developed from eighteen months of ethnographic engagement with the project, an engagement that included analysis of project-related writing, public speaking, interviews, observations, and digital artifacts (e.g., data spreadsheets, data submission tools, etc.). The study received IRB approval, and pseudonyms are used throughout to protect participants' confidentiality. In analyzing the relationship of the team's citizen science communication with their scientific communication and traditional forms of public communication, I found a rhetorical genre framework coupled with the concepts of *uptake* (Austin, 1962) and *recontextualization* (Linell, 1998) proved useful. This framework and these concepts allowed me to trace the relationships between genres as well as to model broader changes to the scientific genre chains and networks. While multidirectional, interconnected models of scientific communication have been theorized (Bucchi, 1998; Hilgartner, 1990; Lewenstein, 1995; Myers, 2003), examining the relationships between genres provides a specific mechanism for how this multidirectionality occurs and recurs, and demonstrates the potential for genre change that citizen science presents. Specifically, citizen science, by bookending the dominant genre of scientific discourse—the research article—with public-facing genres, responds to some of scientists' most pressing rhetorical exigences while simultaneously exerting pressure for professional scientific genres, to change. In addition, analysis of the Heartbeats Project's communication suggests that scientists engaging with such projects benefit from them in unanticipated ways, namely at the level of rhetorical invention, and that this inventional work provides an additional mechanism through which citizen science influences professional scientific writing. I conclude with a discussion of the implications for those engaged in or teaching scientific communication, including the rhetorical and ethical considerations presented by revised relationships with members of the public.

## Theoretical Framework

The relationship between scientific discourse and public discourse about science has been theorized for many decades, with the most prevalent model showing scientific knowledge moving unidirectionally from science to the public through the mass media, generally losing precision along the way (Bucchi, 1998, p. 5; Hilgartner, 1990, p. 519). Several theorists, however, have challenged the accuracy of this model, calling for more bidirectional (or multidirectional) accounts of how ideas move between discourses. Based on his study of communication related to cold fusion, for example, Bruce Lewenstein (1995) troubled the idea of linear dissemination of information to the public, instead proposing a "web of science communication contexts" that includes everything from journals, grant proposals, and talks to mass media, textbooks, and policy reports, "with all forms of communication leading to each other" (p. 426). Around the same time, Massimiano Bucchi (1998), in *Science and the Media*, offered the "continuity model" of scientific communication as an alternative that, instead of theorizing science and the public as discrete spheres, theorizes a continuous and reciprocal movement of scientific information through four stages: the intraspecialistic, interspecialistic, pedagogical, and popular stages (p. 13). More recently, Bucchi (2004) presented the double helix as a metaphor that can model how scientific and public discourses develop in parallel, mutually acting on one another at "junctions," with influence moving both ways (p. 279). Focusing here on the specialist and public discourse on genes, Bucchi noted the long history of public discourse on heredity, "as documented, for example, by the famous claim by French novelist Emile Zola—thirty years before the rediscovery of Mendel's laws of heredity—that 'heredity has its laws, just like gravitation'" (p. 274). Rather than an "impoverished" version of specialist ideas, Bucchi points out that public ideas on heredity have evolved in parallel to scientific discourse, with the two intersecting at various points in a mutually reinforcing pattern. In this same vein, Greg Myers (2003) made a similar case against the dominant model of popularization, arguing that, instead, "scientific discourses are embedded in and intertwined with other discourses" (p. 271).

The study I describe here contributes to this troubling of the dominant account of the relationship between scientific discourse and the public. I use rhetorical genre theory as a framework that provides a view of the recurring types of communication within these two larger spheres, as well as the routine patterns of interaction that knit the two together. Rhetorical genre theory, rather than focusing on shared formal features as the basis for genre, focuses on the pragmatic *actions* genres perform for communities. To quote Carolyn Miller's (1984) influential definition, genres are "typified rhetorical actions based in recurrent situations" (p. 159). In this paradigm, genres are a complex of the "substantive, situational, and stylistic" (Campbell & Jamieson, 1978, p. 18). Mediating between individual action and culture, genres help rhetorical communities, "the relationships we carry around in our heads, to reproduce and reconstruct themselves, to continue their stories" (Miller, 1994, p. 75).

While studies of individual genres have yielded important insights into a range of rhetorical communities and events, a number of genre theorists have found it productive to expand their focus to *groups* of genres, such as genre sets, systems, and networks, for a fuller account of the processes at work in the production of events, texts, and communities (Bazerman, 1994; Berkenkotter, 2001; Devitt, 1991; Swales, 2004). In this same vein, the concept of "intertextual chains" has been useful (Fairclough, 1992; Linell, 1998). These chains, once routinized into fairly predictable, recurrent patterns of interaction, might best be thought of as "genre chains" (Swales, 2004). The relationships between texts in these chains can vary in nature. Some texts directly prompt or form the exigence for another, while others bear more implicit traces of each other in what Mikhail Bakhtin (1986) has called the "dialogic overtones" of all language—the "echoes and reverberations of other utterances" that fill our own utterances (p. 91).

For the first, more directly linked relationships, I have drawn on John Austin's (1962) concept of *uptake*, particularly as it has been put into conversation with genre theory by Anne Freadman (2002), who theorizes that "a text is contrived to secure a certain class of uptakes" and that "the uptake text confirms [the first text's] generic status by conforming itself to this contrivance" and responding in the expected way (p. 40). While warning against the impulse to systematize these utterance-uptake relationships into rigid sets of rules, Freadman offers a rationale for looking at pairs of texts (and ultimately genre chains) as a productive way to understand both the relationships between genres in a given context and, through this, the social actions of individual genres. For the second, more implicit intertextual relationship, I have drawn on Linell's (1998) recontextualization, defined roughly as "the extrication of some part or aspect from a text or discourse, or from a genre of texts or discourses, and fitting of this part or aspect into another context" (p. 145). This can involve direct quoting or reworking of material for another context, as well as "vague influences" between texts (p. 148).

While these are different types of relationships between texts, both can become routinized into recurring patterns that can be usefully mapped into genre chains. For my purposes, they have provided useful analytical tools for concretely mapping some of the paths professional scientists and citizen scientists travel in interacting with each other. They therefore also provided some concrete mechanisms for how scientific discourse and public discourse about science influence each other. As John Swales (2004) points out, however, we should be careful about overly systematizing these relationships with a term like *genre system*, which "suggests that we have a greater understanding of how everything fits together in a 'system' than is likely the case" (p 23). I have therefore opted for Swales's term, *genre network*.

## Studying the Heartbeats Project

The Heartbeats Project is one project of many at a biology lab in a large Southeastern U.S. public university and includes data collected by citizen scientists as well as data collected by members of the lab. The project is conceived of as a response to the limited data behind the rule that on average mammals' hearts beat one billion times per lifetime. The project's researchers have sought to add substantially to this data, to test whether the original rule holds, and to look at the relationship between heart rate and lifespan for other biological classes, like birds and amphibians. In part in order to speed up the process of gathering heart rate data from the scientific literature, the lab created a webpage that solicits submission of relevant species heartrate data and research articles by citizen scientists, which are then vetted by members of the project team before inclusion or exclusion in the data set. This lab has a strong commitment to public science and experience running citizen science projects, with some of those projects reaching participation in the tens of thousands of citizen scientists. At the time of writing, however, the Heartbeats Project had only garnered a little over 100 citizen science contributions, a number high enough to help address the limited data of the original research in this area, but that calls attention to the project's difficulty in engaging citizen scientists, a fact also reinforced by the one-star rating given it in the SciStarter database. The team has hypothesized a number of reasons for this low engagement, with the dominant explanation that this is related to the project's focus on the scientific literature, which is often inaccessible to the public and which does not fit the schema of "doing science" many citizen scientists are seeking. The team running the project consisted of five core people, though other members of the lab and campus resources were tapped as needed:

- Clay – the postdoc leading the Heartbeats Project and lead author on the first research article manuscript.
- Jada – the undergraduate researcher assigned to the project.
- Summer – a lab manager and research associate assisting with project visualizations.
- Soren – the principal investigator (PI) of the lab who began the project.
- Rachel – a former member of the lab assisting with statistical analysis.

The findings I report on here were developed from eighteen months of ethnographic engagement with the Heartbeats Project's writing and focus on the team's inventional work, meaning the process of developing scientific findings, ideas, and material for their research article. This study employed qualitative research methods and proceeded inductively, with ongoing analysis driving further data collection. In order to situate the team's writing practices within a larger context, I took an ethnographic approach informed by the "connective" practices described by Christine Hine (2015) in *Ethnography for the Internet*, practices that integrate mediated forms of engagement with participants and the field into ethnographic inquiry in order to avoid increasingly problematic divisions between online/offline activity. In practical terms, this means that digital artifacts and interactions (e.g., emails, the project website, Twitter events, etc.) were included in my analysis alongside interviews and observations (see Table 1.1).

I analyzed data for this chapter through three approaches. First, I mapped the relationships between texts, both those with direct utterance-uptake relationships and those with signs of recontextualization. Second, I performed rhetorical analysis of the texts included in this mapping. Third, I coded collected data using MAXQDA, a qualitative data analysis tool. While my larger study of this team included several other codes, this chapter focuses on three main codes, along with their subcodes: (1) public communication, (2) scientific communication, and (3) genre talk.

*Table 1.1* Types and Quantities of Data Collected

| *Within Team* | *Beyond Team* |
|---|---|
| 9 Interviews (9 hours) | SciStarter observations (4 projects) |
| 5 Observations (6 hours) | AnAge database observations (3 entries) |
| Drafts & writing samples (9 texts) | Twitter #CitiSciChat events (3 events) |
| Project data spreadsheets (5 spreadsheets) | CitSci listserv observations (270 listserv posts) |
| Project website/lab blog posts (14 posts) | Citizen science participation (2 projects) |
| Emails (70 emails) | Local citizen science events (3 events) |
| Media coverage of the project/lab (12 articles) | National Science Foundation documents and databases (4 documents) |
| Lab social media account subscriptions (3 platforms) | Citizen Science Association website and blog (2 site visits) |
| Participation in the Heartbeats Project (1 submission) | |

## Overlapping Models of Communication

Before examining the Heartbeats Project team's innovative communication practices, it is important to note that the team engages in traditional scientific communication practices like writing research articles and communicating with the public after the publication of research articles alongside their citizen science writing. In fact, the dominant model of scientific communication between experts and the public was strongly present in their work, both as a standard to be pushed against and as a resource to be enlisted. Clay, the postdoc leading the project, referenced a typical chain of genres resembling the dominant model and the desired uptake between those genres many times over the eighteen months of this study (see Figure 1.1), an order that amounted to important procedural knowledge for acting effectively as a scientist.

Clay explained that the way to set this chain in motion in his institutional context was to contact the university public information officer assigned to them, Brendan Cross, as soon as a research article was accepted. The desired uptake from the press release Brendan produced was widespread coverage of their work through both traditional news media and through social media, though this uptake was by no means guaranteed. Having a press release ready to send out while the research article was still under embargo or on the day the article was published was one way to increase the chances of success, since, as Brendan explained to me, "Depending on the discipline, [the research article's] shelf life can