

Time is of the Essence: The Centrality of Time in Science Plays and the Cultural Implications

By

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Abstract

Time is of the Essence: The Centrality of Time in Science Plays and the Cultural Implications examines how time operates within the narrative and structure of science plays. Combining analysis of play texts and production critiques with phenomenological theories of time and embodiment, and also exploring related theories about time in physics and philosophy, I extrapolate what science plays may illuminate about our cultural relationship to science because of how we experience time—both in and out of the theatre. In the dissertation I investigate three groups of science plays: 1) contemporary plays that display time in innovative ways, such as Tom Stoppard's *Arcadia* (1993), Anna Ziegler's *Photograph 51* (2011), Shelagh Stephenson's *An Experiment with an Air Pump* (2000), and Nick Payne's *Constellations* (2012); 2) plays about the atomic bomb that presented apprehensions mankind made a scientific device to end time as we knew it, seen in Robert Nichols and Maurice Browne's *Wings Over Europe* (1927), Arch Oboler's *Night of the Auk* (1956), Lorraine Hansberry's *What Use Are Flowers?* (1969), Arthur Kopit's *The End of the World* (1984), and Michael Frayn's *Copenhagen* (1998); and 3) plays about climate change that demonstrate how mankind may be running out of time to change the course of events, including Moira Buffini, Matt Charman, Penelope Skinner, and Jack Thorne's *Greenland* (2011), Mike Bartlett's *Earthquakes in London* (2010), and Stephen Emmott's *Ten Billion* (2012). I compare these plays to other representations of science in film, museums, and literature, contrasting the phenomenological experiences and positioning theatre as a rare, time-oriented art that can reveal important scientific ideas. By investigating science plays, I argue that theatre, because of its own phenomenological and temporal particularities, enables us to examine how we as a culture view our scientific past, present, and future in ways few other experiences can compare.

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Introduction: The Times When Theatre and Science Meet

“For all that science has contributed to our lives in the past half century, it hasn’t yet universally changed the way we think. And it won’t unless we understand and address why.”¹

--Adam Bly, *Science is Culture*

At a glance it is hard to discern how greatly science has affected and influenced our culture in the past hundred years, or if it has changed the way we think, as Adam Bly suggests. In considering such thoughts, this dissertation is an investigation of science plays, specifically examining the various ways in which science plays utilize time in their narrative and structure. I argue that theatre, because of its own phenomenological and temporal particularities, enables us to envision how we as a culture view science as part of our past, present, and future in ways few other experiences can equal. To do so, in this dissertation I establish parameters of time theory, primarily as time is understood through phenomenology, and closely examine three groups of science plays—contemporary plays where time is integral to the story, plays about the atomic bomb, and plays about climate change. The play titles examined are Tom Stoppard’s *Arcadia* (1993), Anna Ziegler’s *Photograph 51* (2011), Shelagh Stephenson’s *An Experiment with an Air Pump* (2000), and Nick Payne’s *Constellations* (2012) in Chapter Two, Robert Nichols and Maurice Browne’s *Wings Over Europe* (1927), Arch Oboler’s *Night of the Auk* (1956), Lorraine Hansberry’s *What Use Are Flowers?* (1969), Arthur Kopit’s *The End of the World* (1984), and Michael Frayn’s *Copenhagen* (1998) in Chapter Three, and Stephen Emmott’s *Ten Billion* (2012), Moira Buffini, Matt Charman, Penelope Skinner, and Jack Thorne’s *Greenland* (2011), and Mike Bartlett’s *Earthquakes in London* (2010) in Chapter Four. In analyzing each play within each

group, I consider the play as a piece of dramatic literature and a produced performance, evaluating what it says about our culture's relationship to science, best illuminated by assessing how each playwright deploys time within their work. The purpose of this dissertation is to explore the relationship between culture, time, and science that distinctively manifests itself within science plays, answering the question that if science has (or has not) affected the way we think and behave, why that might be so.

Indisputably, science is profoundly significant to our lives. Yet, scholars, journalists, and sometimes even scientists themselves have analyzed and written about how our culture is occasionally at odds with science and its findings.² We are in awe of what new planets we may find in other galaxies, but still debate the possibility of climate change.³ We wonder when scientists can create a vaccine for escalating, virulent viruses like Ebola, or more recently Zika. Yet, in recent years there has been an increase in measles outbreaks because of disbelief in medical and scientific advice, and consequently, children have not been vaccinated.⁴ It is our need to understand this inconsistent positioning of science within our present culture—as contributor to and byproduct of culture, as a beacon of human progress and fear-provoking danger, as our potential rescuer and creator of our inevitable demise—that sets the backdrop to my dissertation. Thus, this study examines science as it is portrayed in theatre: the art form that reflects upon and represents our culture in ways no other art form can. Eva-Sabine Zehelein in *Science: Dramatic: Science Plays in America and Great Britain 1990-2007* writes, “theater is a format which takes up past and present issues from culture(s),” and that “theater is, and has been since its inception, the forum for an audience-oriented (re)negotiation of social, political, and cultural issues.”⁵ Theatre, and specifically the genre of science plays, offers a chance to look at science as part of our culture *and* as a practice of culture through the unparalleled experience of watching a play and potentially renegotiating its role. It is theatre, because of its temporal structures and conventions, which

grants science plays the time to depict scientific stories, ideas, and criticisms, and the chance to embody them in ways other mediums cannot. And it is by looking at science plays, with the concept and concretization of time offering new considerations for analysis, where the cultural dichotomies of how we treat science emerge, often elucidating that how we think, perceive, and sense time are interwoven with our fickle cultural relationship to science.

The following introduction outlines the key ideas and basic arguments that are further explored throughout this dissertation, including defining the terms science plays, time, and phenomenology. In addition to a literature review, it also presents the scope of each chapter in the dissertation that weaves these three terms together, thereby establishing how this dissertation displays that science plays offer us timely insights about science and theatre and their culturally revealing exchanges that can be realized on stage.

Clarifying Key Terms: Science Plays, Time, and Phenomenology

In the last three decades the genre of science plays has emerged. Despite having origins as far back as Christopher Marlowe's *Doctor Faustus*, the "science play" is a relatively new phenomenon. With Tom Stoppard's 1993 *Arcadia* and Michael Frayn's 1998 *Copenhagen*, both of which will be examined in this dissertation, science plays became a definable genre that started gaining notice. The critical acclaim and commercial success achieved by these two works compelled scholars, critics, and playwrights to note how science plays offered opportunities to tell a new kind of story in the theatre; and consequently, a multitude of science-centered titles started to appear on stage. Scholarly articles investigating the intersection of theatre and science appeared more often in journals in the 1990s and 2000s. Eva-Sabine Zehelein and Kirsten Shepherd-Barr published science play surveys that considered the recurring features of the genre and analyzed several science play titles, initiating the basic understanding of what science plays are. According to Zehelein and

Shepard-Barr, science plays are those that deal with scientific themes and ideas, have historical scientific moments central to the storytelling, and/or often feature scientists as main characters or catalysts for the main action within the play. Thus, the purview of science plays in this dissertation builds from the momentum of the previous work by these science play scholars.

The dissertation includes a diverse range of titles—a range that is less strict about the definition of science plays than found in Zehelein and Shepherd-Barr’s books; I challenge the narrow description of what a science play is that both scholars describe but still find these definitions resourceful. Shepherd-Barr defines a science play as one that has “the scientist as hero or villain (or sometimes both), a direct engagement with ‘real’ scientific ideas, a complex ethical discussion, and an interdependence of form and content that often relies on performance to convey the science.”⁶ Zehelein asserts that science plays “use script and spoken words to communicate their message,” and “includes some realistic science.”⁷ These taxonomies are as limiting as they are helpful, as the idea of “real” and “realistic” can be troublesome terms when discussing science on stage, for many theoretical and theatrical reasons.⁸ This is particularly true as I am not interested in confining conversations about science in the theatre to only what is presently possible or even what exactly happened in our past. I think this fails to account for the artistic possibilities in plays about science and also reflects a presentist mindset about science. For example, a play like Payne’s *Constellations*, which utilizes the theory of a multiverse, is not realistic in the sense that a multiverse conception of the universe is yet verifiable: does this make it unrealistic science, even though physicists theoretically debate this possibility? In Chapter Three I consider several atomic bomb plays, and many present a fear of what could have happened with an escalating nuclear war or threats. While this is not realistic about the scientific and cultural moment that actually came to pass, the fear that underlies these plays was real at the time they were written.

Therefore, my definition of science plays includes works that fall within the descriptions Shepherd-Barr and Zehelein have introduced, but also includes dramatic works that engage scientific potentialities and/or that portray anxieties about scientific consequences, as I think both inclusions reflect how our culture may sometimes view science.

In analyzing science plays, I extrapolate how each playwright implements time in their dramatic work as either a structural or thematic element. To foreground this investigation, time is analyzed in a multitude of ways, indicating that defining time is a complex project given time's own ubiquitousness and elusiveness. At the most rudimentary level, it is difficult to define what time even is, as will be addressed thoroughly in Chapter One. Nevertheless, time has continued to captivate the interest of scholars, predominantly those in physics and those in philosophy, who have delved into the minutiae and the broader generalizations of what time means, what it potentially is and is not, and why it continues to mystify us.

Time's significance in relation to science plays is multifaceted. Firstly, some science plays directly explore notions of time, drawing upon scientific concepts explored in physics. Scientific theories like the second law of thermodynamics, the potential of multiverses instead of a universe, the arrow and flow of time, the contentious nature of tensed time (past, present, and future), the idea of presentism in an age of relativity, and the correlation of time and space appear in the plays analyzed in this dissertation—sometimes specifically so, as these ideas relate to the structure of the play or major themes in the play. Science, and physics in particular, have undoubtedly changed what we can know about time. It is therefore only fitting that science plays, examined through a lens of time, highlight how integral and interestingly time is incorporated from a scientific vantage point within many of these plays. Shepherd-Barr writes in *Science on Stage*, “There seems to be an impulse on the part of the science playwright to call on the audience's imagination more than is usually done in the

theater.”⁹ Shepherd-Barr writes this sentence after assessing how science plays often utilize the alternation of time periods within the story, which I analyze in plays such as Mike Bartlett’s *Earthquakes in London* and Shelagh Stephenson’s *An Experiment with an Air Pump*. While on the one hand, this juxtaposing of timelines is an entertaining storytelling device because it offers the audience engaging contrasts between a “then” and “now,” it more significantly probes a deeper meaning of the play that has to do with science. The alternation of timelines and the collapsing of different tenses—which appear in Michael Frayn’s *Copenhagen* and Anna Ziegler’s *Photograph 51*—allows time to function differently than it can in real life and highlights important ideas within the plays about how science has affected people across time. In science plays, “playing” with time in such ways is regularly a distinctive feature.

Secondly, theatre always has a unique relationship with time, or as Tracy Davis reminds us in “Performative Time,” “In drama, however, the present brokers past and future.”¹⁰ Theatre and time are entwined, evident by the curtain time, the focus on pacing, calculations of needed rehearsal hours, and the theatre artist’s desire to control an audience’s time. These realities make theatre an exceptionally time-oriented art. Theatre artists have the uncanny ability to write and perform a re-imagined past, a potential future, or a supposed present that is revealed in the *real* present. Its events are ephemeral and by “necessity recede in time;” plays make the past come to life again by “giv[ing] life to a nonliving thing,” and we go to the theatre knowing “the arbitrary but practical use of designating when the event begins set[ting] up one of the temporal dimensions that frame a theatrical event.”¹¹ These are descriptions from Alice Rayner, writing about the phenomenology of theatre and its temporal particularities. The theatrical experience, which requires us to sit in the dark, to turn off our phones, and to watch the events unfold in a time we cannot fast forward, pause, or distract ourselves from, is increasingly unusual. All of these temporal rules and expectations make

theatre a phenomenological rarity—as I will demonstrate throughout this dissertation when comparing theatre to other arts and experiences that represent science such as film, museum exhibits, and nonfiction literature.

In comparing theatre to other scientific representations in this dissertation, I often use phenomenology to assess some of the differences. In trying to simultaneously understand some of theatre's matchless qualities (liveness, embodiment, and ephemerality) and also understand time, both in and out of the theatre, phenomenology offers the most useful guide. Mark Fortier describes: "Phenomenology is not concerned with the world as it exists in itself but with how the world appears (as phenomena) to the humans who encounter it."¹² In deploying phenomenology, we look at objects and events in theatre, and attempt to make sense about how they appear to us perceptually and why they experientially feel to us the way they do. Phenomenology enables one to analyze the theatrical experience and time from this perspective. Throughout this study, I compare how time is implemented in science plays to the phenomenological experience of time, demonstrating why our cultural concept of time manifests itself the way it does and what that may mean for science: this is the third reason why time matters in relation to science plays. I also compare the phenomenology of watching a play to the phenomenological experience of being at a museum, film, or reading a book to extrapolate why theatre allows us to have different perceptions and experiences of science that are culturally relevant. Additionally, how the body is central to phenomenological perceptions indicates that it is not only time in the theatre that is distinct within science plays, but also the vital feature of embodiment. It is something else entirely to have a scientist embodied as a character or to observe how science actually affects the characters/humans that are visibly before us compared to the ways other mediums represent scientific ideas and thoughts that lack this corporeality feature.

Phenomenology is a broad discipline, with many incarnations and nuances. It appeals to performance scholars because of its ability to communicate how “theater—unlike fiction, painting, sculpture, and film—is really a language whose words consist to an unusual degree of things that *are* what they seem to be.”¹³ Phenomenology allows us to look at the “thingness” of the theatre, and to understand why theatre inhabits the many contradictions that it does. Phenomenology thus privileges the experience, the observer, the body, and what we know by what we perceive and sense. In the ephemeral world of theatre, it is evident why phenomenology is such a valuable resource because theatres scholars attempt to discuss the experience of watching a play that is already gone, vanished from our analytical gaze. Without phenomenology, it is difficult to otherwise express what that subjective experience was like. Bert States reminds us that theatre is a medium where “its affective corporeality [is] the carrier of meanings,” conveying that its performance, its embodiments, its required presence of actor and audience, and its need for a person’s time is not only critical to the experience of watching a play, but critical to understanding the meaning of the play.¹⁴ In this dissertation, science plays, time, and phenomenology are extensively scrutinized to drive toward the cultural meaning of these dramatic works. All three are critically important to investigating how theatre intervenes with and depicts science’s role in our culture, predominantly by presenting science and scientists in ways other mediums cannot due to this three-pronged relationship that transpires on stage.

Literature Review

As I have mentioned, this dissertation builds on the work of Shepherd-Barr and Zehelein’s thorough science play surveys, respectively titled *Science on Stage: From Doctor Faustus to Copenhagen* and *Science: Dramatic: Science Plays in America and Great Britain 1990-2007*. These books established that science plays were a formidable genre and one

worthy of separate categorization and independent study, and these works have provided the parameters of the term “science play” that I referenced earlier. Within each scholar’s text, Zehelein and Shepherd-Barr find the ways in which science plays have been structured and what scientific ideas playwrights have often tackled, with many works broaching themes about scientific ethics. Throughout this dissertation, I refer to the intelligent research done by Zehelein and Shepherd-Barr as they have written about several of the plays I analyze. I utilize these scholars most often when it helps illuminate patterns of science plays, be it of what they do, how they do it, or how they differentiate from other types of representations of science.

Additionally, both scholars discuss the emergence of theatre as a potential intervention with the persistent and divisive “Two Cultures” C. P. Snow wrote about decades ago between the arts/humanities and sciences, which is impossible to not touch upon given the scope of my dissertation and which I return to in Chapter Two, Section One.¹⁵ Both scholars make it clear that not only do science plays engage pieces of drama, but works that have cultural import, given the significance of science in our society. In terms of approach, Shepherd Barr was more interested in the performance elements of the plays she assessed, arguing that science plays blend form and content in a way that can be seen in the production design, direction, and performance of the plays. Zehelein disputed this claim in her own analysis, writing it put “too strong of an emphasis on one special way of staging science.”¹⁶ Zehelein instead is more interested in the dramatic literature component, suggesting that Shepherd-Barr had an “insistence” to focus on “performance and performativity for the evaluation,” but that the plays are better understood as literature instead of as “performance projects.”¹⁷ While I use both scholars’ work and their examinations of plays have inspired my own dramatic analysis, I veer more toward Shepherd-Barr’s approach, evident in my aim to look at the phenomenology involved in the plays as performed. Additionally, after discussing

each play, I also address the performance of it through examples of notable productions and reviews from critics.

Shepherd-Barr has continued to write about the overlaps between science and theatre, furthering this topic in her more recent work, *Theatre and Evolution from Ibsen to Beckett*. In it she writes, “Theatre provides a particularly potent and fascinating example of how scientific ideas make their way into culture because of its combination of liveness and immediacy, kinetic human bodies in action, and time working on two levels (‘real’ and ‘theatrical’ time).”¹⁸ She has continued extrapolating the performativity of dramatic literature in exciting ways through her scholarship, and in this statement expresses the phenomenological uniqueness of theatre that is offered to science—time being no exception. Her statement’s validity is one that is threaded throughout the next several chapters. To this end, theatre allows science to feel like a human endeavor, because the scientist is characterized before the audience and scientific pursuits are striven for out of engaging motivations and relatable emotions via a dimensional performance. Scientist turned science playwright Carl Djerassi (who greatly influenced Zehelein’s work) further explains, “The majority of scientifically untrained persons are afraid of science,” but through science plays there is a chance to “bridge the gap between science and the other cultures, to make science as real to people as any other job a human being might do [...] to illustrate how scientists behave.”¹⁹ Science feels real in science plays because the scientist is performed by an actor and is no longer an abstract idea we non-scientists know little about. Shepherd-Barr acknowledges in *Science on Stage*, “Science is, paradoxically, at once ubiquitous yet still largely opaque and inaccessible.”²⁰ By the means of a science play, and understood through phenomenology, theatre provides science an opportunity to counter this perception through a necessary corporeality and a shared space and time of audience and performer.

Although Shepherd-Barr and Zehelein answered what science plays are by looking at the subject matter of the plays and sought to answer how the plays thematically explored questions about science, often about scientific ethics, my dissertation goes a step beyond. I evaluate the cultural relevance of these plays because of how they deal with, theorize, navigate, and articulate anxieties and ideas about time in relation to science, and I do so by implementing theories of time and theories of phenomenology. To foreground phenomenology in this dissertation, I explicate phenomenology and how phenomenologists have explained the experience of time. Doing so, I draw on Edmund Husserl's *On the Phenomenology of the Consciousness of Internal Time*, Martin Heidegger's *Being and Time*, and Maurice Merleau-Ponty's *Phenomenology of Perception*. Each of these texts in different ways clearly articulates how phenomenology explains our experiences of time as mentally- and bodily-observed phenomena. Husserl and Heidegger investigated, albeit differently, how an awareness of time and a personal sense of temporality are fundamental to our sense of self and consciousness. They were both aware of the finiteness of experiences; Husserl with how memory and self worked in remembering or anticipating an event—such as performance—and Heidegger with his explorations of Dasein (being) and death. To understand what happens in our consciousness when we perceive phenomena in a temporal sense, as Husserl explains, we have to acknowledge that time is always a part of our experience of the world. Husserl describes, “the perception of a temporal object itself has a temporality, that perception of duration itself presupposes the duration of perception.”²¹ Through these words, he defines how temporality shapes not only the object (as I will often refer to as a performance) but also perception itself; that time is embedded in our very acts of consciousness that allow us to perceive. As Husserl indicates and I elaborate upon, time is everywhere: even in our internal sense of thinking, perceiving, and being. Speaking of being, Heidegger writes, “the central range of problems of all ontology is rooted in the phenomenon

of time.”²² Heidegger suggests our very sense of being and lives are structured by time; the way we make meaning of phenomena in correlation to our lives is by understanding that our being itself has a definite end. Death and the end of being is a theme that reoccurs in the many play texts I analyze, illustrating that time is not only an elusive entity, but also one that shapes the way we experience life due to the time boundaries we encounter through our set lifespans. In going back to these primary texts and reinvestigating what Husserl and Heidegger say about time, I explain the temporal experience of watching a play, how time is experienced by characters in these specific science plays, and how we as a culture and individuals experience time are rooted in phenomenological theory. Heidegger and Husserl’s explorations of time are useful in clarifying the phenomenological perspective of time.

Merleau-Ponty’s phenomenological theory builds on these foundations but also moves in other directions, integrating a full conceptualization of the body as vital to experience and sensory, which explains why many theatre scholars gravitate toward his phenomenology in their own writing. In relation to science plays, Merleau-Ponty touches upon scientific and objective knowledge—a recurring trend by many phenomenologists who critique the authority given to it over perception/experience. He writes, “All my knowledge of the world, even my scientific knowledge, is garnered from my own particular point of view.”²³ Critical to that “point of view” is the reality that perception is shaped by our particular bodies as objects for perception and the apparatus by which we perceive, including experiences of time. Merleau-Ponty’s work helps me bridge the experience of time with the theory of embodiment, given his emphasis on the body being critical to how we perceive and experience phenomena like time. This connection allows me to better clarify that theatre’s shared space and time is the rarity it is because it is inhabited by bodies—both of performers and audience—who are mutually perceiving and observing. By looking at phenomenology and time as I do in Chapter Two, Section One, I introduce why an audience experiences

something unprecedented in the theatre because of how theatre plays with time, its embodied liveness, and its abilities to present ideas that real life cannot replicate, such as jumping back and forth in time—much like Shepherd-Barr’s description I mentioned above. Thus, I use these foundational texts of phenomenologists and analyze the ways in which they express time and embodiment to demonstrate the deeply-woven links between time and perception that are helpful in seeing how time operates in science plays and in general human experience. Moreover, I continue to refer to these phenomenologists when discussing performance and in my analysis of the dramatic texts, correlating their theories with an application toward theatre.

To further comprehend the theoretical underpinnings of phenomenology in theatre, I also turn to theatre scholars who have written about the subject. Stanton Garner writing in *Bodied Spaces: Phenomenology and Performance in Contemporary Drama* asserts that all phenomenologies are a “redirect [of] attention from the world as it conceived by the abstracting ‘scientific’ gaze (the objective world) to the world as it appears or discloses itself to the perceiving subject (the phenomenal world), to pursue the thing as it is given to consciousness in direct experience.”²⁴ What does it mean, however to have direct experience in the theatre when the world disclosed is itself a scientific play? Garner’s work, as well as Bert States’s *Great Reckonings in Little Rooms: On the Phenomenology of Theater* and Alice Rayner’s *Ghosts: Death’s Double and Phenomena of Theatre* are cornerstones for my own understanding of how theatre exists as a place where phenomenological experience operates under different pretenses than it does in the real world. For example, I refer to Garner’s work to give a framework that highlights the many ways in which theatre operates as a phenomenologically rich space, in large part because of the ways in which embodiment is central to it (hence his book’s title). Garner’s work gives insightful descriptions of the fictive versus real world, and the “is” and “as if” of the theatre world that we in the audience

undertake as theatre elides the make believe and real in ways that are not always easy to delineate. It is hard to parse out these differences when in front of us an actor, real and embodied, performs a character, perhaps fictional or not. I reference Garner when embodiment in the theatre confronts this line of reality and theatricality. This idea also taps into some of what States describes in his critically foundational book. His work initiated many of the arguments phenomenologists of the theatre continue to draw upon, including how once things are placed on stage, like water, a chair, a dog, or even a clock, they inhabit a new world and are experienced in a uniquely phenomenological way as they either comply with or resist the illusions of the stage. I too am indebted to the ways States rather simply and ingeniously looks at the dynamics in theatre and their phenomenological life once in a performance. For it is one thing to encounter a clock or think about time in our day-to-day, but when placed on the stage or embedded into a script these entities reveal new sides of themselves to the audience. As I discuss time in a science play—whether it is through the structure of the plot or how the characters speak/think of time in abstract or specific ways—it is with States’s ideas in mind that we begin to comprehend how time in the theatre plays by new rules.

Rayner investigates the phenomenology of theatre but does so through the metaphor of ghosts: “theatre itself is a ghostly place in which the living and the dead come together in a productive encounter.”²⁵ This metaphor allows her to explore how theatre is a place of repetition, and yet also a place where everything is always new because remembering and creating are happening simultaneously. Her theorizing touches upon the liveness of performance and the reality of the performance, as everything is preplanned and also open to chance. She echoes much of what Husserl described in how our mental processes perceive phenomena. I refer to Rayner’s first chapter, “Tonight at 8:00, the Missed Encounter,” as it exemplifies her interest in exploring the phenomenology of time in the theatre; she navigates

how it has both connections to our conscious and unconscious. Moreover, her explorations of time indicate how clearly the theatrical experience is dictated by the demands of time, no matter the type of play at hand. Her work allows me to best explain the time-oriented nature of theatre that is specifically interlaced with its identity as an art—unlike Garner, whose work I use to focus more on the reality boundaries of theatre and embodiment, and States, whom I refer to address the phenomenological components of theatre performance. Of course, in a science play that utilizes time either as central to the narrative in form or content, these phenomenological experiences of time in theatre only become more complicated. Therefore, in using the work of phenomenologists and theatre phenomenologists, I take their work further by considering this extra layer of time beyond real-world time or general theatrical time: what happens when time is central to a play's plot, structure, or theme, particularly in a scientific sense? I continue to juxtapose the phenomenology of how we as a culture experience time and how we encounter time in these science plays, arguing that theatre contributes significantly to our culture because of what it demands of our time and our sense of experience—best explained by phenomenology.

Phenomenology is, of course, not the only field of study that investigates time. Therefore, the examples of time extrapolated from science plays will be explored from other perspectives. More often than not this is to illustrate the uncertainty of how we understand and treat time as a culture. Many of the contradictions regarding our Western concept of time can be best explained by how we *experience* time, illuminated through phenomenology and contrasted to how time might scientifically and theoretically actually function. For example, we often describe time as passing or flowing, but it is argued from a physicist's perspective that time does not truly function this way. There is discord felt when we think about this idea, because it does feel like time passes or that it flows from our subjective perspective. The climate change play *Earthquakes in London* by Mike Bartlett, for example, presents the past,

present, and future of a family affected by and significant to the political and scientific fight against climate change. The play appears to demonstrate how past, present, and future all matter in the path of climate change—much like many physicists argue “that the passage of time is an illusion. There is no difference between the past and the future.”²⁶ It is this division—between what many scholars argue about what time is and its operations versus how time feels and how we experience it, which phenomenology helps to explain—that will emerge in each chapter, considering where plays fall within this divide and how characters in each play confront such disparities. To understand these various time depictions and their cultural relevance, it is important the rift between these time perspectives is first defined.

While philosophers and physicists debate theories of time, science plays dare to stage such ideas. Yet without understanding time first, one misses how theatre articulates and challenges explicit time theories. Thus in explaining time theory that comes to significance in relation to specific play titles (i.e., the second law of thermodynamics in *Arcadia* or multiverse theory in *Constellations*), I refer most often to Sean Carroll’s *From Eternity to Here: The Quest for the Ultimate Theory of Time*, Brian Greene’s *The Fabric of the Cosmos: Space, Time, and the Texture of Reality*, and Adam Frank’s *About Time: Cosmology and Culture at the Twilight of the Big Bang*. Each of these physicists in their respective books gives clear explanations about the physics of time and communicate this effectively to a layperson audience. Greene and Carroll provide exhaustive research on time and science that is readable and full of cogent descriptions, and I reference their books accordingly as I myself cannot articulate the complicated science in simpler terms better than they could. As I make abundantly clear, the analysis I am doing in this dissertation cannot explain the science in the way that a scientist can, and that is not my goal or purpose. Therefore, it is necessary to bring actual scientists’ arguments and suggestions to the forefront when explaining a pertinent scientific theory or science. I use Greene’s and Carroll’s analysis to assess how playwrights

have also referred to or seem to be influenced by scientific theories in their plays, or in order to contrast the scientific theories to the phenomenological experiences of time that are furthered explored in each chapter.

Adam Frank's work has helped me draw the connections between scientific theories of time and their interrelatedness to how our culture treats time. He explains:

This braiding of science and culture is a story that we are unused to telling. It is easy to think of science as some kind of lumbering giant [...] But the knife-sharp separation of science from other human endeavors such as art, politics and spiritual longing is too abstract to be true or helpful.²⁷

His book explicates that as we as a culture have advanced and increasingly been more influenced by science, our conceptualization and experience of time have changed as well. His book has been instrumental to this dissertation in verifying my argument for the dynamic relationship between science, culture, and time. As Frank and other physicists, historians of science, philosophers, and science play scholars consider, thinking about science as part of our culture is critical but too seldom done. I aim to rectify this in part with my work. While I cannot explain the scientific mechanisms in science plays the ways a scientist can, I am aiming instead to explain the cultural importance and human aspect of science. I take ideas like Frank's into a new direction by applying it to an analysis of science plays, where we are given another opportunity to explore science as influential on and impacted by culture. In our culture, the sciences continue to be largely valued for their outcomes and profits and the arts for the potential of enrichment, which does not give them as much merit under capitalist economics.²⁸ However, this is not the only pressing issue when considering time and science

and our cultural perceptions of both, and how theatre and science mutually give the other meaning and relevance when meeting on stage.

To incorporate as full of a picture regarding time as I can, I also integrate various philosophers' works into my analysis of how time operates and how we experience it. This includes Adrian Bardon's *A Brief History of the Philosophy of Time*, David Couzens Hoy's *The Time of Our Lives: A Critical History of Temporality*, and D.H. Mellor's *Real Time* and *Real Time II*. Each of these texts explores how philosophers and philosophy in general help us to consider how time functions, in ways different from how physicists understand time, and sometimes also separate from a phenomenological perspective. The argumentation in these philosophical explorations proves yet again the very elusive nature of time, as time itself sometimes is neither something we can explain scientifically or phenomenologically experience in ways that fully captures its essence, existence, or functions. As I try to make evident throughout this dissertation, I offer as much about time as I can, not in an attempt to obfuscate the topic of time, but in order to address just how multifaceted and complicated time is in our lives and to our relationship to science. Doing so, I also broaden the conversation and include linguistic professor Vyvan Evans's book *The Structure of Time: Language, Meaning and Temporal Cognition*, sociologist Barbara Adam's *Time*, and an assortment of ideas from other scholars across disciplines who have written about time and its complex nature. "Time adds an important and necessary dimension to our understanding of the world and our place in it," writes Evans, but it is important to understand that time operates on many different levels—which this dissertation continues to buttress.²⁹ As society has progressed through science's advances, we have pushed ahead with the way we think of time. It is a continually shifting concept, and I address this aspect of time by demonstrating the ways science has aided or been subject to the shifts.

In this dissertation I oscillate between examining science plays and correlating them to the many ideas about theatre, time, phenomenology, and science from the scholars I have mentioned above. Very few people have written about science plays in longer studies. One rare example is Vivian Appler's 2015 dissertation *Embodied Astronomies: Performances of Telescopes and Other Detection Devices*, which explored the use of telescopes in science plays. In it, she argues that theatre offers a chance for the nonscientists to "participate in the production of science ideas," which I also agree science plays offer.³⁰ Others, such as Ralph Willingham and Theresa May, whose dissertations later became book projects, tap into some of same ideas I discuss in this dissertation like science fiction and theatre and ecology and theatre. While other studies examine the performativity of science or seeing the ways in which science has appeared specifically in plays throughout theatre history, any research on science plays is limited. In my attempt to write about this topic, I have utilized the research of scholars before me, but am forging ahead in areas that are underwritten and undertheorized. As may be evident from my bibliography, I have integrated the work of many scholars, theorists, critics, and journalists into this dissertation to capture the breadth of the topic. I am delving into some yet untraveled terrain in order to elucidate the study's relevance and its implications both inside theatre scholarship and beyond the theatre doors.

Structure

If time is the backdrop in this dissertation, the main attractions are the science plays. In this study, I examine each group of science plays, explaining what concerns they offer about how we view science and noting how these concerns are visible when surveying how time materializes within the play. My choice in the plays I have selected are based on the central criteria: 1) they are Anglo and American science plays published in the last twenty years, and/or 2) they have an interesting vantage point on a major scientific moment that has

cultural resonance, 3) they deal with time, either in structure or idea, and 4) they invite the opportunity for us to see how our culture responds to science. I investigate three groups of science plays— contemporary science plays, atomic science plays, and climate change plays—and I relate each group to existing time theories and phenomenological explanations of time. This dissertation is structured over four chapters, each comprised of two sections. The first section of each chapter introduces relevant theories about time (mostly derived from philosophy and physics) that are most germane to the following section, which are then deliberated on within the theatrical analysis of the plays. Chapter One describes the theoretical underpinnings of time—both in a broad sense as defined by physics and philosophy, and specifically in looking closely at phenomenology—and Chapters Two through Four contain the detailed analysis of the three groups of science plays.

To explore how science plays depict time, in Chapter One I draw out the discrepancies about how we think and know time, conveying the time philosophies that are most useful for the following chapters. There are things scholars in different disciplines agree upon regarding abstract concepts of time, sometimes for the same reasons, and sometimes for reasons that are justified within their own disciplines' logic and methods. Often physicists and philosophers cannot seem to conclude who should have the ultimate say on time (not that this tension is particular to time alone).³¹ Physicist Nikolić explains, “Everyone knows what time is [...] until one starts to think seriously about it.”³² However, as this dissertation will prove, the tensions over time are fascinating to explore from a theoretical and scholarly vantage point; and, more significantly, illustrate the striking problem with misunderstanding time that has real bearing on our cultural relationship to science. Therefore, in Section One of Chapter One, I explore the basic questions of what is time and how we know time, because these considerations emerge in the dissertation as I probe deeper into my analysis of science plays. These inquiries introduce theories of time by physicists like Carroll, Greene, and

Frank, and incite some phenomenological contrasts that indicate how we “know” time may not have much to do with how we “experience” time. To elaborate on this further, I also deliberate how we use time in language through Evans’s analysis—which points toward some of the very common problems in writing about time, in plays utilizing time, and the debates about how time is conceived. In Section Two, I investigate time further, focusing on how phenomenology elucidates how we treat time and are aware of it both in and out of the theatre. I also posit why considering the body matters in thinking about time and performance. This section’s evaluation engages the phenomenological theories of Husserl, Heidegger, and Merleau-Ponty and theatre phenomenologists like States, Rayner, and Garner. This second section positions why phenomenology is resourceful when using time as a lens for analysis regarding science plays; and it also helps to build the groundwork of why time theory—derived from physics and philosophy and other disciplines—is often in contrast to how we as a culture respond to time, and therefore science.

Having established the theoretical tools for this dissertation in Chapter One, namely time and phenomenology, my next three chapters focus on the three groups of science plays. In Chapter Two I focus on contemporary plays that are about science in various ways. In Section One of this chapter (2.1), I first consider how time and science are culturally influential and culturally constructed. By seeing how time and science are not just theoretical or knowledge-oriented, but rather consequential toward how we culturally operate, I underscore the human component in both time and science that will emerge in my examination of science plays. This leads to my exploration in Section Two of Chapter Two (2.2), of contemporary science plays to reconsider science’s role in our culture, particularly as it is performed by humans and is significant to humans in ways that are interwoven with our relationship to time. Tom Stoppard’s *Arcadia* (1993), Anna Ziegler’s *Photograph 51* (2011), Shelagh Stephenson’s *An Experiment with an Air Pump* (2000), and Nick Payne’s

Constellations (2012), analyzed in the chapter, demonstrate such possibilities. Through these plays we see the interplay potentials between science and theatre, and how science can offer theatre “whole new territories of subject matter for playwrights to address, beyond the stale and melodramatic material of dysfunctional families.”³³ In return, theatre elucidates that science is part of our cultural milieu, and not just in terms of its outcomes, but also in terms that affect how we can think about our own lives, individually and socially.

In Stoppard’s *Arcadia*, the audience sees how events that occur in 1809, including the intelligent thoughts of a young girl, Thomasina, impact the research by scholars in 1993. Stoppard brilliantly utilizes the second law of thermodynamics in his play and evokes ideas about causality and inevitability in considering the arrow of time; he does this not only in the structure of the plot, but also in the thoughts shared by young Thomasina in 1809 and how scholars in 1993 grasp what happened to her and her adult peers. Stephenson’s *An Experiment with an Air Pump* also uses this back and forth construction of timelines, this time comparing the ethical demands and gendered relationships between scientists in 1799 with those in 1999, all of whom share the same residence. Through this alternation of time, the audience can see how questions about the purpose of science has as much significance two hundred years later as it did when natural philosophers debated the future of science centuries prior. Ziegler’s play, *Photograph 51* examines the scientific career of Rosalind Franklin at King’s College and her work on discovering the DNA double helix structure. The play both discusses the events of the past from an undetermined future, and also reenacts the past as part of the present that the audience experiences. Doing so, Ziegler critiques the treatment Franklin endured by her male peers and colleagues, and extends questions about how the personal relationship Franklin had with her scientific partner, Maurice Wilkins, was dampened by her gender and the expectations placed on her. Payne’s *Constellations* engages with multiverse theory to tell a love story between a physicist, Marianne, and a beekeeper,

Roland. In deploying a multiverse conceptualization of the universe, the audience watches many different timelines evolve between these two lovers, both in ways where they work out and at times when they part. The play explains the scientific theory underneath this plot device through Marianne's grasp on science, and in her attempt to convince Roland they cannot ever have more time, even as she faces her death. The science in the play emerges through this play of time and scientific theory, and through it, the physicist Marianne realizes how she experiences time is ultimately informed by her scientific knowledge of time.

In looking at these plays we see how theories of time and ideas about science can come to life on stage. Moreover, these four plays prove that science's role in our culture is often too distant and remote; here it is offered as an illuminating enterprise because of what it can help us rethink about our existence, in large part to what these plays do with time. The scientific theories of time we find within these plays make them more meaningful; and through these science plays, we can see that science can be inspiring, poignant, and beautiful. It is a meaningful feat for science plays to humanize science in our culture, which I argue that these plays provide, through their thoughtful engagement with time.

This dissertation contrasts how we think about time versus how we experience it; accordingly, I try to contrast how we experience theatre versus how we experience other representations of science. Correlated to how we as a culture experience time and theatre, I extrapolate examples of how other mediums characterize the relationship between science and time to fully assert why theatre is unique—a word I use often in this dissertation, but fittingly so in describing why theatre offers phenomenological experiences other modes of performance and representations cannot. In Chapter Two, I also look at Christopher Nolan's 2014 film *Interstellar*, and an episode of the *StarTalk* radio program, hosted by the renowned astrophysicist Neil deGrasse Tyson, dedicated to discussing the movie's science and interviewing Nolan about it. The film encapsulates many themes that science plays in this

dissertation cover, including how time is precious, the relativity of time, and the effects of climate change. I contrast the film with contemporary science plays to explain that even though the movie can do things in its storytelling a play can not, its phenomenological time constraints and lack of shared space between performer and audience make it a different experience for an audience to absorb the story. Having seen *Constellations* on Broadway in Spring 2015, I also discuss the phenomenological experience of watching a science play.

In having explored in Chapter Two how science and time matter in human lives and how science is performed by humans (quite literally on stage when the scientist is a character), in Chapters Three and Four I turn toward two major scientific events: the dropping of the atomic bomb and climate change. The atomic bomb was a monumental scientific moment that shaped science's relationship to our culture, government, and global politics. Astrophysicist Martin Rees in *Our Final Hour* writes, "The twentieth century brought us the bomb, and the nuclear threat will never leave us."³⁴ Many of the physicists in the early years of the twentieth century could never foresee the horrors of Hiroshima, and some physicists after the bomb dropped worked fervently toward halting the increasing arms race in the United States and the Soviet Union.³⁵ Unavoidably, the bomb created some responses of fear toward science and scientists, which I explore in Chapter Three. What interests me about the bomb in relation to time is how we as a culture have treated this as a past event, as if this tensed demarcation encases this moment and its consequences in time. In Chapter Three, I explore this idea in Section One (3.1) by critiquing why the idea of tensed time is highly debated in physics and philosophy. This includes examining how we have constructed the bomb as part of our past and how problematic tense is as a way of thinking about time. I then use this argument to explore plays about atomic science and the atomic bomb that spanned the twentieth century in Chapter Three, Section Two (3.2). Robert Nichols and Maurice Browne's *Wings Over Europe* (1927) depicts a young scientist who has

discovered how to harness the power of the atom and presents this idea to a top government committee in England. When the scientist refuses to destroy his research, as the committee suggests, the scientist threatens the committee that he will end the world. The play, like others in this chapter, highlights a feeling of inevitability surrounding the atom and the atomic bomb—as if time and the historical narrative could go no other direction than the way they do. Arch Oboler's *Night of the Auk* (1956), like *Wings*, jumps ahead in time as an American space crew successfully reaches the moon and communicates this achievement back home. The communication is also received by a hostile nation (seemingly the unnamed Russia), and the crew hopelessly watches as nuclear war breaks out back on earth during their ill-fated journey home. Lorraine Hansberry's *What Use Are Flowers?* (1969) is set in a future, postnuclear holocaust. In this world exists an old hermit who remembers civilization as it was, and a group of uncivilized children who are left to raise themselves and barely able to speak. The old hermit tries to educate the children, but learns man may be doomed to repeat his violent history when he fails to instruct them how to behave peacefully in his last days of life. Arthur Kopit's *The End of the World* (1984) is a satiric look at the nuclear arms race. When a playwright attempts to write a play about nuclear weapons, he learns that even those in power have very few answers as to why any of it has evolved the way it has. Kopit mocks the progression of nuclear arms by illustrating that even many decades later, why we have come thus far with nuclear weapons remains a mystery and that few lessons were learned from the past. The play encounters the time-causality absurdity that “the deadly weaponry can be neither grasped nor avoided.”³⁶ Finally, Michael Frayn's *Copenhagen* (1998) details a conversation between Niels Bohr and Werner Heisenberg occurring in Denmark during World War II. The play circles around questions about scientists corroborating with powerful governments, a scientist's responsibility in pursuing scientific possibility, and the ethics of creating the bomb. *Copenhagen* unfolds in “real” time and

retrospective time, and it echoes many questions scientists must face today regarding responsibility for their work.

The atomic science/atomic bomb plays capture a cultural psyche that could not quite make sense of the science or the actuality of the bomb dropping. In this inability to articulate what the bomb or atomic science's evolutions meant for present society, we see that Hansberry, Browne and Nichols, and Oboler set their plays in the future, Kopit (written years later) sets his play in a present that explores what it means to teeter, for decades, near the brink of the world ending. Finally, Frayn's play (written late in the century) reexamines the past and what we think we understand about the atomic bomb creation. These plays exemplify why the theatrical response to the bomb was as peculiar as it was and heavily shaped by ideas of time, tense, and temporality. When we dismiss these plays, we are treating them with the same attitude with which we view the bomb: this is a past we have transcended.

Chapter Three also incorporates my experience of visiting two museums dedicated to the atomic bomb: the Bradbury Science Museum, part of the Los Alamos National Laboratory in New Mexico, and the National Museum of Nuclear Science and History in Albuquerque. The museum in Los Alamos focuses on the Manhattan Project and the progression of the atomic bomb prior to and following Hiroshima and Nagasaki. The national museum displays a wider history of atomic science, including similar projects occurring in Japan and Germany, and the increased militarization of atomic science after the war ended. The spatial component of the museums will also be explored, because stationary sites in historically situated locations evoke intriguing ideas about the relationship between space and time. For example, the Bradbury Science Museum in Los Alamos conjures thoughts about what it means to be on the actual spot where the Manhattan Project unfolded. Moreover, both museums are located next to and in collaboration with major national laboratories that still

facilitate much of what happens with nuclear arms and nuclear stockpiles in this country. I describe how the exhibits in these museums utilize time and timelines, maintain tense distinctions between past/present/future, recall a spatio-temporal history, and tell a specific narrative that is contingent on the positioning of exhibits. Museums operate phenomenologically in a variety of ways different than theatre, but particularly in this case by how they shape and present the narrative of the atomic bomb in relation to time and causality.³⁷ The bomb feels like a faraway past; it was dropped seventy years ago. But to imply that seventy years was a long time ago makes a temporally constructed judgment on a measurement of time that may or may not have any basis on a reality that matters. This is something I will investigate by looking closely at tense and the construction of timelines that scholars like philosopher D.H. Mellor and historian Reinhart Koselleck, respectively, have written about. Considering how these playwrights handled the problem of the bomb in their dramatizations pinpoints a problem with how we conceptualize this event and its ramifications. From this theatrical analysis it appears that controlling the atom—the supposed building block of nature—shifted our cultural perceptions of time *and* science, evident in the plays evaluated in Chapter Three.

Shifting to a more recent but also pressing matter, in Chapter Four I examine science plays that deal with climate change, which often highlight presentist cultural behaviors. In Section One (4.1), I introduce the term presentism and evaluate it from angles in physics and philosophy against the ideas of relativity and eternalism, clarifying its parameters as a theory of time. In Section Two (4.2) I contemplate a series of climate change plays, drawing on this theory of presentism and exploring it further as a cultural attitude that may be seen in our response to climate change. The plays examined include Moira Buffini, Matt Charman, Penelope Skinner, and Jack Thorne's *Greenland* (2011), Mike Bartlett's *Earthquakes in London* (2010), and Stephen Emmott's 2012 hybrid science presentation/theatrical event

staged at the Royal Court Theatre, *Ten Billion*. *Earthquakes* is about a climate scientist who hides his research to protect the airlines, his employer, from the public learning that aircrafts are helping to destroy the environment. The play jumps back and forth to these early scenes with the scientist and the effects of his decisions, to scenes about how his daughters have to deal with climate change in the present in their personal and professional lives. The play positions easy politics versus long-term effects of climate change, hinting at the damage such choices create under presentist thinking, which in turn, affects this family for decades.

Greenland follows a large cast of characters that are trying to come to terms with and find their role within the fight for climate change. The characters are diverse, from climate scientists, to activists, to biologists, to politicians; all of whom are experiencing the frustration in reversing the effects of climate change because of ineffective policies, regulations, and social behaviors that do not heed the urgency of global warming. Both *Greenland* and *Earthquakes* demonstrate the effects of climate change on a personal and global scale. *Ten Billion* is an unrelenting look at the effects of a swelling global population facing finite resources due to climate change, and critiques many of our current cultural behaviors and practices that continue to be wasteful, beneficial only in the short-term, and irreversibly damaging. The one-man performance was created at the Royal Court Theatre and is a science-play-lecture hybrid, merging science and theatre together in an innovative approach: Emmott is a real scientist. The three plays illustrate the conflict of scientific knowledge being overlooked for presentist interests in preserving the status quo, usually due to capitalist interests. Each of the plays in its own way illustrates that the demands of climate change on our culture are a matter of grave concern, and must be addressed urgently in our present to avoid a future our species may not be able to weather.

In analyzing these plays, we see the complications with presentist thinking, and to further this conversation, in Section Two (4.2) I draw on David Rushkoff's book, *Present*

Shock: When Everything Happens Now. Rushkoff's book explains why presentism reflects our current cultural behaviors, describing our distractions due to incoming stimuli from our 24/7 technology. This constant incoming of news and data via social media and the Internet makes it nearly impossible to think ahead about something like climate change as we are swamped in the present, mitigating through a constant stream of information. Rushkoff explicates several cultural responses that happen due to this, including a general compression of time so that the "now" is all that can matter and long-term thinking goes to the wayside. To emphasize this presentist dilemma, this chapter also touches on how climate change and the fear of the end of human time materializes in our cultural consciousness, evident in the growing field of literature dedicated to this phenomenon. In Chapter Four I compare theatre to the rising field of scientifically themed books that highlight the fear of climate change's effects. Such books meticulously investigate consequences of climate change—from shortages of food and water, to the extinction of species, to critiques of why capitalism is often at odds with measures to protect the environment and biodiversity. I include Naomi Klein's *This Changes Everything* (and the documentary I attended based on the book), Elizabeth Kolbert's *The Sixth Extinction*, and Seamus McGraw's *Betting the Farm on a Drought*. Rushkoff writes that in our present moment we have lost a sense of time, and that "Without time, we can't understand things in terms of where they came from or where they are going to go."³⁸ Endorsing this critique, the rise of nonfiction doomsday-like prognostications (and dystopian-future evocations in the plays I evaluate) demonstrate that while we are interested in thinking about the future, we are also societally stuck in a present where we are not doing enough to prevent the potentially cataclysmic consequences of climate change. From a phenomenological perspective, a book offers considerably more information than a play could ever provide. Yet, the question remains about the efficacy of information and narratives in overcoming the resistance to take climate change seriously.

These considerations and many more like them appear throughout this dissertation in an attempt to investigate what relevance science plays have for our culture due to how they can present science, time, and provide a phenomenologically unique experience. As I demonstrate throughout, playwrights have shaped fascinating and culturally reflective dramatic works that present our complicated understanding and treatment of science. Why, as will be discovered throughout this dissertation, has a lot to do with how time is experienced and known, and the temporality of our own lives and existence.

Significance of Study

The dichotomy of living in a culture surrounded by science and valuing its outcomes, but also fearing it, ignoring it, or dismissing it is what is so engaging when investigating the concurrent emergence of science plays. However, in the current literature, the genre of science plays is infrequently referenced/studied; and moreover, hardly theorized or deeply analyzed. I expect this dissertation to close some of that gap. Contemplating about why science plays are more common today, Kirsten Shepherd-Barr considers C.P. Snow's discussion of *The Two Cultures*, and writes:

The theatrical experience is doubly dialogic; characters converse on stage, while in a larger sense the actors maintain an unspoken dialogue with the audience. The many recent science plays show how effective this multidimensional conversation can be, suggesting that the intersection of science and the stage may represent precisely the kind of 'third culture' that Snow envisioned.³⁹

By this dissertation's conclusion I hope it is understood how theatre can provide the potentially missing component to communicating ideas and thereby better understanding

science and its place in our culture. Theatre is a cultural institution that celebrates its ability to communicate through story and performance. Science is a cultural institution where communication is vital, but not always happening to the degree it can or should. A large part of the failure in communicating science, I contend, is attributed to the fact of our own cultural inability to slow down, listen, and think carefully and our unfamiliarity with the messengers. However, I argue that theatre encourages and even expects us to slow down, listen, and think by its own conventions, particularly the tradition of watching a story unfold under time strictures over which we have no control. Moreover, while theatre cannot convey the scientific message like a scientist can, it can humanize science, proving its impact on our culture, and provide the messengers (the scientists) with a quality of being relatable. By exploring time in relation to science plays we see that these vast ideas about time, temporality, and science can be palatable and relatable as the actor takes center stage, performs an embodied character, and brings to life a dimensional story.

This dissertation covers an assortment of science play titles that indicate the diversity and complexity of the genre. It also proves that time is an extraordinarily complicated and simultaneously enlightening lens through which to examine theatre, science, and culture. The dissertation speaks to the growing subfield in theatre that looks at how the STEM fields are influencing artistic representations, presenting ways in which the intersections between humanities, the arts, and sciences can bring forth pertinent questions for cultural reflection and for scholarly inquiry. It is of use to those studying dramatic literature, contemporary plays, exploring the application of phenomenology and philosophy in performance, and those interested in the ways theatrical analysis can relate to and provide meaning across disciplines and fields of research—particularly the sciences. Beyond academia and theatre, these stories matter within the conversation about how our culture often narrowly constructs a short-term or generally inconsistent relationship with science. That is not a concern just for scholars, but

one for all humans in trying to understand what role science will play in our culture in the twenty-first century. To this end, if I could add one personal mission to this dissertation, it would be to demonstrate that because of cultural constructs of time, theatre's storytelling still matters in an age of smartphones, Netflix, and social media. I believe science plays and the contemplations they can spark about science, time, and culture prove why theatre's role is timeless for our culture.

However, before we can understand how these science plays use time, a greater understanding of time is necessary—as it functions, as it is understood, as it relates to phenomenology, and as it lives another life within the theatre. Quite simply, when considering science plays, time is of the essence in understanding the mechanisms at play and to understanding why science plays are culturally relevant. For this, Chapter One dives into the theories of time that will be pertinent for the play analysis that proceeds over the course of this dissertation.

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1. Adam Bly, "Introduction," *Science is Culture: Conversations at the New Intersection of Science + Society*, ed. Adam Bly (New York: Harper Perennial, 2010) ix.
 2. Jay A Labinger and Harry Collins, *One Culture?: A Conversation About Science* (Chicago: University of Chicago Press, 2001) has several essays that explore our varied and sometimes skeptical cultural response to science. Bly's *Science is Culture* also presents several scientists and nonscientists debating major scientific issues and why we as culture respond the ways we do to scientific knowledge.
 3. Andrew J. Hoffman, *How Culture Shapes the Climate Change Debates* (Stanford: Stanford University Press, 2015) 9. A Yale Project on Climate Change Communication surveyed that only 63% of Americans believe that global warming is happening, cited in Hoffman's book.
 4. Steven Salzberg, a contributor to *Forbes* magazine and described as "fighting pseudoscience," documents the rise of measles in early 2015, as he also did with whooping cough two years prior. Both were due to the rise of the anti-vaccine movement that ignored scientific urgings to vaccinate children. See, Salzberg "Anti-Vaccine Movement Causes Worst Measles Epidemic In 20 Years," *Forbes.com*, 1 Feb. 2015, <<http://www.forbes>.

com/sites/stevensalzberg/2015/02/01/anti-vaccine-movement-causes-worst-measles-epidemic-in-20-years/#57da1d137ef9> (accessed 1 Jan. 2016).

5. Eva-Sabine Zehelein, *Science: Dramatic: Science Plays in America and Great Britain 1990-2007* (Heidelberg: Universitätsverlag Winter Heidelberg, 2009) 83 and 84.

6. Kirsten Shepherd-Barr, *Science on Stage: From Doctor Faustus to Copenhagen* (Princeton: Princeton University Press, 2006) 2.

7. Zehelein 97 and 99.

8. Phenomenologically and even physically speaking, the definition of “real” is something I come back to later in this dissertation in Chapter One, Section One, explaining that it is a difficult concept to express with any certainty. Moreover, the term of “real science” may also evoke contested notions about historical accuracy in these plays, such as happened with *Copenhagen*—which I discuss in Chapter Three, Section Two. As will be apparent, even plays that tackle “real” science from history use many fictive storytelling devices and are not documentary-style science plays.

9. Shepherd-Barr, *Stage 2*.

10. Tracy C. Davis, “Performative Time,” in *Representing the Past: Performance Historiography*, eds. Thomas Postlewait and Charlotte Canning (Iowa City: University of Iowa, 2010) 142.

11. Alice Rayner, *Ghosts: Death’s Double and Phenomena of Theatre* (Minneapolis: University of Minnesota Press, 2006) xv, xix, and xxx.

12. Mark Fortier, *Theory/Theatre: An Introduction* (New York: Routledge, 2002) 38.

13. Bert States, *Great Reckonings in Little Rooms: On the Phenomenology of Theater* (Los Angeles: University of California Press, 1985) 20.

14. States 27.

15. C.P. Snow in his *The Two Cultures* (1959) argued that culture was divided between the humanities and sciences, and suggested major world problems would not be resolved until those in the humanities saw the legitimacy and value of the sciences that often had been overlooked.

16. Zehelein 79.

17. Zehelein 79.

18. Kirsten Shepherd-Barr, *Theatre and Evolution from Ibsen to Beckett* (New York: Columbia University Press, 2015) 2.

19. Carl Djerassi, “Science as Theater” in “Study Guide for *Oxygen*” (Weinheim: Wiley-VCH, 2001. E-copy): 15. Emphasis in original text.

20. Djerassi 15.

21. Edmund Husserl, *On the Phenomenology of the Consciousness of Internal Time (1893-1917)*, trans. John Barnett Brough (Norwell, MA: Kluwer Academic Publishers, 1991) 24.

22. Martin Heidegger, *Being and Time*, trans. Joan Stambaugh (Albany: State University of New York Press, 1996) 16.

23. Maurice Merleau-Ponty, *Phenomenology of Perception*, trans. Colin Smith (New York: Routledge, 1945. 2002) viii.

24. Stanton Garner, *Bodied Spaces: Phenomenology and Performance in Contemporary Drama* (Ithaca: Cornell University Press, 1994) 2.

25. Rayner xii.

26. Zeeya Merali, “Is the Future Already Written?,” *Discover Magazine*, 30 Apr. 2015, <<http://discovermagazine.com/2015/june/18-tomorrow-never-was>> (accessed 18 Feb. 2017).

27. Adam Frank, *About Time: Cosmology and Culture at the Twilight of the Big Bang* (New York: Simon & Schuster, 2011) xvii.

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28. Ella Delany wrote in “Humanities Studies Under Strain Around the Globe” that financing for humanities research has fallen since 2009 and “in 2011 was less than half of one percent of the amount dedicated to science and engineering research and development.” The political and institutional decisions regarding this funding is due to the fact that humanities disciplines do not offer skills or research that are as profitable. Certainly the sciences too fall victim to budget cuts and reduced funding. However, it is hard to justify the funding given to the humanities, as the products of that research do not often result in “short term pay offs.” The article quotes Homi Bhabha: “If you consider the value of the humanities to the cultural sector, for example, I don’t think people can make the rather closed-minded arguments that they make about the utility of the humanities and its contributions.” *New York Times*, 1 Dec. 2013, <<http://www.nytimes.com/2013/12/02/us/humanities-studies-under-strain-around-the-globe.html>> (accessed 5 Feb. 2016).
29. Vyvan Evans, *The Structure of Time: Language, Meaning and Temporal Cognition* (Philadelphia: John Benjamins Publishing Co., 2003) 3.
30. Vivan Appler, “Embodied Astronomies: Performances of Telescopes and Other Detection Devices,” (dissertation, University of Pittsburgh, 2015) abstract.
31. I explore this idea throughout this dissertation, but to give an example, D.H. Mellor on *Philosophy Bites* argues that too often physicists think of time as a puzzle to be solved instead of just an “ordinary, physical variable.” He suggests that physicists get excited that time is an illusion, but as D.H. Mellor argues, it is rather that tense is an illusion and not a property of time itself. D.H. Mellor, “Hugh Mellor on Time,” interview by Nigel Warburton, *Philosophy Bites*, podcast audio, 15 Feb. 2008, <<http://philosophybites.com/2008/02/hugh-mellor-on.html>> (accessed 2 Feb. 2016).
32. Hrvoje Nikolić, “Block Time: Why Many Physicists Still Don’t Accept it?,” 24 Sept. 2008, <<http://fqxi.org/community/forum/topic/259>> (accessed 25 June 2015), 2.
33. Shepherd-Barr, *Stage* 12.
34. Martin Rees, *Our Final Hour: A Scientist’s Warning* (New York: Basic Books, 2004) 1.
35. “A Petition from Leo Szilard and Other Scientists to President Harry S. Truman,” *U.S. National Archives*, <<http://research.archives.gov/description/6250638>>. It should be noted that there were physicists who believed the bomb prevented further bloodshed in the war and helped successfully end the war. Robert Jay Lifton in “Nuclear Energy and the Wisdom of the Body” wrote that the majority of those scientists involved in creating the atomic bomb went about their work, “perhaps with some sense of inner doubt,” leaving a minority that were either fervently opposed or in support of the bomb. Lifton, *Bulletin of the Atomic Sciences* 32.7 (Sept. 1976): 18.
36. Dragan Klaić, *The Plot of the Future: Utopia and Dystopia in Modern Drama* (Ann Arbor: University of Michigan Press, 1991) 90.
37. Causality, in a basic sense, is the idea that one occurrence or event will cause another, and it is usually assumed this event precedes the caused event. This is an idea often explored in relation to the possibility of time travel and concepts of tense (whether past events can cause future events and questions about whether we in the present could affect the past).
38. Douglas Rushkoff, *Present Shock: When Everything Happens Now* (New York: Penguin Group, 2013) 199.
39. Shepherd-Barr, *Stage* 45.

Chapter 1.1: An Overview of Time

The topic of time within the theatre constitutes a central part of this study. Many scholars have addressed aspects of this topic in their writings, many of which will appear in the pages ahead. Outside of the theatre, time is no less complicated. Through investigating scholarly inquiries into time, a similar refrain emerges: time is an extraordinarily difficult concept to describe. Physicist Brian Greene in *Fabric of the Cosmos* writes, “Time is among the most familiar yet least understood concepts that humanity has ever encountered.”¹

Physicist Sean Carroll in *From Eternity to Here: The Quest for the Ultimate Theory of Time* explains that one can define time, precisely in ways “applicable to all fields,” but what is less clear is “why time has the properties that it does”² Physicist Julian Barbour in *The End of Time* suggests that Einstein and Newton treat “time as a given,” but instead posits, “time does not exist” and asks, “is it what it seems to be?”³ Linguistics Professor Vyvyan Evans says that while humans are aware of time, we cannot perceive it, and he therefore wonders, “what is the nature and status of time.”⁴ Philosophy Professor David Couzens Hoy also presents the dichotomy that time appears to be real but doubts, “do we perceive time itself?”⁵

Evident from these excerpts, the concept of time is a complicated entity that usually provokes more questions than prompts answers. Perhaps this is not surprising, given that “‘time’ is the most commonly used noun in the English language.”⁶ Nevertheless, because this dissertation looks at how time appears in science plays and in the theatre, it is necessary to understand more about time itself. This includes defining some of the parameters of its elusive nature. In this section I present some fundamental contemplations about time that lead to explorations about what time is. I then introduce some of the complications in looking at time subjectively versus objectively that will resurface in chapters ahead. This chapter’s purpose is to lay out the foundations for the examinations of time ahead, so that the ways in

which time appears in science plays is better grasped and understood against a larger backdrop about how time works. A thought exercise: define time. What definition you may choose will likely be more subjective and phenomenologically oriented—describing time as a phenomenon that a person experiences—or perhaps is instead more objective, based on scientific principles and ideas of measurement. Time scholars, predominantly in physics and philosophy, continue to debate and analyze what time is, and these debates have not led to any sweeping conclusion that now, in this moment, we conclusively understand time (even the concept of “now” is fraught with time uncertainties). If there is a compromise to make with time it is reconciling the fact that studying time opens more paths for inquiry, and these paths often do not end anywhere definitive—at least not yet, as many physicists writing about time tend to propose. This is a fundamental “problem” with time, of which there are many other problems, and some of which I introduce in this section and in the chapters ahead.

I am a theatre scholar, not a philosopher or physicist; as a theatre scholar I am intrigued by the relationship of science and time as it appears in science plays and theatre, observing what such plays may say about our cultural relationship with science. To do that, my analysis requires me to familiarize myself with time. In this section I offer to do the same for the reader, as certain threads of time theory will reappear in the dissertation. Providing a broad perspective on the topic of time, the next section looks toward the phenomenological perspective of time in the theatre. To this end, I unequivocally agree with sentiments espoused by Carroll, for example, who writes, “Despite all the ink that has been spilled and all the noise generated by discussions about the nature of time, I would argue that it’s been discussed too little, rather than too much.”⁷

Time Is...

Understanding time, one can easily oscillate between objective and subjective perceptions, finding thoughts in physics, philosophy, and other fields that assess time with logical deductions.⁸ One interesting feature of a science play that has thus far been under analyzed by other scholars is how they exemplify a variety of ideas about time. As a scholar looking at science plays and time, I can examine time from many angles—including its phenomenological descriptions, the scientific explanations, its peculiar life in the theatre, and its cultural implications. This is possible due to the vast and multifaceted qualities of time. In defining what time is, this question often returns to the deliberation of what time does. Carroll's research on time in *From Eternity to Here* is insightfully comprehensive. Early in the book, he establishes three different aspects of time that may be useful in considering how we think about time. Carroll's three-point list defines time as such:

1. Time labels moments in the universe.

Time is a coordinate, it helps us locate things.

2. Time measures the duration elapsed between events.

Time is what clocks measure.

3. Time is a medium through which we move.

Time is the agent of change. We move through it, or—equivalently—time flows past us, from the past, through the present, toward the future.⁹

Carroll follows this list by acknowledging that while these points look straightforward, each of these ideas are “independent concepts” and not necessarily related to one another.¹⁰

Addressing point one, this concept hints at Einstein's theory of general and special relativity and spacetime, versus earlier conceptualizations of time, such as Newton's idea that time is absolute. The shift between Newtonian and Einsteinian physics irreversibly altered

perceptions of time. Newton's theory of absolute time argued, "that one could unambiguously measure the interval of time between two events, and that this time would be the same whoever measured it, provided they used a good clock."¹¹ In Newtonian physics time could be "pictured as a one-dimensional line, consisting of an infinite sequence of instants, all lined up in order of occurrence," and that time and space were "absolute and immutable entities that provided the universe with a rigid, unchangeable arena."¹² Greene states that Newton's definitions of space and time, though drawing disputations by some of his contemporaries, answered enough questions about these two entities in relation to the structure of the universe so that they remained "dogma" for the next two hundred years. Greene adds, "These assumptions about space and time comport with our daily experiences."¹³ Experience is a fundamental base returned to frequently when thinking about time.

As our understanding of the universe and cosmology has broadened with physics, largely due to Einstein, we have learned that Newton's absolute concept of time was not correct: time is not separate from space, and time and space are part of the same continuum. Nola Taylor Redd summarizes that Einstein's theory of special relativity "determined that the laws of physics are the same for all non-accelerating observers; and he showed that the speed of light within a vacuum is the same no matter the speed at which an observer travels. As a result, he found that space and time were interwoven into a single continuum known as space-time. Events that occur at the same time for one observer could occur at different times for another."¹⁴ These contributions to how we conceptualize physics and the universe cannot be overstated. "Einstein's general theory of relativity seems to govern the large-scale structure of the universe," writes Stephen Hawking.¹⁵ Greene adds that the "relativity of space and of time is a startling conclusion," and that while the mathematics of Einstein's discovery are not hard to replicate, "the ideas are foreign and apparently inconsistent with our

everyday experience.”¹⁶ This admission is significant. One way to think of Einstein’s complex theories, as Greene suggests, is that looking at a parked car from your vantage point will make it appear stationary. If that same car were to drive away, “some of its motion through time is *diverted* into motion through space [...] the speed of the car through *time* slows down when it diverts some of its motion through time into motion through *space*.”¹⁷ What this then means is that time moves more slowly for the moving car “*and its driver than it elapses for you and everything else that remains stationary*.”¹⁸

After Einstein failed to find a theory of gravity consistent with special relativity, he assumed that “gravity is not a force like other forces, but is a consequence of the fact that space-time is not flat [...] it is curved, or ‘warped,’ by the distribution of mass and energy in it.”¹⁹ The idea of spacetime, further described by Hermann Minkowski—a teacher of Einstein—looks at the universe as composed of four-dimensional coordinates, with three coordinates representing space and the fourth representing time. “Einstein realized that there are different, equally valid ways to slice up a region of spacetime [...] into regions of space at moments of time,” writes Greene; and while this may sound simple to state, “it’s the basis for overturning some of the most basic intuitions that we’ve held for thousands of years.”²⁰ This has drastically altered how we can think of time, even if it has not altered on a day-to-day level how we treat time. Nevertheless, these scientific principles have mattered for our culture as Einstein’s theories revolutionized science in the twentieth century from enabling the synchronization of GPS systems to understanding how time factors into air and space travel. Science and time are thus interwoven in the twentieth and twenty-first centuries largely due to Einstein’s theories. The science plays I analyze will illustrate some of the implications of these theories when we see science against this backdrop of theorized time.

Moving to point two that describes time as measuring the duration elapsed between events, Carroll explains that for one to measure time, the measuring device and measurement

need to be consistent. The key, he writes, is “*synchronized repetition*—a wide variety of processes occur over and over again.”²¹ In discussing clocks and measuring time, Carroll returns to Einstein’s special theory of relativity. He gives the example of two clocks leaving the same event with the same coordinate, taking two different paths across the universe, and arriving at the same coordinate. If this were to happen, the two clocks will “generally experience different durations along the journey, slipping out of synchronization.”²² This is possible to conceive when understanding that time is like space, and that time is not absolute. The clocks will read differently because “time measured by a clock depends on the particular trajectory that the clock takes, much like the total distance covered by a runner depends on their path.”²³

Putting the scientific perspective of time measurement aside, Carroll’s second point also hints at a subjective undercurrent. Human beings think of time and experience time in relation to clocks and calendars and measure time as the distance (or is it space? —I touch on linguistic problems shortly) between events. Moreover, the accuracy of clocks has continued to evolve as our need for time specificity has increased in the globalized economy and modern world. Frank describes this in his book in regard to the development of time zones that occurred under the progression of train travel in the nineteenth century, which created havoc until their implementation.²⁴ Michael Shallis writes in “Time and Cosmology” that “The history of our culture has [...] been a history of the progressive pinning down of time, of making ever more accurate clocks.”²⁵ In recent history, we frequently consider time as something with which we need to coordinate our lives and schedules—what time we wake up, go to work, can use public transportation, meet friends, and go to bed are often based on time’s exact hours and minutes. We are a time-oriented species, and one that no longer adheres to natural circadian rhythms, given the technology we have to light the night and the ability to receive information and communication at any hour. Given our technological

abilities, we have more options to do the things we want and need to do at any hour of the day. This has changed our perception of time and the importance of time's measurement, which is a topic I will return to in my evaluations of science plays and their relationship to our culture. Our culture has dictated the need to measure time.

As aging life forms, we also think of time in larger measurements. We think of how many years ago we graduated, how long ago a personal milestone occurred, or think about how many potential years we have left in our lives. We also consider time by how many years since a major event happened in our society—wars, civil rights established, considering where we were when 9/11 happened or JFK was shot. We may politicize how we as a culture have changed since “then,” and how we may long to go back to these simpler times, as many a politician has evoked. Consequently, time as a measurement can be construed as such by both objective and subjective theories of time. The idea of time as a measurement recurs in chapters ahead, often in correlation with the symbolism of a clock and commonly when characters confront the realities of time's demands and limits.

Finally, Carroll's third point illustrates that regardless of how we conceptualize time, reminisce about it, or try to change its effects, time moves—or so we think. In exploring his third point, Carroll asserts that it is a popular description of time favored by non-physicists. While he understands why people come to articulate time in this way, it is incorrect in relation to physical knowledge. We gather from our experiences that time passes, flows, and moves. We believe it changes us as it moves forward; for example, it is commonly said that time will heal all wounds. We also change our concepts of time as we progress as a culture or as an individual. We view time differently as our lives change, whether it feels like it is flying by or barely moves. We also live different lives than our parents, our grandparents, and our great grandparents. There are a host of reasons as to why this is true, but we know the past is not the same as the present, nor will either be like the future. When we tense time this

way and differentiate the tenses by change, we substantiate the idea that time passes. This aspect of time will be significant for my discussion of science plays because they often “play” with tense.

Clarified by Carroll, pinpointing what time is suggests some of the ways objective/scientific concepts of time may be contrasted to subjective/phenomenological experiences of time. None of these conceptualizations about time are false, though some may be truer than others depending on what standard we are measuring these statements against. As noted, Carroll as a physicist acknowledges that he thinks of time like a physicist. His three time points make for interesting intellectual comparisons, but they also express an underlying conundrum of time. That conundrum stems from the fact that how we think of time, formulate time, and experience time may not have much—or sometimes any—basis in a scientific and often-more-objective understanding of time. Carroll summarizes, “The struggle to understand time is a puzzle of long standing, and what is ‘real’ and what is ‘useful’ have been very much up for debate.”²⁶ This is an important delineation to make. What is real for a physicist may not be particularly useful for a phenomenologist in articulating how time operates for people in relation to their experiences. Phenomenologists, for example, are critical of any consideration of time (or other phenomena) that does not posit the observer as essential to its observation. For physicists, the science of time does not hold humans as central to its existence, and for most philosophers and phenomenologists it is impossible, or perhaps irrelevant, to separate time from human experience and thought. These perspectives—each valid from its own perspectives—also inform our cultural attitudes toward time and science. For the purpose of this dissertation, grasping the scientific/objective premises of time *and* the subjective premises of time—which are often experientially deduced, culturally ingrained, and/or hard to mentally overlook—are relevant to understand when science plays confront our perceptions of time. Carroll’s three points, unassuming at

first glance, hint at some of the very difficulties of grasping our thought-provoking problems with time.

Time and Language

Even if developments in physics allow us to understand more about time in the twenty-first century, the ways that we communicate about time through language illustrate more complications. Part of our scientific unfamiliarity with time is undoubtedly related to the fact that it is extremely difficult to communicate physical concepts of time in simple language or in language at all. Having attempted to read denser physical articles and essays, I can attest that it is challenging as a non-scientist to follow what is being reported about time.²⁷ Undoubtedly, these readings are not always meant to be comprehensible for the non-scientist, but simultaneously, scientists have not always had the primary goal to make their work graspable by the public or explaining their research for popular consumption.²⁸ This is one of the reasons I continue to find interest in science plays: they may help in the communication gap between science and the public, as I stated in my introduction. To this end, Gillian Beer describes how literature, and I include language in general, is often insufficient in parlaying complex, scientific concepts in terms laypeople understand. She writes, “One of the primary functions of technical language is to keep non-professionals out,” and adds: “Literature cannot, even if it would, take on the task of technical translator when scientists find themselves from time to time in the dilemma that their scrupulousness has sustained agreed meaning but rendered their knowledge and purpose inscrutable to others beyond the trained circle.”²⁹

Putting scientific ideas into language, whether in literary works, science plays, or for popular science writing, can inadvertently alter the science at hand, as is often the case when conveying scientific conceptualizations of time. When we do not fully understand science

due to language barriers, we may try to abbreviate the popular scientific terms and ideas for our own discipline's metaphors and ideas, perhaps unintentionally changing the scientific meanings in the process. This has been a criticism sometimes lobbed at the humanities by those in the sciences. In "Science, History, Theatre: Theorizing in Two Alternatives to Positivism," Tobin Nellhaus critiques Rosemarie Bank's and Michal Kobiak's essays in the 1989 issue of the *Journal of Dramatic Theory and Criticism* that used quantum mechanical language, and the "degree of metaphor" the two used from physics and quantum mechanics in discussing theatre history. Nellhaus describes how using scientific terms and language in such ways is problematic as it mixes the inherent meanings by the language deployed. "Taken metaphorically," he writes, "these terms are suggestive and stimulating and may be particularly evocative for actors [...] But as analytical concepts applied to theatre history, I find most of them unclear or even misleading."³⁰ Nellhaus is somewhat strident in this criticism, but his point demonstrates that we sometimes do not fully comprehend or explain the appealing scientific concepts when using them metaphorically, only adding to the problem of the language issues involving scientific thought. In line with this criticism, Beer questions, "How then do we recognize the activities of science in literary works if translation will not suffice and transformation may invert the initiating meaning?"³¹

No science play or anything I write in this dissertation can sufficiently explain the physics of time in a way that an actual physicist could. Having discussed science plays in classes, at conferences, and with scientists and other scholars, I have been adamant that the purpose of a science play is not to educate an audience about the science as fact but instead to tell a story that represents science as a human endeavor. I follow Beer and Shepherd-Barr's lead in moving ahead by investigating works of art that attempt to address scientific ideas, including a scientific (and not only scientific) notion as complex as time. Beer suggests that a transformation does happen when integrating scientific ideas into literature, but adds that this

is a natural aspect of “social and artistic questioning,” describing that, “The questioning of meaning in (and across) science and literature needs to be sustained without always seeking reconciliation.”³² Beer recognizes that placing science into a play or a work of literature changes some of the science, but this is unavoidable and does not mean the topic or ideas should be altogether avoided. More importantly, doing so may bring forth new and engaging ideas about the intersection between the two fields by this irreconcilable transformation. Whereas these artistic transformations of science likely will not better present science as science, they may instead display science as part of culture, interrogate the ethics of science, depict the roles and responsibilities of scientists, and humanize a field of knowledge through embodied characterizations of scientists that can otherwise appear remote. Moreover, such works may pique interest about the very scientific ideas and scientists represented, encouraging those in the audience to do more investigating once gone from the theatre. Shepherd-Barr similarly concludes, “Theatre is no handmaiden to science, a means of transmitting its findings.”³³ These words resist the idea that science is the dominant player when literary and dramatic artists consider, think about, represent or utilize science and scientific ideas—the same ideas that also shape and influence our cultural behavior, policy, economics, military practices, and other aspects of society. Theatrical interventions of science are meant to represent science as part of our culture, which I contend is a necessary intermediation.

The objective and subjective complications related to thinking about time may create obstacles in communication due to language inadequacies. Objectively, it can be hard to state in laymen’s terms physical phenomena involving when time begins, how time functions, and the principles of time. However, even from a subjective perspective articulating time is a difficult undertaking. Vyvyan Evans analyzes this in his book *The Structure of Time*. He discusses the linguistic problem with time in that “we ordinarily think and talk about time not

in time's own terms, whatever these may be," specifying that time is instead "lexicalized in terms of space and motion through three-dimensional space."³⁴ For Evans, time is not perceptible, and "our experience of time cannot be equated with an objective real entity inhering in the world 'out there.'"³⁵ For example, Evans states that we think about time based on how we "'feel' the passage of time," like in the case of protracted duration—described as when an event is experienced more slowly than usual.³⁶ We may undergo such protracted duration when experiencing "suffering and intense emotions, violence and danger, waiting and boredom," exemplifying that time is related to our personal encounters with the world.³⁷ Evans's book provides a multitude of examples of how we conceptualize time with language in this way: "The relationship lasted a long time" addresses time in terms of physical length in a Duration Sense ("an interval bounded by two 'boundary' events"); "Time flies (by) when you're having fun" speaks about time in relation to temporal compression, which is the opposite of protracted duration; "The time for a decision has arrived" or "It is one of the hallmarks of our time" treats time in a Moment Sense, described by Evans as when time "prompts for a conceptualisation of a discrete or punctual point or moment without reference to its duration."³⁸

Evans's multiple "senses" are related to ways we experience time and then use language to express these experiences that depict time's meaning. In this way, time is seen as part of an experiential and language construct; and Evans proposes that we think about time phenomenologically. These various senses of time cover the landscape of metaphors we use when thinking about time, and they reveal just as much about how we temporalize so much of our lives and experiences as they explain what time is. Evans explicates this further when he writes, "While we intuitively experience time there appears to be nothing tangible in the world which can be pointed to and identified as time."³⁹ Evans's work is a noteworthy contribution to understanding language and its role with time. Moreover, his contribution is

pertinent to this dissertation's exploration because plays inevitably are structured around language. In addition, time in the plays I analyze is either on display through the structure of the play, the tensed setting, and/or most often, the language that characters use. Characters often resort to metaphors to discuss time—explaining the anxiety that time is running out, that there is not enough of it, that it has passed, or suggesting how things have changed over a duration of time.

At the same time, and problematically, Evans more or less dismisses physics and its conceptualizations of time. He writes about time in modern physics indulging the “counter-intuitive consequences” about spacetime and past, present, and future.⁴⁰ Evans describes how physics conflicts with his suggestion that time is internal and not an “external attribute of the universe.”⁴¹ He concludes that given the world is mediated for us by our bodies, there can “be no mind-independent objectivist world in which there are multiple times.”⁴² Significantly, he cites the infamous Bergson and Einstein debates and sides with Bergson's conclusions. On April 6, 1922 when Einstein and Henri Bergson publicly debated their ideas of time, their differences of opinion—of the subjective and objective, philosophy and physics—were on full display. Jimena Canales writes in detail about this event in her book, *The Physicist and the Philosopher: Einstein, Bergson, and the Debate That Changed Our Understanding of Time*. History would prove that Einstein's theories outlasted Bergson's refutations of time dilation and some of his misunderstandings of relativity. Yet, Bergson was still on to something when he suggested that time was “imperfectly grasped by science.”⁴³ It is not that science is *wrong* about time, I clarify, while agreeing with Bergson, but rather that its explanations have not fully explained all concepts or considerations of time or our human experiences of time. I return to Bergson briefly in 1.2, because his ideas influenced many phenomenologists in regard to time. After the debate, Einstein came away with the perspective that philosophy had no place in the explorations of time, contending there are two

ways to understand time: “physical and psychological.”⁴⁴ Joe Gelonesi, writing about Canales’s book, adds to this longstanding debate, remembering how Stephen Hawking proclaimed the end of philosophy in 2011. He elaborates, “In some ways the pronouncement was to be expected; physics triumphalism dictates that at some point philosophy will exhaust itself and be unable to solve the mysteries that science seems to conquer in leaps.”⁴⁵ Needless to say, such proclamations do not usually sit well with philosophers.

Nevertheless, many great philosophers have written about time, which Adrian Bardon surveys in *A Brief History of the Philosophy of Time*. His account of the evolving and shifting philosophical perspectives of time does not sound all that different from many ideas still debated about time today. Bardon describes how Aristotle thought time was not a process, but rather “a kind of system that captures something real about nature without really being a part of nature”—a concept Bardon describes as relationism, in that time is simply a way to think about how two events “can be objectively related to each other.”⁴⁶ Centuries later, Augustine surmised that time “and change are subjective phenomena of human mentality,” and that “time only exists in the mind.”⁴⁷ Later, Immanuel Kant argued that people experience things “*temporally and spatially*” and that reality itself is “atemporal.”⁴⁸ He thought that experience “presupposes time.”⁴⁹ Gottfried Wilhelm Leibniz, a contemporary of Newton, supposed, “Time cannot exist in itself because, were time real, it would still only exist at any moment in the form of an instant; and nothing can be composed of instants.”⁵⁰ Philosophers have continued to write about time and explore time, trying to fully reveal its multitudinous nature. In my next section I explore phenomenology, which upholds a philosophy of time that uses the first person point of view. Yet it is in the twentieth and twenty-first centuries, with the rise of physics and STEM fields, that the value of philosophical questioning, even in regard to time, has been increasingly contested.⁵¹

In the disputations between subjectivity and objectivity, philosophy and physics, time is one issue where scholars may move closer to one perspective or the other, taking a stand to proclaim another's purportedly useful perspective. I have stumbled across these contentions and argumentations multiple times in my research. It just so happens that these either/or debates themselves are not particularly effective in thinking about time. Can it not be that time is both subjective and objective without dismissing one or the other? Is there not something valuable in the irreconcilable differences—as Beer articulates in her writing? Can it not be that various types of time exist, and as we figure out more about the objective aspects of time our subjective experiences and summations about time *may* be altered, rather than disproven? It seems that the disparagement of physics by philosophers or philosophy by physicists is rooted in a desire to deduce where the subjective and objective perspectives and the sciences and humanities divide in value, echoing the “Two Cultures” rift that C.P. Snow espoused. I am not interested in reconciling the differences between philosophy and physics in this dissertation regarding time. Instead, I present this friction to portray some of the inherent complexities and ongoing problems with understanding time, and to show what fields of knowledge, arguments, and ideas this dissertation engages to consider time in science plays. Accordingly, I use multiple theories and ideas from a swath of disciplines. Moreover, the most revelatory books I have read about time are written by scholars who put aside their disciplinary bias, and, if nothing else, at least suggest what the other side offers without dismissing it.⁵²

In Summary

In their structure and content, science plays do not reconcile all of these subjective/objective and philosophy/physics bifurcations. A science play instead does something quite unusual. It often illustrates how such objective and subjective experiences

collide. We in the audience are confronted by these various time perspectives in an experientially diverse art form, absorbing the performance in the fleeting moments of time unfolding. Adding a third piece to this puzzle, often how our culture treats or responds to time can be in contrast to how philosophers or physicists contend that time operates. I will draw out such examples in the chapters ahead to exemplify the fascinating experiences happening in the theatre, as ideas about time and science clash against and merge with our cultural experiences and expectations. As I stated in my introduction, the crux of looking at time in relation to science plays is to understand that what we *know* about time is not always the same as how we *experience* time. This section has addressed some of the ways that we can understand time and some of the reasons our knowledge about time hits certain barriers intellectually and academically. Shallis astutely summarizes, “I would suggest that we are unlikely to discover some ultimate truth about the nature of time in any philosophic or scientific enquiry; that the most we can hope for is to understand how a particular culture thinks about the nature of time, perceives and describes it, and how that culture’s perception of time reflect and influences its cosmology.”⁵³ With Shallis’s words in mind, the next section explains some of the ways humans experience time by exploring phenomenology and its relationship to time and theatre. To argue that science plays are demonstrating science and time in relation to our culture differently than other mediums, the phenomenological particularities of time in and out of the theatre must first be closer examined.

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1. Brian Greene, *The Fabric of the Cosmos: Space, Time, and the Texture of Reality* (New York: Alfred A. Knopf, 2004) 127.
 2. Sean Carroll, *From Eternity to Here: The Quest for the Ultimate Theory of Time* (New York: Penguin Group, 2010) 1.
 3. Julian Barbour, *The End of Time: The Next Revolution in Physics* (Oxford: Oxford University Press, 1999) 11 and 14.
 4. Vyvyan Evans, *The Structure of Time: Language, Meaning and Temporal Cognition* (Philadelphia: John Benjamins Publishing Co., 2003) 4.
 5. David Couzens Hoy, *The Time of Our Lives: A Critical History of Temporality* (Cambridge: MIT Press, 2012) xv and xvi.

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6. Judy Wacjman, "Life in the fast lane? Towards a sociology of technology and time," *The British Journal of Sociology* 59.1 (2008): 59.
 7. Carroll 375.
 8. The terms subjective and objective can be vague. Merriam-Webster defines subjective as: "relating to the way a person experiences things in his or her own mind; based on feelings or opinions rather than facts; characteristic of or belonging to reality as perceived rather than as independent of mind; phenomenal." Objective is defined as: "based on facts rather than feelings or opinions; not influenced by feelings; existing outside of the mind; existing in the real world." These definitions themselves are hinting at some of the differences I continue to extrapolate in relation to how we perceive time—what is experiential and based on perceptions is not the same as what is observational and a feature of life and universe that has no bearing on the perceptible. Some of these differences are inherently true when looking at time through philosophy/phenomenology and looking at time through science/physics. However, the use of the terms "reality," "facts," and "feelings" can be biased language—where privileging knowledge as fact/real and objective is more correct than valuing knowledge that is felt/perceived. Furthermore, many philosophers question what is real, even if something appears objective and real. And, this also does not answer the debate as to whether science itself is any more objective than philosophy. I cannot resolve all of these variances in an endnote, but I use these terms to be diagnostic rather than prescriptive about the differences between subjective and objective knowledge as it is related to time.
 9. Carroll 10.
 10. Carroll 10.
 11. Stephen Hawking, *A Brief History of Time* (New York: Bantam Books, 1988) 18.
 12. Frank Arntzenius, *Space, Time, and Stuff* (Oxford: Oxford UP, 2012) 7; Greene 8.
 13. Greene 46.
 14. Nola Taylor Redd, "Einstein's General Theory of Relativity," *Space.com*, 11 Feb. 2016, <<http://www.space.com/17661-theory-general-relativity.html#sthash.sx5lh8A6.dpuf>> (accessed 5 Jun. 2016).
 15. Hawking 63.
 16. Greene 47.
 17. Greene 48.
 18. Greene 48. Greene summarizes that this is an example of special relativity. And yes, if you are having to read that example a few times to understand it even on a surface level as I have had to, you can see why scientific concepts of time seem so discordant with what we think we know about time. Italics in original text.
 19. Hawking 30.
 20. Hawking 55.
 21. Carroll 15.
 22. Carroll 20. Why is this so? Carroll explains, "because *the duration elapsed along two trajectories connecting two events in spacetime need not be the same*" (20). He suggests that what Einstein's theory of relativity reveals is that "time labels different moments" and "time is what clocks measure" are not equivalent or interchangeable, and this is true when understanding that time is like space. He offers that we think of clocks as odometers in this sense. Italics in original text.
 23. Carroll 74.
 24. Frank 119-123.
 25. Michael Shallis, "Time and Cosmology," *The Nature of Time*, eds. Raymond Flood and Michael Lockwood (New York: Basil Blackwell Ltd, 1986) 65. The diagram Shallis includes in this essay shows an interesting progression of clock measurement from the first pendulum

clocks to the first atomic clock, and the errors in seconds per day of these clocks in correlation to when they emerged in time.

26. Carroll 24.

27. Even reading popular science magazines like *Scientific American* can be difficult for the non-scientist to comprehend. My point is that science can be difficult to simplify for public reading, and when it is simplified, something is lost. I do not think, however, this is any reason not to highly value popular science writing, as this dissertation is full of books and articles written from this perspective. Without them, I would not be able to grasp many of the scientific ideas I discuss.

28. In *Science in Public: Communication, Culture, and Credibility* (Cambridge: Perseus Publishing, 2000) Jane Gregory and Steve Miller write about the last decade or so, “scientists have been delivered a new commandment from on high: thou shalt communicate” (1). The book dives into why public understanding (which is differentiated from public knowledge) of science is important; in part, to help science and scientists with increased funding. I am a proponent of better public knowledge and understanding of science, and for the public to be more engaged with science as a cultural institution due to science’s impact on our society. Yet, I also acknowledge that sometimes reducing complex scientific ideas into understandable, readable material is extremely difficult, if not at times impossible, without transforming some of the information.

29. Gillian Beer, “Translation or Transformation? The Relation of Literature and Science,” *Open Fields: Science in Cultural Encounter* (Oxford: Oxford University Press, 1996) 183-184.

30. Tobin Nellhaus, “Science, History, Theatre: Theorizing in Two Alternatives to Positivism,” *Theatre Journal* 45.4 (Dec 1993): 512.

31. Beer 193.

32. Beer 195.

33. Shepherd-Barr, *Stage* 4.

34. Evans 5, 13

35. Evans 8.

36. Evans 19

37. Evans 20.

38 These examples and definitions are explored on Evans, pages 113, 108, 115, 123, 127, and 159, respectively.

39. Evans 252

40. Evans 243.

41. Evans 244

42. Evans 249.

43. Jimena Canales, *The Physicist and the Philosopher: Einstein, Bergson, and the Debate That Changed Our Understanding of Time* (Princeton: Princeton University Press, 2015) 9, 25-26, and quotation on 7.

44. Canales 5

45. Joe Gelonesi, “Einstein vs Bergson, science vs philosophy and the meaning of time,” 24 June 2015, *Australian Broadcasting Channel*, <<http://www.abc.net.au/radionational/programs/philosopherszone/science-vs-philosophy-and-the-meaning-of-time/6539568>> (accessed 12 Feb. 2016).

46. Adrian Bardon, *A Brief History of the Philosophy of Time* (Oxford: Oxford University Press, 2013) 13-14.

47. Bardon 24-25.

48. Bardon 33.

49. Bardon 33.

50. Bardon 57.

51. Natalie Wolchover's "A Fight for the Soul of Science," describes how some physicists are now troubled by the "wildly speculative nature of modern physics theories, which they say reflects a dangerous departure from the scientific method." This has generated a question on the need for philosophy in physics. Over one particular three-day summit, "scholars grappled with the meaning of *theory*, *confirmation* and *truth*; how science works; and whether, in this day and age, philosophy should guide research in physics or the other way around." See, Wolchover, *Quanta Magazine*, 16 Dec. 2015 <<https://www.quantamagazine.org/20151216-physicists-and-philosophers-debate-the-boundaries-of-science/>> (accessed 5 June 2016).

See also, Tim Maudlin, "Why Physics Needs Philosophy," *PBS: NOVA*, 23 Apr. 2015, <<http://www.pbs.org/wgbh/nova/blogs/physics/2015/04/physics-needs-philosophy/>> (accessed 5 June 2016).

52. Carlo Rovelli, a theoretical physicist, asserts that the relationship between philosophy and physics should be stronger. Rovelli discusses that in the past, physicists like Heisenberg and Newton welcomed philosophy when probing such deep questions such as what is space or time. He says that Einstein read Schopenhauer, Kant, and Leibniz, even if he disagreed with Bergson. While there are differences in methods between these disciplines, both fields can learn from each other. Rovelli even suggests a current "sterility" in physics because philosophy is not used enough within it. See, Carlo Rovelli, "Physics and Philosophy," interview by Nigel Warburton, Nigel Warburton, *Philosophy Bites*, podcast audio, 11 Nov. 2015.

53. Shallis 63.

Chapter 1.2: Phenomenology, Time, and the Body

“...the copresence of performers and audience creates a kind of temporal mirror for the present in which what is passing is known while it is passing. The copresence in the theater is not *just* about live bodies being in one another’s presence but about experience itself as a form of knowing the trauma of the impossible present as it passes...”¹

Alice Rayner, *Ghosts: Death’s Double and the Phenomena of Theatre*

Evident from Alice Rayner’s words, it is hard to ignore the concept of time in the theatre. The performance time matters, with some productions and theatres stipulating you cannot be seated late. Rayner describes, “By going to the theater at a certain time, I enter a space in which a repetition is planned but still open to accident,” and an audience can play a part in the shifts of the repetition, minor though they might be.² If you are seated past curtain time, you may not get the seats you paid for or you may draw the ire of those already seated as an usher guides you to your seat—your lateness will be on full display and incorporated into the performance experience for some audience members. You watch a performance in darkness, and for most performances you are expected to give your full attention to the production unfolding. Despite the rise of smart phones and the bevy of anecdotal stories from Broadway or a star performer stopping the show to scold a rude patron who chooses to ignore these expectations by texting, photographing, or even answering a call, the theatre largely remains one of the last places phones or other distractions are taboo. The play is performed live. As an audience member you have to pay attention to follow the story, especially as many plays are more aural than visual in storytelling. This is predominantly true for science plays, and as Shepard-Barr argues, is a strength of science plays over other scientific

representations.³ If there is an intermission, you need to quickly take a bathroom break or stretch your legs before the house manager flashes the lights in the lobby, warning you that time is almost over. Watching the performance you perhaps have a moment of recognition of time as the play flies by or lulls, providing some measure of success of the performance's pacing. At the end of the play you applaud and the show is done, maybe with time to spare for your late night dinner reservation. These experiences are not exceptional for the theatre, but they are exceptional compared to many other events where our timeliness as audience members or spectators is somewhat irrelevant.⁴ These thoughts also say nothing of the time prior to a performance spent by everyone involved with the production, the spatio-temporal unity of performer and audience (a perhaps stranger occurrence when the performer is a celebrity or star),⁵ or the unusual awareness of time and temporality that may be heightened and reshaped within a play. Phenomenology imbues meaning toward these experiences in the theatre.

This chapter section looks closely at two strands of phenomenology relevant to the theatre and this dissertation: time and the body. There are many ways in which explorations of time are manifested in this dissertation. To speak of culture and human interactions with time as I do in future chapters naturally leads to questions of how we experience time—which I argue that phenomenology best answers. Therefore, this section investigates how phenomenology and theatre are related to one another and are also inseparably related to time and the body. I explain some fundamental phenomenological notions of time and temporality, and interweave their application toward theatre and science plays. I also introduce ideas from theatre scholars who use phenomenology to investigate how time and the body appear in their work.⁶ I do this to posit the main argument that overlays this dissertation: science plays, because of their phenomenological particularities, enable us to see how we as a culture regard

science in an unparalleled manner. It just so happens many of the ways we consider science have a direct correlation to how we also treat time.

In this section, I first explore why phenomenology is used in a dissertation about science plays, setting up general ideas of phenomenology's usefulness for the purposes of this study. Then I provide basic tenants of phenomenology, articulating the correlation between Henri Bergson and the work of phenomenologists like Edmund Husserl, Martin Heidegger, and especially of Maurice Merleau-Ponty. I examine these theorists in order to apply their contributions to how we think about, and more importantly, experience time. I pinpoint certain features within their writing that are useful for examining time in science plays. Their ideas lay out basic foundations for thinking of time as an experience and noting how time is interlaced with concepts of consciousness, being, and embodiment. Throughout this dissertation I take a recurring stance that to know where we are going, we should know where we are coming from.⁷ It is important to start with the original work of phenomenologists before delving into how theatre scholars use many phenomenological theories, as they are extrapolating ideas from these earlier works.

In looking at Merleau-Ponty's theories, I wed the topic of temporality evaluated by phenomenologists that predate him with his focus on the body and ideas of embodiment—relevant threads when thinking of live, embodied performance that occurs in theatre. A focus on embodiment, as Merleau-Ponty's work facilitates, also illustrates how the body both perceives and projects phenomena, often in correlation with cultural expectations. As much as phenomenology has dealt with the perceptual and experiential, describing the abstract ideas of “perception, thought, memory, imagination, emotion, desire, and volition,” it also deals with “bodily awareness, embodied action, and social activity, including linguistic activity.”⁸ Theatre too negotiates between these types of entities: both the thought and story of a play are analyzable, but the play is also actualized by performance through the

embodiment of actors in an inhabitable space for an audience to experience. In my examination of phenomenology and theatre, I then look at theatre scholars who have thoroughly investigated the philosophy of phenomenology, including Rayner, Bert States, and Stanton Garner. I conclude the chapter by seeing how these scholars have used phenomenology, substantiating my claims as to why theatre is so different. This is in part due to its incomparable phenomenological particularities, and in part because of how time is integrated into the theatrical processes. Throughout this chapter, time and embodiment reappear: they are phenomenological cornerstones for my argument as to why science plays are exceptional compared to other mediums that represent science and deploy differing uses of time and/or embodiment.

Why Phenomenology?

There are many reasons why I contend that phenomenology offers a helpful perspective in evaluating the significance of science plays. My study is aided by a phenomenological examination that allows me to analyze time in science plays (both as experienced or lived time, as well as the way that playwrights conceive of time as related to scientific concerns in their plays). Yet, before delving into the analysis of phenomenology, it is appropriate to address why I examine phenomenology in a dissertation about *science* plays, which will be further elucidated through this chapter. Phenomenology and science are not the easiest of bedfellows, which warrants such a clarification in using both in conversation with one another. Evan Thompson explains that phenomenology is often positioned against naturalism, which can include the natural sciences: “Phenomenologists generally argue that naturalism overlooks and cannot account for the necessary conditions of its own possibility.”⁹ Thompson continues, explaining that for Husserl, naturalism bases an object’s existence on its physicalism, whereas phenomenologists would counter that consciousness matters as a

“necessary condition of possibility for any entity to appear in whatever way it does and with whatever meaning it has.”¹⁰ Mark S. Muldoon in *Tricks of Time* suggests that Merleau-Ponty was perplexed by the “ontological bias” in modern science, critiquing its “devaluation or even suppression of the phenomenal or appearing world in favor of the ‘real’ world of ‘physical facts.’”¹¹ Discussing Merleau-Ponty further, Muldoon suggests that Merleau-Ponty was interested instead in asking “who exactly it is that perceives,” further arguing that often the “empiricist adopts an impersonal approach whereby he totally neglects the fact that he *lives* perception and *is* the perceiving subject even in his very study of perception itself and that perception is the very condition of there being any facts at all for us.”¹² Evident from these statements are the philosophical underpinnings of phenomenology, questioning not only *what* we can know but also *how* we can know, and thus relying heavily on the necessity and power of perception. Indeed, Husserl, Merleau-Ponty, and other phenomenologists could be critical of the sciences and their methods; thereby solidifying a belief that phenomenology is “anti-scientific.”¹³ Yet, as articulated in their introduction to *Phenomenology: Critical Concepts in Philosophy*, and citing John J. Compton, Dermot Moran and Lester Embree describe that phenomenology is simply looking at the world subjectively while science looks at the world objectively, and phenomenologists’ main criticism is often not against science but rather “scientism and positivistic epistemology.”¹⁴ This hints at a critical delineation made for the purposes of this dissertation: phenomenology, as applied here, is not inherently antiscientific—it instead addresses and answers different questions about time and experience than science.¹⁵ While phenomenologists have critiqued aspects of science, the relationship between this branch of philosophy and physics does not signal a zero-sum game.

Moreover, phenomenologists add a dynamic piece to the puzzle of time by positing that time experienced *is* time known: or more reductively, experience is knowledge. As a theatre scholar, I am investigating what theatre does with time dichotomies and science on

the stage. In this dissertation, no position or discipline has the final say on time (as if one ever could). Instead, I explore how these science plays use time, what these plays say about science and time by doing so, and consider why these plays matter in a culture that treats time the way it does—a diagnostic approach to assessing what these plays signify. I attempt to correlate theories (from other branches of philosophy, physics, and other fields) with the phenomenological and its focus on the perceived and experienced. In addressing the phenomenological, I find inspiration from Susan Kozel, who has written often about her experiences as a dancer in phenomenological terms. She writes that phenomenology is an “embodied and situated methodology for conducting scholarly enquiry,” and that there is a potential “process of enacting a phenomenology.”¹⁶ She states this speaking of creating and devising work as a practitioner, but phenomenology easily extends itself to the researcher, like myself, who wants to consider what is unique about the theatre experience and wants to consider how the experiential (individually, of others, collectively, and culturally) are interconnected.

To this end, the experience of time emerges in science plays for both characters in the play and audience members in the house. Scientists in science plays are often the central characters. In these plays, they are frequently confronted with the awareness that their scientific knowledge is challenged or illuminated by realities of time they must also experience. Zehelein asserts that science plays “ask questions by employing either scientists as representations or personifications of ideas, or scientific tidbits for social commentary.”¹⁷ By looking at science plays and extrapolating what scientists and other characters say and do with time, I detail how theories of time align with or are not parallel to phenomenological/temporal experiences (and why that matters). Doing so also elucidates how characters are thereby forced to see time and science in a new light. These characters often have scientific knowledge of some kind or are inundated in a world where science has

changed the stakes. Such changes of perception directly correlate with ideas inherent in phenomenology.

Phenomenology also helps me address the other prominent part of a play performance: the audience. The scope of this dissertation precludes a discussion of audience reception theories, but phenomenology nevertheless offers some saliency to the idea that what an audience experiences during a performance is remarkable, requiring different modes of attention and retention than other mediums and events. Rayner reminds us that phenomenology “seeks to identify the moment of emergence in which the world is generated by its perception and at the same time has preceded perception, giving one the sense of both remembering and creating in the same moment.”¹⁸ Husserl, years prior to Rayner, hinted at such possibilities when considering how one undergoes a highly specific temporal experience when taking in an ephemeral performance (like his description of hearing a melody that I explore shortly). Audiences are not only recipients of a performance, but give the performance meaning by means of their perceptions of it. This is no more evident than the value of theatre critics, who in the present time give prestige to a production and potentially aid its success or failure, and in the historical archive, have the import of their work live on, as their documented perceptions become a significant way in which we can know about a performance. I refer to the critical and potential public reception of plays after analyzing them, because critics give insight into experiencing the play that I cannot speak to as a reader.

Shepherd-Barr, evaluating the power of theatre in staging science, refers to Gillian Beer’s thoughts when writing, “liveness and immediacy of the stage enact a kind of transformation as audience and actors engage one another.”¹⁹ This idea, too, suggests that there is something phenomenologically rare about theatre because of its liveness and immediacy—the connection between actors and audience—all of which is exceptionally powerful. Science plays “stage this dialectical aspect of human knowledge” we call science,

but does so through an experience that is fundamentally different than a movie or a podcast interview that may cover similar terrain.²⁰ Liveness, immediacy, and ephemerality share something in common: they are interwoven into the performance event that unfolds in real time, contingent on corporeality and the copresence of actual bodies being in a shared time and space. Moreover, these features all point to phenomenology for clarification of their distinctiveness. The experiential components of living in time, of time in theatre, and of theatre itself, are what I endeavor to explicate in this chapter via phenomenology. It is phenomenology that offers theatre a way to address what about it is so rare regarding its ephemerality, liveness, corporeality, and most vital here—its sense of time. It is phenomenology that clarifies why theatre offers such an uncommon experience in the twenty-first century.

A Framework of Experiencing Time: Bergson and Husserl

In *Theatre and Time*, David Wiles asserts that Henri Bergson influenced many modern artists in the twentieth century. Wiles writes that Bergson thought, “we should uncouple time from space, and seek the pure experience of duration,” and that while space was an aspect of the external world, time itself was an aspect of “consciousness and self.”²¹ Thinking of time as internal rather than external was an inspiring notion for artists to consider, Wiles contends, because it encourages the idea that time is a part of ourselves. I have already referenced Bergson in relation to time, citing Canales’s book that analyzed the debate between Einstein and Bergson, where Einstein—as history would suggest—came out the victor in the time debate. Muldoon, instead, gives credit to Bergson, writing that he “attempts to separate what is truly human from the merely scientific, he wants to detail an expression of our human existence that in no way falls prey to quantification.”²² Craig Chamberlain explains that the debate between Bergson and Einstein resulted in the fact that

“Einstein's theory did not consider time as it was lived in human experience, the aspects of time that could not be captured by clocks or formulas.”²³ This thought is critical when thinking about why phenomenologists would gravitate toward Bergson's work: he valued experience and knew it is something that science could not explain in full. The history of Bergson, as a “passé” philosopher once trumped by Einstein, is a specific historical narrative where science is pitted as the unstoppable force of the twentieth century.²⁴ This narrative misses the nuances of a fuller history; Bergson was a highly influential philosopher prior to and at the beginning of the twentieth century, whose impact only lessened after the Second World War and surged again in the mid-1960s.²⁵

Bergson's ideas appear often in the works of phenomenologists, Husserl even once proclaimed that “We are the true Bergsonians,” despite never having direct knowledge of Bergson's ideas before writing his own phenomenological thoughts about time.²⁶ Merleau-Ponty in *Phenomenology of Perception* writes, “Bergson saw that the body and mind communicate with each other through the medium of time, that to be a mind is to stand above time's flow and that to have a body is to have a present.”²⁷ Heath Massey describes Bergson's influence on Heidegger as difficult to pinpoint, but nevertheless “deep, almost subterranean.”²⁸ As Muldoon puts it: “Bergson's dissertation on duration bec[ame] an expert document on expounding the nonlinear aspects of time since he asserts that the time of the human subject is structured differently than time employed in the sciences.”²⁹ This suggests that time may never feel consistent for a human, even if a clock can measure that each minute lasts the same duration. Bergson countered that duration “is the indivisible continuity of change.”³⁰ The idea of change as part of observing and perceiving time recurs in phenomenology and other philosophical writings regarding time, as this dissertation will illustrate. It should be no surprise, then, that Bergson continues to appear in current scholarship that looks at time, often linking his thoughts to phenomenologists who used his

ideas to further explore the notion of time as experience. Bergson is emblematic: he signifies why thinking about time from multiple vantages is necessary *and* complex. He also marks a disciplinary-biased warning that I hope the interdisciplinary scope of this dissertation aids to debunk: to stop viewing different approaches to time as either/or but instead as both/and.

On the first page of his Introduction of *Great Reckonings in Little Rooms: On the Phenomenology of Theater*, Bert States writes, “I am less concerned with the scientific purity of my perspective and method than with retrieving something from the theater experience that seems to me worthy of our critical admiration.”³¹ States’s assertion demonstrates many common themes in phenomenology—it is less concerned with the scientific and it is more interested in engaging with the experiential, which may elicit information that would otherwise not garner critical attention. Phenomenology is rooted in describing features within experiences and answering how these experiences relate to our subjectivity, consciousness, and or/being. These experiences include objects and events, otherwise called phenomena. In this dissertation, theatre and time are the two phenomena most closely examined (each composed of its smaller phenomenon within them, seen in States and Rayner’s explorations of props, the stage curtain, actors, etc.).

As a philosophical movement, phenomenology emerged in the twentieth century with the writings of Husserl. Robert J. Dostal describes Husserl as disturbed by the “increasing relativism and historicism of Western culture in the beginning of the twentieth century.” Instead, he wanted philosophy to reach “incontrovertible truths,” and he believed phenomenology would be one way to achieve this.³² He was interested in understanding what happens when we experience phenomena: “aim[ing] to look at particular examples without theoretical presuppositions (such as the phenomena of intentionality, of love, of two hands touching each other, and so forth), before then discerning what is essential and necessary to these experiences.”³³ In short, Husserl’s phenomenology is a desire to return to the “things

themselves,” describing a wish to focus on such a thing “as it presents itself in our experiences,” then leading to discoveries that are “beyond all possible doubt.”³⁴ In a generalized description, then, phenomenology is an attempt to understand phenomena through observation without confirmation bias. Phenomenology, like all movements, has developed beyond its founding philosopher, expanding into other disciplines and fields of inquiry. For example, semiotics often has appeared in tandem with phenomenology, as well as in theatre scholarship. Although I do not research semiotics in this dissertation, it is important to recognize that when looking at objects in theatre “the sign will always represent a check to any aspirations that phenomenology might harbor toward totalizing description,” and that these two fields can be where an “objec[t] oscillat[es] between the experiential and referential.”³⁵ For the purposes of this dissertation, however, phenomenology is better suited for looking at how time, which due to its intangibility, exhibits itself in the experiential.

Husserl established that our bodies are “a locus of distinctive sorts of sensations that can only be felt firsthand by the embodied experiencer concerned,” and, as James Mensch adds, “embodiment is implied from the beginning of the constitutive process”—meaning it is both part of the perceiving and the perceived.³⁶ While Husserl understood that the body sees, hears, and feels experiences, his work more closely examines the processes occurring in our consciousness. The difficulty in reading Husserl is grasping exactly to what extent he explains the mental processes that take place when we experience phenomena.³⁷ In *The Phenomenology of the Consciousness of Internal Time*, Husserl agrees that objective time exists, but its qualities and the examination of its features “are not the tasks of phenomenology.”³⁸ Rather, Husserl evaluates the “*immanent time* of the flow of consciousness, but not the time of the experienced world.”³⁹ Aware that many phenomena inhabit a temporal moment, he writes about how such phenomena relate to consciousness through mental processes like perception and memory. To roughly summarize Husserl’s

phenomenology in relation to time: (1) he examines the minutiae that occur when we perceive, (2) he describes how we perceive phenomena in the moment to moment, (3) he evaluates what then collectively happens in our consciousness as we interpret these perceptions, and (4) he articulates how we may recall this now *past* experience in future moments when encountering a similar phenomenon. For example, he describes “temporal apprehensions,” a phenomenon that has no existence in the real world, but is the experience in “which the temporal in the objective sense appears.”⁴⁰ Part of this apprehension means that we consistently waver between retention and protention—retaining an act in our consciousness shortly after it has happened (different from a memory given it happens directly after the experience) or anticipating an act in our consciousness that may or may not happen. This idea challenges what it even means to be presently conscious if we are often thinking about what just happened or anticipating what will soon happen. As I noted before, the word “now” is fraught with such temporal complications.

A Husserlian Model of Perceiving Performance

Husserl also describes how perceiving a phenomenon is often a temporal experience, referring to the duration of perception, for example, when one listens to a melody.⁴¹ Theatre performance is analogous. The way our consciousness works, Husserl contends, is that we have temporal apprehensions of a tone that when played lasts a duration that “endures and fades away.” In truth, Husserl affirmed that he did not “hear” the melody, but rather a “single present tone,” while the tones that have faded remain part of the retention in our flow of consciousness. Each note is part of an ephemeral now, which once played, stays in our consciousness as our mind connects the notes: the flow of consciousness matches the flow of the melody. That is until we are conscious of what Husserl considered a “continuity of phases as ‘immediately past,’” which signal that the melody was over. He clarifies: “After the

melody has died away, we no longer have it perceived as present, but we do still have it in consciousness. It is not a present melody but one just past.”⁴² He suggests that such a past melody remembered becomes a re-represented past, never an actual past relived in memory or a perceived past. It is an interesting delineation, clarifying that our past is always disappearing never again to be recalled precisely as it *was*. Our memory is always remembering a performance differently this way. This has important implications for theatre. In contemporary theatre in the technological age, we tend to react to the photographs or videos of a live performance the same way—it is a re-represented performance but not the actual performance or even the perceived performance that the live audience experienced. I can think of recorded productions of performances I have seen live, arguing that the recording does not quite capture what I saw or experienced, as my brain “recorded” these moments differently. For Husserl, the experiences of perception, retention, and protention belong to a flow of consciousness, occurring simultaneously. Our brains never stop perceiving new phenomena as they also interpret what it is we just perceived.

Evident by these ideas is the introduction of more complications regarding tense. The past, present, and future of this micro-moment on a Husserlian scale are constantly being formed and reformed. Husserl puts it thus: “Therefore the perceiving of a melody is in fact a temporally extended, gradually and continuously unfolding act, which is constantly an act of perceiving.”⁴³ These words could easily describe the ephemerality of live performance as everything in the theatre is part of the perceptible, and the performance is framed not only by the start of the play but even by the entrance into the theatre. Not surprisingly, these sentiments reappear in Rayner’s discussions of time. As time itself cannot be perceived, Husserl’s phenomenological account illuminates how time appears in experiences (of a melody or a play performance) *and* how we interpret such appearances of time to give them meaning.⁴⁴ No moment of time can be held frozen, no memory can conjure the past as

present again, and every now is constantly replaced with a new now. Our brain ties together these little moments of time into a composite. This composite uses our experiences and knowledge to formulate what we perceive: our brains are not blank slates for incoming stimuli. Husserl's concept of phenomenology and time illustrates that "To grasp temporal relations, we must turn inward, that is, regard our memories and anticipations."⁴⁵ Because of this personalized experience, it is not uncommon for false apprehensions to occur, "that is, apprehensions to which no reality corresponds."⁴⁶ This may be a useful consideration when seeing how people respond to science with which they may not have much familiarity —i.e., elusive physical concepts, the atomic bomb that seems long past, or the future implications of climate change that are irreconcilable with our present comforts and lives. Our brains are not perfect engines for storing data, and the acts of consciousness that occur are subject to influences by past experiences and perceptions that may have no bearing on the reality as it unfolds now—psychological studies have illustrated as much in looking at false memory or the unreliability of eyewitness testimony. When considering a live performance of a play, it is clear that Husserl's explanations are instructive. Whether we are familiar with the play will certainly shape our anticipations, including how an actor may perform a role or how a set design aligns with our expectations. These anticipations may be formed by any number of experiences—reading the play, being involved with a previous production, or hearing others discuss the performance. If we are not familiar with the play, we try to comprehend many moments of now that are coalescing together. What does this mean for a science play? Generally speaking, any play unfolds for an audience in a series of nows they we cannot re-read, re-watch, or re-listen. This is part of its ephemerality. Yet, science plays demand our temporal attention because the performance's flow moves with the flow of our consciousness, while these works *simultaneously* often depict ideas of time—either in dialogue, structure of the play, or in topic—that many other types of plays simply do not and

other representations of science cannot. A representation of science in film, museum, or literature does not require the same mental energy (or flow of consciousness) if we know we can review or re-view the experience. And while I can do the same with the play script, I cannot with a performance of the play. Knowing this, I pay a different attention to the event, having it affect my consciousness in such a way Husserl describes, interacting with it in a mental way I may not with other representations.

Angst and Dasein

Husserl's writings set the stage for phenomenology's continued emphasis on time and embodiment. Martin Heidegger, a once junior colleague and assistant of Husserl, also writes about time in *Being and Time*. He differentiates his ideas from Husserl, being less invested in the exploration of phenomenology in relation to consciousness, and more interested in its relation to being. For Heidegger the idea of time is "linked to the *basic question of philosophy*, if indeed this asks about the *being* of entities, the actuality of the actual, the reality of the real."⁴⁷ He believes that our being is temporal—linked to Dasein (an emphasis on being which "makes issue with its own being"), while positing "temporality as the primordial meaning of Dasein's being."⁴⁸ Heidegger's ideas are helpful for this dissertation in revealing how our being is inseparable from how we experience the world, and that as beings we are temporal, constructed of an individual past, present, and future. Therefore, temporality informs how we are oriented and how we experience everything in the world.⁴⁹ Time in this regard is ontologically relevant. This is especially pertinent to thinking about science plays if they may not appear to be specifically about time or temporality; both are already inherent in the play, either as an event temporally experienced by the audience or for the characters in the play simply by the presentation of their experiences.

As temporal beings we are at times aware of our temporality, given our existence is “finite, limited” and it “inevitably, must meet its ultimate end.”⁵⁰ This awareness is not only a present, fleeting moment of realization, but instead an ongoing and lived experience, juxtaposing tense and temporality within our own lives. Heidegger believed that our past shapes our identity and our future, and that in facing our future’s inevitable ending, we confront our past again. Our sense of past is thus created in our experience with the knowledge we have a limited future. This not only affects our perception of our personal timeline but also informs us that we are a “determinate self, a self endowed with a particular life history.”⁵¹ Heidegger writes that “death is ontologically constituted by mineness and existence,” and that it is “not an event, but a phenomenon to be understood existentially.”⁵² As temporal beings, Heidegger’s words articulate the surreal realization that at some point we simply will not be. In his view, this is so peculiar because death’s actuality is unlike any other experience we have in being, thus creating certain “*Angst*.”⁵³ Heidegger even suggests, arguably, that this *Angst* does not stem from fear of one’s death, per se, but arrives as an “attunement of the *Da-sein*, the disclosedness of the fact the *Da-sein* exists as thrown into being-*toward-its-end*.”⁵⁴ Piotr Hoffman writes more about this existential anxiety:

[. . .] my coming face to face with the (indefinite) possibility of death not only forces me to abandon the ordinary, everyday framework of intelligibility and truth, but at the same time leads me to discover the unshakeable certainty and truth of my *sum* [...] insofar as anxiety brings an individual face to face with the indefiniteness of death’s threat to him, his public world is suddenly discovered as failing him.⁵⁵

Heidegger’s notion of a temporally-constructed anxiety allows us to understand something about the content and structure of science plays. Realizations about the finiteness of death

color them; in fact, every play I analyze includes death in one way or another—either by a character’s death or the awareness that death may be imminent due to circumstances. Certainly, death in the theatre is not a unique concept, but in relation to science plays the inevitability of death, a strange awareness by the characters of no longer being, often reflects a larger thematic exploration within the play. It does so in Thomasina’s death in Tom Stoppard’s *Arcadia*, in Marianne’s confrontation of her mortality in Nick Payne’s *Constellations*, in the body found in Shelagh Stephenson’s *An Experiment with an Air Pump*, in Rosalind Franklin’s death in Anna Ziegler’s *Photograph 51*, in the old Hermit’s passing in Lorraine Hansberry’s *What Use are Flowers?*, in the final thoughts of the cabinet members in Robert Nichols and Maurice Browne’s *Wings Over Europe* who face their life’s end, in the inevitability of death considered by the space crew in Arch Oboler’s *Night of the Auk*, in the responsibility of death due to the bomb debated in Michael Frayn’s *Copenhagen* and Arthur Kopit’s *The End of the World*, in Freya’s comatose hallucination as she faces her death in Mike Bartlett’s *Earthquakes in London*, and in the vastness of implications spelling potential death for our human species in Moira Buffini, Matt Charman, Penelope Skinner, and Jack Thorne’s *Greenland* and Stephen Emmott’s *Ten Billion*. All of these characters confront the reality that life has an end, that being has an end. We are aware that we exist and aware that we die, unlike other species. While we may grasp this on the individual level in different moments of our lives, plays about atomic bombs and climate change go even further by confronting the possibility of death on a larger, catastrophic level. I contend that while we can comprehend—albeit with reluctance—the finiteness of our lives and being, the ability for us to fathom the collective demise of our species is not a cultural phenomenon many of us living today in the United States have had to consider.⁵⁶

Obviously, temporality and time appear differently in the work of phenomenologists. Yet, it is clear in the writings of Bergson, Husserl, and Heidegger that the experience of time

is something we perceive through the phenomenon that our consciousness makes sense of and through our own lives' temporal orientation. I have extrapolated only threads of each writer's extensive work to discuss time. Nevertheless, these ideas—like Bergson conjecturing that the experience of time differs in ways science cannot account for, or Husserl arguing that time shapes how our consciousness perceives temporal events, or Heidegger explaining that we are temporal beings aware of our finiteness—will reappear in future chapters as I investigate how time manifests in the theatre and in the narrative of science plays. Moreover, phenomenology helps explain that to perceive time is not only an abstract concept, but an experience centered first and foremost in and through the body, as Merleau-Ponty's phenomenology argues.

Merleau-Ponty and the Complexities of a Body

Maurice-Merleau-Ponty asks, “For what is precisely meant by saying that the world existed before any human consciousness?”⁵⁷ This statement challenges some of the ideas already noted that physicists have expressed about time. Merleau-Ponty adds, on the other hand, that experiences are only possible because we have a body, basing “his entire phenomenological project of an account of bodily intentionality,” writes Taylor Carman in “The Body in Husserl and Merleau-Ponty.”⁵⁸ The body is foundational for Merleau-Ponty. His ideas analyzed here correlate the body with time, to perceptions of ourselves and others (an essential component of theatre performance that I associate with acting), and to notions of cultural embodiment. Merleau-Ponty, influenced by Bergson, Husserl, and Heidegger, builds on their work, but clarifies that the “actual existence of my body is indispensable to that of my ‘consciousness.’”⁵⁹ Katherine Morris, describing Merleau-Ponty's philosophy on *Philosophy Bites*, presents his focus on the body as an exceptional deviation compared to the work of Jean-Paul Sartre, Immanuel Kant, and others. Morris says his work went beyond

thinking of the body as an “anatomical object” in a way that the sciences may suggest it is, and instead borrows from Husserl the idea that to be human is “being-in-the-world.” Yet, for that to be true, Merleau-Ponty stressed we must first acknowledge that being “must be embodied.”⁶⁰ It is an idea that dismisses mind/body dualism.⁶¹ For theatre scholars, Merleau-Ponty’s emphasis on the body is particularly useful when thinking about how theatre is different than other mediums that can represent science. Museums, literature, podcasts, and films cannot replicate theatre’s ability to showcase the body; in theatre the audience member can observe another human in whole, rather than fragments of the face at a moment, the disembodied voice, or with no representation of another person present at all.

Time is woven into embodiment for Merleau-Ponty. He insisted that human beings are temporal and that to be human means to “*inhabit* and be a part of time.”⁶² Where Merleau-Ponty differentiated from Bergson and goes further than Husserl is his refusal to separate mind from body in temporal conceptualizations. It is not just that we are conscious of time or that we live time— an attribute of mental awareness— but that we embody time. Time is not a real “process;” but rather “arises from *my* relation to things” as a physical being.⁶³ Our relation to things—to each other, to events marked in time, to inanimate objects—is only possible through and with our bodies. In fact, Merleau-Ponty theorizes that the present is the “primary dimension of time” because the subject is treated “first and foremost [as] a phenomenal body.”⁶⁴ Time for Merleau-Ponty “simply is,” explains Muldoon, and “there is only one time, the time of the body in the phenomenal world at present.”⁶⁵ This is not introducing a presentist argument, but rather illustrates that the phenomenal body (described as the body through which we experience), can only be perceived to exist or perceive anything else in the present.⁶⁶ It also illustrates why thinking of time in other ways, such as looking back at the past or thinking ahead of the future, may be discordant with how our own selves perceive time due to our bodies.

Merleau-Ponty's contribution to the study of time emphasizes that we cannot conceive of time or understand anything about time without our body. Merleau-Ponty states that to believe that time passes, a recurring idea in this dissertation, we understand that a subject must be positioned in a specific time and space, observing things changing, and providing a "spatio-temporal totality of the objective world."⁶⁷ This person in a specific time-space sees observable change, such as one would experience when perceiving a glacier melting. To correlate this to theatre, it is worth asking what might this mean for a spectator at a play about science? As I sat in the audience watching *Constellations* I was "aware" of how quickly the play was happening, wanting to savor the experience in part because I was enjoying it and (also because I knew it was a shorter play and an expensive ticket). My ability to say the play happened quickly is directly related to my experiences and the perception that things were changing from my vantage point in that theatre during that time; these feelings were not simply thoughts I had that the play was well paced or scenes changed quickly. It was also related to physical awareness that I was not yet feeling uncomfortable sitting for a length of time, and that I wanted to catch every moment with my sight and would shift my body to do so in my seat. It is easy to dismiss this physical reality of watching, but putting my body in that space mattered to me, more so than watching any recording would have been.

"It is essential to me not only to have a body but to have *this* body," writes Merleau-Ponty.⁶⁸ Undeniably, it is not his contributions to time for which Merleau-Ponty is known, but rather his insight of "elucidating the uniqueness of our corporeal presence in the world."⁶⁹ Merleau-Ponty makes some fascinating observations about the body, whose aptness to theatre and performance are irrefutable given the bodily copresence of audience members and actors and the awareness of each other throughout a performance. Merleau-Ponty suggests, "there is no such category as pure thought," because the body is the "place where consciousness and

reality in fact come to occupy the very same conceptual space.”⁷⁰ In theatre, we can agree with these ideas as they often come up in acting training. We know that an actor must sometimes do first rather than think and plan, because what choices she will demonstrate with her body in stance, positioning, facial reactions, and even vocal production (a physical act correlated to bodily technique) will nevertheless present her intentions. It is not that thought gets in the way and the body must be free of it, but rather that the body is already part of thinking that must be free to express its embodied knowledge. Some acting teachers refer to this as an outside-in rather than an inside-out approach to acting. We fine-tune an actor’s body on stage with blocking and movement or detailed notes on what physical choices they are making in order for the audience to quickly ascertain what it is we want to communicate about this character in this moment. The audience, versed in reading bodies in our everyday lives, needs no instruction to interpret. Our bodies can easily present and perceive meaning, and sometimes to degrees that are surprising.⁷¹ Yet, it is useful to note that while our bodies are perceived, we ourselves so rarely perceive our own bodies. Merleau-Ponty writes that his body, “is always near me, always there for me,” but “I cannot array it before my eyes [...] it remains marginal to all my perceptions.”⁷² It is a distinctive experience, which we in the theatre know because performers cannot watch themselves, requiring a director or acting coach to guide them in choices made. These aspects of embodied communication are intrinsic to how we generally analyze plays. As I explore science plays in the chapters ahead, however, it is vital to emphasize that this genre of play provides a unique example of embodiment: seldom before have scientists as characters become a part of such bodily and phenomenological communication on stage.

Throughout *Phenomenology of Perception*, Merleau-Ponty returns to the idea of the body as our fundamental source of knowledge, stating rather simply at times that we *are* our bodies, that we cannot grasp anything of the world or any phenomena without our bodies,

and that our bodies are inarguably connected to time, writing: “In every focusing movement my body unites present, past, and future, it secretes time, or rather it becomes that location in nature [...] My body takes possession of time; it brings into existence a past and a future for a present; it is not a thing, but creates time instead of submitting to it.”⁷³ In many ways, Merleau-Ponty reiterates ideas from Husserl. The uniting of past, present, and future in the body is similar to Husserl’s notions of protention and retention as we encounter a melody or the first words of a play spoken. Merleau-Ponty, however, establishes that our body is part of this process rather than time or ideas being acts only of mental consciousness. For Merleau-Ponty, our bodies are shaped by our memories and anticipations, that then shape how we perceive and how we react to what we will perceive via our senses. As you sit in the audience your body shapes the reception of the performance differently than mine does for me. This could be for minute reasons like the variations of our eyesight or ability to hear clearly. Our personal experiences inform our bodily perceptions, and our personal perceptual history play into what we think of what we perceive. Our bodies, to this end, do not just perceive time but are informed by time. This is true in thinking about aging, which often inscribes the effects of time onto our bodies. Our bodies are malleable in this way, continuing to change what we perceive, how we perceive, and what others perceive about us.

In “The Challenge of Merleau-Ponty’s Phenomenology of Embodiment for Cognitive Science,” Huber Dreyfus and Stuart Dreyfus discuss how the body correlates to cognitive functions and assessments. They give the example that something challenging, like climbing a mountain, is not contingent on a mental willingness of whether a person could conceive this reality; it is a challenge we can mentally assess because mountains are physically taller in relation to us, and whether we can pass or climb them ultimately depends on our physical climbing capabilities. However, what intrigues me most about Dreyfus and Dreyfus’s article is that they describe how our culture also shapes our bodies. Referencing psychologist J. J.

Gibson, who examined visual perception and environmental influences on it, they describe our bodies as determined by “innate structure, general acquired skills, and specific cultural skills,” because the “cultural world is thus correlative with our body,” and we thus have an “acquired cultural embodiment.”⁷⁴

In the modern age in the western world, looking at the ways in which culture influences our body is perhaps even more relevant than thinking about how our world is shaped by our physical limitations or capacities.⁷⁵ Merleau-Ponty conceptualized the idea of “habits,” and that our bodies learn how to do things through imitation and social expectation in order to exist in the world we find ourselves in. He gives the specific example of a blind man learning to use a walking stick, which becomes a motor and perceptual habit.⁷⁶ He suggests that the blind man does not perceive the stick (as such), but perceives *with* the stick—the stick becomes a perceptual organ.⁷⁷ The blind man operates within a visual culture, and thus must find a way to live within the culture through the walking stick. Another example is typing on a keyboard—your hands do it *naturally*—but if asked the specifics of where each letter key is you would find it hard to recall because your body possesses that knowledge in embodied fashion.⁷⁸ In both examples our bodies demonstrate an extension of our knowledge. The blind man now can walk in the world fluidly with his walking stick, and the typist can construct complex sentences with the logic of the ‘qwerty’ keyboard via embodied knowledge. Morris, referring to Merleau-Ponty’s habits, describes how we recognize these habits when someone else also partakes of them. For example, when someone picks up a glass of water and moves it to their mouth, we understand what that person is doing—creating a “bodily reciprocity,” especially when we share a “class and culture” that readily helps us interpret what a person will likely do by their physicalized actions.⁷⁹

In the context of cultural and social behavior, understanding that our bodies not only perceive the world, but also shape the world around us through culturally-learned embodied actions is part of phenomenology's contribution to significant fields of knowledge. We are deliberate about what we want our bodies to present for perception because we are culturally trained in our physical behavior. Actors are trained in movement technique to be highly conscious of their physicality. Meanwhile, scholars have analyzed what different bodies on stage can represent by the ways they behave. Habits are "both constraining and liberating," often because the act of socialization is learning such habits that are deemed culturally necessary and appropriate and dismissing those that are not.⁸⁰ The body, viewed as such, has been studied in anthropology and sociology for this reason. Thomas Csordas writes that phenomenology enabled an approach to analyzing embodiment, illustrating that the body is not the object, but rather "the *subject* of culture."⁸¹ He, like other scholars, connects Merleau-Ponty's habits to Pierre Bourdieu's *habitus*, where Bourdieu describes the body as not only a phenomenal body but also a socially informed body.⁸² For Bourdieu, habitus is the changing of "history turned into nature," and where practices appear "'sensible' and 'reasonable'" because they are correlated between members of the same group and class.⁸³ Physicalized behaviors, even those that mirror social tastes and values, become ingrained to the point that their origins as social custom are unapparent.⁸⁴ Bourdieu writes in *Distinction* about social conditioning occurring in the social world that happens due to one's "relation to one's own body, a way of bearing one's body, presenting it to others, moving it, making space for it, which give the body its social physiognomy."⁸⁵ Bourdieu's work reminds us that the body is not a neutral object, but is shaped by the culture it finds itself in—gestures and postures included.⁸⁶

Susan Kozel writes about her use of phenomenology as a dancer and choreographer, describing that its efficacy as a method of analysis not only allows her to discuss her

subjective experiences, but also provides “dynamics for revealing broader cultural assumptions and practices.”⁸⁷ She too references Bourdieu in her work for this reason. Our bodies perceive, but we are not always aware of what we are absorbing for perception because it feels naturalized as others around us indulge in similar behavior. Colin Counsell in his introduction to *Performance, Embodiment, and Cultural Memory* provides a concise exploration to these similar veins of thought, describing how scholars in Performance Studies have examined cultural acts as “essentially constructive, *making* meaning.”⁸⁸ He reminds us that scholars like Diana Taylor and Joseph Roach have looked at the ways in which specific bodies perform specific acts that are attached to cultural memory or embodied practice; and we note from such scholarship that the body is never just *a* body on stage. He explains:

What emerges from the interaction of these perspectives is a vision of performance as an essentially *constructive* medium, one for which orthodox distinctions between the real and theatrical, and the functional and conceptual, cannot be maintained. However and wherever they appear, bodies and their actions are shaped by, give form to [...] cultural memories.⁸⁹

This is not new terrain to cover. I have introduced these many strands of embodiment and phenomenological thought to emphasize what makes science plays exceptional. We often do not see the “real” scientists, and these works counter that by putting the theatrical scientist on stage—whereby the functional and conceptual difference is collapsed. Therefore, these plays help to construct what it means to be a scientist, and we get to know or empathize with them rather than only abstractly think of them as communicators or advancers of knowledge. Scientists often have a public visibility issue, and yet in science plays, this is an inescapable feature of the performance at hand. For example, we get to see their flaws, see them in love,

or see their expression of worry about the ramifications of their work. Science plays contribute to a phenomenological landscape though the present, live embodiment of such characters. It is a landscape that positions scientists as part of our culture through the presentation of a body on stage. Of course, it is worth noting how the scientist is presented, which includes with what body (typically a white male) and with what characteristics—are playwrights cementing a mad scientist stereotype, are they presenting a character that is introverted but highly intelligent, do they counter expectations in gregarious fashion, or do playwrights collapse representation altogether, as Stephen Emmott does in *Ten Billion*? This often can come down to specific bodily choices and the observable phenomena on stage.

Limitations of the Lens of Phenomenology

Yet, perhaps this is also where a caveat about phenomenology's weakness as a lens of analysis is apparent. Stanton Garner describes how phenomenology has always been more interested in the "perspectival over the universal; it seeks to ground the general in the local instance," explaining that phenomenology can never claim "that individual objects will be seen the same by different subjects."⁹⁰ Bodies are different in our culture—whether for reasons of size, gender, sexuality, race, or age—and they are thus treated differently by our culture. F. Elizabeth Hart in "Performance, phenomenology, and the cognitive turn," discusses Judith Butler's contributions to thinking of the body, as one example, and looking at how the body is correlated with gender performativity. In Butler's work, "Embodiment [...] is thus something that happens *to* the body, is an imposition *upon* the body."⁹¹ In my explorations of phenomenology and theatre, there are these murky waters. As I write about culture and my own phenomenological experiences or those of others', these ideas can never be totalizing statements that are true for all people in one culture. I must acknowledge that each individual's body is composed of differences either informed by biological or

sociological reasons and constructs. I contend, however, there are still cultural facets at play that may be generalized as experienced by many people in a culture, i.e. how our culture as a whole tends to treat science, how our culture views time, or how our culture has responded to science in relation to time. Some of these cultural behaviors are wide spread and ideologically formed, meaning they often can elide individual differences in support of the dominant culture's narrative. Studies in sociology, feminism, poststructuralism, and cultural anthropology have analyzed similar arguments. This is the power of culture, the behemoth that it is, that this dissertation confronts by considering how science exists as part of our contemporary culture and how theatre plays a role. Phenomenology too is shaped by culture: everything it describes, including experiential humans who perceive phenomena, are informed by culture. As phenomenologists have often asked *who* is it that perceives, they might consider that this being—composed of a consciousness and body—also belongs to a culture.

In acknowledging this facet, what does cultural embodiment have to do with theatre? This question foregrounds my explanations of why theatre is a matchless phenomenological experience. I have suggested that theatre is a place where we are expected to behave in ways that direct our attention to the live performance, and these behaviors are culturally shaped by expectations; accordingly, we sit and act politely, just as the term habit/habitus explains. The way we are expected to physically conduct ourselves in the theatre is increasingly rare in our society. In contrast, audience members may be confronted by bodies and physicalized behaviors in theatre performance that *counter* expectations, unsettling and disrupting the sense of anticipating how a person will behave. I contend that this exact experience may be what science plays offer, because they may re-conceptualize the stereotype and perception of a scientist, thereby providing more variety to audience expectations. While Merleau-Ponty never anticipated the many ways in which his analysis has opened up other avenues for

thinking about how the body perceives, experiences, and shapes the world, his ideas resonate in many disciplines, theatre being no exception.

Phenomenology in the Theatre

Through vital ideas in phenomenology that look at time and examine the body, theatre scholars can find apt areas for further exploration. Mark Fortier explains, “Phenomenology is concerned with what it is like for human beings to be alive in the world around them and how they perceive that world.”⁹² It would be easy to replace the word “phenomenology” in that sentence with the word “theatre.” Theatre differentiates from phenomenology in that it is not only interested in describing the world, but representing the world. Given my exploration of how complicated thinking of bodies and embodiment can be, I suggest that by putting people on stage, theatre often transverses such complex terrain. In *Bodied Spaces*, Garner focuses on the idea of embodiment because the theatrical space is “comprised of bodies positioned within a perceptual field,” and because the body is theatre’s “originating site, its zero-point.”⁹³ Semiotics explains some of the reasons why people and objects on stage signify a multitude of meanings, but phenomenology articulates why so much of what happens within the theatre is experientially rare, including its fundamental identity attached to “stag[ing] this body in space before the witness of other bodies.”⁹⁴ Garner writes that theatre offers such “fertile ground for phenomenological inquiry” because it deals directly with perception, subjectivity, otherness, presence, and absence—to name a few of the endless categories.⁹⁵ Phenomenology is about understanding that a person, bodily constituted, observes the world and its phenomena through experiences of perception that then correlate to structures of consciousness and being. It is in the theatre, however, where theatre-makers have deliberately positioned and shaped the phenomena for observation and where the observers (the audience) are positioned in an optimal space (seats facing performance area, lights dark) to best

perceive. In the theatre with our direction, performance, and design, we aim to direct modes of attention toward particular phenomena on stage; and yet, we can never be completely successful as we contend with the liveness of the event where an audience can be distracted or where a cue can be missed. As I argue, theatre's inherent qualities make it a capable arena for considering science as a part of culture, particularly because of how theatre deals with time. Why? Theatre is a space and place where unique phenomena occur that engage our need for stimuli and alert our perceptions; and doing so, its experiences can offer audiences new perspectives on our world that might not otherwise emerge.

The phenomenology of time encompasses the theatre and its activities. Practitioners in the theatre can attest to the words Geoff Proehl writes in "Rehearsing Dramaturg: 'Time is Passing'" when he discusses how "time simmers in the air of rehearsal," reminding us that within the rehearsal schedule, "We want more time because we believe in its efficacy."⁹⁶ Time is integrated in all aspects of theatre, as we plan rehearsals, decide how much time it will take to build the set or hang the lights, shape the play with notes to actors about pacing and timing, and know that the running time of the show will matter for audiences and publicity. We feel the pressure of time with the old adage the "show must go on," as if the relentlessness of time will not acquiesce to any hiccup in production. The integration of an audience happens late in the production timeline, and yet inevitably remains essential to the reason theatre artists plan for weeks and months.

When we are part of an audience, we readily accept the conventions and conditions of the performance, and for the theatre purist, experience agitation if a nearby audience member texts, talks, or sleeps. These reflect habit/habitus behaviors; we have been taught and socially engrained to think that traditional theatre operates this way. Rayner describes this experience as "submit[ting] to the theatrical bargain," which she suggests begins "simply by showing up at the designated time, and we agree to recognize that we get more than we can see."⁹⁷ There

are many particularities in theatre that offer something for phenomenological examination, as suggested by States who writes how theatre fluctuates between the fictive and real, such as when onstage a “chair is a chair pretending to be another chair,” or that we applaud the actor at play’s end for the way they kept up “the illusion the performance signified.”⁹⁸ In many ways, theatre celebrates its boundary crossings and the perpetuation of illusions with which the audience complies: this is part of theatre’s rich identity of multiple meaning-makings. Time plays along with such illusions in theatre, and does so specifically in science plays. In many such plays, playwrights deploy time in ways reality cannot replicate, demonstrating the fictive conditions of time on stage that still somehow make perfect sense. Yet simultaneously, time itself resists illusion. We cannot change its dynamics that push the performance forward. Added to this, and perhaps more interestingly, the enculturated audience senses time and treats it in ways with which we theatre-makers are battling or conforming to.⁹⁹ For in the theatre, time is time pretending to be another time.

James Hamilton writes that when watching a play, one cannot ever step back, instead “taking it in as a whole in a single observation.” He asserts further: “The experience of trying to track the theatrical performance can be like the experience involved in following a dream, filled with gaps, while still seeming to be completely comprehensible.”¹⁰⁰ In a theatre performance we can never pick out only one word of dialogue because we are absorbing the performance as a whole—including the visual design, the temperature of the room, fellow audience members, and the space of the theatre. We cannot, engage with every moment of every performance; there are always gaps of recollection and perception. For example, having watched *Constellations* and then speaking with a class afterward that had read the play, they questioned me about my thoughts regarding one monologue they had discussed at length. I could not recall the moment, and it never struck me in viewing it the way it did for them in reading it. Because of the forward push of theatre performance in real time, we

cannot re-do, watch, or hear the performance again. Even if we buy the play text or view a performance on another night, it will never be the same as it was *that* first night. This ephemerality of theatre—a phenomenological entity—is in its essence about time in the theatre. Erika Fisher-Lichte has written that performance is “fleeting, transient, and exists only in the present,” harkening back to Husserl’s words about what happens in the moment to moment when we hear a note that is fading away just at the moment we realize we are hearing it.¹⁰¹ Looking at this objectively, there are plenty of experiences that are ephemeral—short lived moments that disappear. What makes theatre different is the *appeal* of ephemerality to theatre-makers. Theatre production companies often are adamant in their hesitation for their works to be documented by photographs or captured on film. We then resort to play texts to imagine what the production was and will be like because it is gone. Some of these desires are attached to the idea of liveness in the theatre. In a larger sense, both liveness and ephemerality are connected ideas that construct a quality of theatre: it has a one-timeness. A performance lives in the present and disappears in the present (as perceived by the live audience) because it is an event that lives its specific life one time. Yet, simultaneously, the performance is a repetition of what has been conditioned to happen through rehearsals and meant to recur in the performance in nights before and nights to come. Rayner suggests that this is a “Consciousness *of* performance [...] that includes performer and audience without distinction.” She adds that a condition of this consciousness is the ghosting or haunting that exists, because in the theatre “a fully materialized reality, even a representational reality, is haunted by an appearing not-to-be—that is, by its own negation.”¹⁰² Science plays waver in this real/unreal space—often the theories, people, or concepts in these plays are based on historic or potential realities. Yet, like all theatre, these works also engage with creative storytelling—demonstrating the unparalleled ability to take

artistic liberties. The theatre thus balances both the real and fictive, presenting embodied characters on a dimensional set with actual props that represent another time and place.

Garner writes about these phenomenological particularities. He examines the present in relation to presence; our perception of “theatrical presence” is then related to “the play of actuality,” where we experience the simulation and actuality simultaneously.¹⁰³ What makes present/presence unique in the theatre, according to Garner, is its openness to variation night to night, and how we experience in the theatre the blurriness of “is” and “as if” in “the theatrical *mode* of this presence,” where “phenomena are multiply embodied, evoked in a variety of experiential registers.”¹⁰⁴ Garner gives an example of Sam Shepard’s *Buried Child* when a character carries a bundle, a play prop, but one in which the audience *knows* is only a prop and also *knows* the bundle is a baby. As an audience member, when we perceive and interpret theatre fictions we are not consistently telling ourselves that what is seen is not real. We perceive the death of a character or a kiss between two characters with the same bodies and brains we use to interpret phenomena in the real world. Certainly, we have flickers of reminders that the stage is the world of make-believe when someone coughs next to us, at intermission, or just in receding into our own thoughts about a performance; but our perception blurs the boundaries between is and as if in our flow of consciousness. We do not have time to separate the real and unreal as the performance constantly unfolds. Hence, a scientist on stage matters to our perceptions and conceptualization of what an actual scientist is like.

Rayner examines the idea of time in the theatre extensively, citing Augustine’s inquiries of time, and invoking Husserlian preoccupations about “memories and anticipations” and the role of past, future, and present in consciousness. She correlates a lot of time and consciousness to the idea of dreaming, and how “sensory perceptions are supposed to wake us up from sleep or bring us into the theatre to pay attention.”¹⁰⁵ She

describes how playwrights and directors utilize our sense perceptions to alert us to specific moments in a play. This is significant for science plays because we often are alerted to the perception of time through the attention drawn to it by what characters say and do. In *Wings Over Europe* when the young Francis Lightfoot has threatened to end the world in fifteen minutes, he exits to the beginning sound of a clock ticking, as described by the stage directions. We in the audience know immediately what that sound is without needing a giant clock as a set piece to be flown in. As Rayner astutely summarizes, we are “Conditioned to the conventions of time, we ignore the daily coercions we submit to.”¹⁰⁶ In theatre, we confront some of these conventions either through a hyperawareness of the strictures of time (as I mentioned at the beginning of this chapter) or by the ways in which this event will play with my time and sense of temporality as an audience member, mainly through perception shaping and performative storytelling. Rayner states that while eight o’clock as the curtain time marks the beginning a moment of the show, most of the audience is unaware of this marking: “For the now is an unconscious point that everyone knows and is both within and apart from,” and that the “clock disguises its own failure and conceals the moment of the missed encounter (the now), where past is exchanged for future, reality for the dream.”¹⁰⁷ With these words she articulates how precise, empirical time fleetingly intersects with the ritual repetition of performance. Eight o’clock matters in the theatre; and is also meaningless in this marking of a ritualized beginning. Then the dream starts, which any performance feels like in its real/unreal and is/as if status, making us present “to what happens *while it is happening*.”¹⁰⁸ This is another distinctive phenomenal quality of theatre performance compared to other artistic representations. The artwork is not complete without the performance and audience there to complete it. Walk into any rehearsal, and you will likely hear a director talk to their actors about the audience. In the theatre we always are thinking of the audience, hoping to please or challenge them, but needing them nonetheless. Curtain time

merely marks another beginning because the art is revealed nightly, changing with every performance in the fleeting moments of now that will never be the same the next night. It is uncertain what the audience will experience or how their reception may change the experience through laughter or the rustle of programs, but theatre artists do their best to shape that experience with every choice they make in the production.

These thoughts echo many by States, who has described the strange ways that theatre occurs by “pluck[ing] human experience from time and offer[ing] an aesthetic completion to a process we know to be endless.”¹⁰⁹ There is a certain satisfaction in watching a play, observing the journey of a character, experiencing the potential catharsis as his or her circumstances irreversibly change, and watching the action conclude by curtain call. Only we know that just as the curtain time marks an illusion of beginning, the curtain call too marks an illusion of ending as the show continues through closing night. The structures of many plays, States explains, highlight the peculiarity of time in theatre; he gives the example of exposition, which he claims plants an “embryo future in a reported past and the sealing off of time in an inevitable space. For a beginning, or a past, can only be posited from the vantage of a known future.”¹¹⁰ Science plays often defy this convention; time is more frequently played with and the plot is often not set up with an exposition at the start. Several of the titles I explore do not follow linear timelines or adhere to one timeline. Many also highlight that the future is unknown. It also may be a future that those in the audience would not want to meet. After all, a science play often does not explore the same situations of a family drama. It is instead about “new ethical dilemmas” or the “quest of the scientist,” who seeks the “pursuit of truth, knowledge.”¹¹¹

States writes at the conclusion of his book “that the curtain call is the necessary self-disclosure of the illusion,” and that allows our sense closure to a “known process” that we yearn for by play’s end.¹¹² With the curtain call the actor dispenses with character and bows

as herself. The acknowledgment of the technical crew in the light booth by the cast signifies that the crew helped perpetuate the illusion; and as the curtain falls and the house lights come up, we in the audience relinquish our role in the performance event. We check our watches or phones for the time or missed messages, aware that our own illusion of escaping life's demands has ceased. The question is, what remains with us? What thoughts have we thought differently because of the event we just experienced? At the end of a science play we applaud the end of the illusion, but I would posit that most of this genre of plays provokes thoughts and considerations that will linger with the audience because their perceptions of science/time have been altered, even if only momentarily. The story within many science plays does not so easily give us a resolved dramatic conclusion or a catharsis.

Conclusion

In all of the phenomenological theories I have assessed in this chapter in relation to time, the body, and theatre, it is in science plays where these explorations find a new and different life. I have demonstrated in the exploration of phenomenology, how richly complex it means to experience the world temporally and to be a temporal being itself—as Bergson, Husserl, and Heidegger clarified that time is experiential. Time shapes how we experience the minutiae of life, how we think of what we sense and our interpretation of it, and how we even think of ourselves as beings with a past, present, and future in our limited life timeline. Merleau-Ponty contributes to this picture by saying we are aware of these experiences not only as a mental act, but significantly because we have bodies that perceive and that are perceived.

Both of these ideas—embodiment and our perception of time—come to play specifically in the theatre. The theatre tricks us with collapsing the real and unreal in the present, as Garner described, and while we know what we see is not “real” we seldom break

down that illusion in the moment to moment of our flowing temporal perceptions as we watch a play. We agree to the conformities of theatre—including agreeing upon the illusions and the set time, as Rayner and States elucidated—but these rules are ones of both rigidity and fragility. We have been culturally trained to know how to behave when the lights go down in the theatre; we agree to believe in the story before us and will allow the time for this arranged event to be largely out of our hands as audience members. Yet, everything is still open to chance, even though it has all been thoroughly planned before we ever came to watch. It is these moments in the theatre, inscribed by its liveness, embodiment, and ephemerality, which permit science plays to present science in ways that are unrivaled.

Seldom before has time itself been on display, as science play playwrights intelligently explore, manipulate, and emphasize the theoretical and experiential complexities of time in their works. And due to the ways in which science plays deploy theatre's phenomenologies, seldom have we had the chance to envision how we as a culture view science as part of our past, present, and future. Phenomenology illustrates why time, embodiment, and the existence of both within the theatre is multifaceted and captivating. In the chapters ahead, I demonstrate how science plays specifically exemplify many of these theories of phenomenology as works of theatre and as artistic representations of science that are directly related to time. Doing so, these plays illuminate how we as culture think, treat, behave toward, and ultimately experience science and time.

1. Alice Rayner, *Ghosts: Death's Double and Phenomena of Theatre* (Minneapolis: University of Minnesota Press, 2006) 32.

2. Rayner 28.

3. Shepherd-Barr writes, "Film has consistently failed to engage science as seriously as has the theater" (*Stage* 44). For more on this topic, see Kirsten Shepherd-Barr, *Science on Stage: From Doctor Faustus to Copenhagen* (Princeton: Princeton University Press, 2006), Chapter

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- 2: “Why Theater? The Appeal of Science Plays Now.” I also come back to this argument when discussing the film *Interstellar* in 2.2.
4. In the case of sporting events or a movie you may be late and miss important moments, but it does not necessarily affect the viewing for others in the same way theatre punctuality does. It is also not a disruption for the performers/athletes. Arguably, the same could be true for dance performances and music performances, dependent on the structure and composition of said event. However, given the storytelling aspect of theatre, it may be harder to conceivably “catch up” with a play if you miss the first twenty minutes to comprehend the meaning.
5. Marvin Carlson writes, “In the case of well-known and highly celebrated actors a phenomenon that in some ways is even stranger is not uncommon,” particularly when an audience is “ghosted by fond personal memories,” and “may be affected by the operation of celebrity itself to view and experience a famous actor through an aura of expectations that masks failings that would be troubling in someone less celebrated.” *The Haunted Stage: The Theatre as Memory Machine* (Ann Arbor: U of Michigan Press, 2003) 58-59.
6. Temporality is a term I have not yet discussed in any detail thus far, but it reappears in the writings of phenomenologists. Time and temporality are obviously interconnected—with temporality falling under the umbrella of time. David Couzens Hoy in *The Time of Our Lives: A Critical History of Temporality* looks at the phenomenological experiences of time as articulated in philosophical traditions. He states that his book is not examining time that is scientific and/or objective, but rather the “phenomenology of human temporality—to the ‘time of our lives’” (6). He continues, writing that phenomenology is interested in the very distinctions of “subjective and objective, between the physical and psychological,” and he considers time to be scientific and temporality to be the “time” associated with human experience. This is a useful delineation, yet I am unwilling to completely dispense with the notion that time encumbers all of these features: temporality, experience and phenomenology, scientific theories—it is its very nature to be so mystifying and multifaceted. See Hoy, *The Time of Our Lives: A Critical History of Temporality* (Cambridge: MIT Press, 2012).
7. This is a thought that resurfaces in critiquing presentism in Chapter Five and the modern trend to compress time.
8. David Woodruff Smith, “What is Phenomenology?” *Stanford Encyclopedia of Philosophy*, 16 Dec. 2013, <<http://plato.stanford.edu/entries/phenomenology/>> (accessed 8 Mar. 2016).
9. Evan Thompson, “Review: *Phenomenology and Naturalism: Examining the Relationship between Human Experience and Nature*,” eds. Havi Carel and Darian Meacham, *Notre Dame Philosophical Reviews*, 10 July 2014, <<https://ndpr.nd.edu/news/49272-phenomenology-and-naturalism-examining-the-relationship-between-human-experience-and-nature/>> (accessed 29 Mar. 2016).
10. Physicalism is defined as the idea that all that exists in the world is the physical or is dependent on the physical. Daniel Stoljar describes it as “everything here is necessitated by the physical.” This is in contrast to idealism in philosophy, which favored that reality or reality-as-we-can-know-it is instead based on the mental or spiritual. Consciousness, as emphasized by Husserl, veered closer to idealism in its focus on consciousness. See Daniel Stoljar, *Physicalism* (New York, Routledge 2010).
11. Mark S. Muldoon, *Tricks of Time: Bergson, Merleau-Ponty and Ricoeur in Search of Time, Self and Meaning* (Pittsburgh: Duquesne University Press, 2006) 126.
12. Muldoon 130.
13. Dermot Moran and Lester E. Embree, “Introduction,” *Phenomenology: Critical Concepts in Philosophy, Vol 3.*, eds. Dermot Moran and Lester E. Embree (New York: Routledge, 2004) 1.

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14. Moran and Embree 1.
 15. It is described that phenomenologists like Husserl often treated “theoretical entities of physics” as “the product of higher strata of constitution which are based on the constitution of the life-world” writes Smith and Smith (“Introduction,” in *The Cambridge Companion to Husserl*, eds. Barry Smith and David Woodruff Smith [Cambridge: Cambridge Univ. Press, 1995] 19). Harry P. Reeder writes that Husserl’s phenomenology had components that share “many intriguing features with the objects and principles of contemporary physics, especially quantum mechanics and quantum cosmology,” suggesting that some contemporary physics “has come to resemble Husserl’s careful descriptions of the nature of eidetic knowledge” (Reeder, “Husserl’s Philosophy and Contemporary Science, in *Husserl in Contemporary Context: Prospect and Projects for Phenomenology*, ed. Burt C. Hopkins [Norwell, MA: Kluwer Academic Publishing, 1997] 4).
 16. Susan Kozel, “Process Phenomenologies,” *Performance and Phenomenology: Traditions and Transformations*, eds. Maaïke Bleeker, Jon Foley Sherman, and Eirini Nedelkopoulou (New York: Routledge, 2015) 55.
 17. Eva-Sabine Zehelein, *Science: Dramatic: Science Plays in America and Great Britain 1990-2007* (Universitatverlag Winter Heidelberg, 2009) 9.
 18. Rayner xix.
 19. Shepherd-Barr, *Stage* 59.
 20. Shepherd-Barr, *Stage* 59
 21. David Wiles, *Theatre and Time* (London: Palgrave, 2014) 9.
 22. Muldoon 75.
 23. Craig Chamberlain, “Science historian tells a timely story about Einstein and his most dangerous critic,” *Phys.org*, 26 May 2015, <<http://phys.org/news/2015-05-science-historian-story-einstein-dangerous.html>> (accessed, 14 Mar. 2016).
 24. In Chapter Three I continue to explore the complications of historical narratives in relation to time, timelines, and ideology. Often these historical constructs (appearing most directly in this dissertation when looking at museums) are treated as more factual than a play. While it is true that a museum has different aims than a play, the historical veracity is still up for debate in considering how history is written and remembered.
 25. Leonard Lawlor, “Henri Bergson,” *The Stanford Encyclopedia of Philosophy*, 21 Mar. 2016, <<http://plato.stanford.edu/entries/bergson/>> (accessed 8 Apr. 2016); Muldoon 68.
 26. Christian Dupont, *Phenomenology in French Philosophy: Early Encounters* (New York: Springer, 2014) 47-48. I should note that my brother, Dr. Justin Tiehen, a Philosophy Professor at University of Puget Sound, recently posited, “At any other time has the philosophical community misjudged the lasting significance of a contemporary figure as much as they did Bergson?” When I pushed for clarification, he stated that some cite Bergson as one of the greatest philosophers to exist, illustrating that it is not only in science circles where Bergson’s reputation is questioned.
 27. Maurice Merleau-Ponty, *Phenomenology of Perception*, trans. Colin Smith (New York: Routledge, 1994) 79. In his disagreements with Bergson, Merleau-Ponty adds that Bergson never compiles the body, consciousness, and time together in a composite that he deems essential.
 28. Heath Massey, *The Origin of Time: Heidegger and Bergson* (Albany: State University of New York Press, 2015) 3.
 29. Muldoon 82.
 30. Muldoon 81.
 31. Bert States, *Great Reckonings in Little Rooms: On the Phenomenology of Theater* (Los Angeles: University of California Press, 1985) 1.

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32. Robert J. Dostal, "Time and phenomenology in Husserl and Heidegger," *The Cambridge Companion to Heidegger, Second Edition*, ed. Charles B. Guignon (Cambridge: Cambridge UP, 2006) 120.
33. Marianne Sawicki, "Edmund Husserl (1859-1938)," *Internet Encyclopedia of Philosophy* <<http://www.iep.utm.edu/husserl/#H2>> (accessed 13 Mar. 2016).
34. Sawicki.
35. Stanton B. Garner Jr., *Bodied Spaces: Phenomenology and Performances in Contemporary Drama* (Ithaca: Cornell UP, 1994) 14, 15.
36. Elizabeth Behnke, "Edmund Husserl: Phenomenology of Embodiment," *Internet Encyclopedia of Philosophy* <<http://www.iep.utm.edu/husspemb/>> (accessed 15 Mar. 2016); James Mensch, *Husserl's Account of Our Consciousness of Time* (Milwaukee: Marquette UP, 2010) 248. Constitution in constitutive phenomenology is concerned with the *correlation* between "experiencing" and "that which is experienced"—for example, between perceiving and the perceived (Behnke).
37. As I mention this, one might ask given the subjective and objective deliberations I have already raised how Husserl's explanations about consciousness and mental operations fare against explanations from cognitive scientists, who have intensively researched what happens in the brain when we experience things and events. Phenomenology and cognitive science do have crossovers in their attention to mental functioning, but they are not interested in asking or answering all of the same questions. Cognitive science can explain some of the exact functions of the brain, and what happens within certain areas of the brain when encountering stimulus. It also has been increasingly of interest for scholars in theatre, but it is still not definitive in all of its findings given the expense of doing such research. As difficult as it is to ascertain research funding in the sciences, it is even more so to secure funding for scientific research that would be used directed towards arts and theatre—i.e., much of the research used by theatre scholars is extrapolated research from other studies applied to theatre and acting training. Moreover, cognitive science is not interested in the descriptive element phenomenology is interested in pursuing. To summarize: phenomenology often emphasizes *describing* how mental operations like memory, perception, retention, and imagination work when we experience phenomena. Of course these fields continue to find intersections, evident in the emergence of Cognitive Phenomenology and including journals like *Phenomenology and the Cognitive Sciences*.
38. Edmund Husserl, *On the Phenomenology of the Consciousness of Internal Time (1893-1917)*, trans. John Barnett Brough (Norwell, MA: Kluwer Academic Publishers, 1991) 4.
39. Experienced here means the objective—not the experiential, as I often reference in correlation with phenomenology.
40. Husserl 6.
41. Husserl 28.
42. These statements can be found in Husserl pages 34-38.
43. Husserl 172.
44. Mensch 66.
45. Husserl 8.
46. Husserl 157.
47. Martin Heidegger, *History of the Concept of Time: Prolegomena*, trans. Theodore Kisiel (Bloomington: U of Indiana P, 1992) 6.
48. W. J. Korab-Karpowicz, "Martin Heidegger (1889-1976)," *Internet Encyclopedia of Philosophy*, <<http://www.iep.utm.edu/heidegge/#H3>> (accessed 3 Apr. 2016).
49. Dostal 135.

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50. Piotr Hoffman, "Death, time, history: Division II of *Being and Time*," *The Cambridge Companion to Heidegger, Second Edition*, ed. Charles B. Guignon (Cambridge: Cambridge UP, 2006) 232.
51. Hoffman 232.
52. Martin Heidegger, *Being and Time*, trans. Joan Stambaugh (Albany: State University of New York Press, 1996) 223.
53. Heidegger *Being*, 232.
54. Heidegger *Being*, 232-233.
55. Heidegger *Being*, 230.
56. This is not to say we live in blissful ignorance, as 9/11 and other acts of terrorism have obviously changed our fears of cultural destruction. Jesse Kavaldo in *American Popular Culture in the Era of Terror* (Santa Barbara: Praeger, 2015) refers to this as an "era of terror," and that since the event "Movie after movie, book after book, and image after image" have reflected 9/11, reminding "Americans who we lost and that we have not narratively moved on" (xiv). That said, the targeted acts of most terrorism—while horrific and unpredictable—are a different phenomena than the larger catastrophic demise that the atomic bomb evoked and, even more so, climate change deem possible. This is also not a consideration that we often extend to other species, despite the rise of extinction rates for many species we should find scientifically troubling. These particular struggles will come to light in future chapters.
57. Merleau-Ponty 433.
58. Taylor Carman, "The Body in Husserl and Merleau-Ponty," *Philosophical Topics* 27.2 (Fall 1999): 206.
59. Merleau-Ponty 433.
60. Katherine Morris, "Katherine Morris on Maurice Merleau-Ponty on the Body," interview by Nigel Warburton, *Philosophy Bites*, podcast audio, 2 Mar. 2016.
61. This idea comes from René Descartes, who proposed the mind and body were distinct, and that "the nature of the mind (that is, a thinking, non-extended thing) is completely different from that of the body (that is, an extended, non-thinking thing)." See Justin Skirry, "René Descartes: The Mind-Body Distinction," *Internet Encyclopedia of Philosophy*, <<http://www.iep.utm.edu/descmind/>> (accessed 4 Jan. 2017).
62. Wiles 9.
63. Merleau-Ponty 410-411.
64. Muldoon 150.
65. Muldoon 150-151.
66. While our minds or more clearly, our thoughts, experience protention and retention (anticipating and remembering) according to Husserl, our bodies cannot separate themselves from the present time in any way, according to Merleau-Ponty.
67. Merleau-Ponty 411.
68. Merleau-Ponty 431. Worthy of note, Muldoon critiques Merleau-Ponty for his work on temporality, suggesting he is not doing much different than Husserl, Heidegger, and Bergson. Muldoon even says that Merleau-Ponty's discussion of temporality "contains glaring inconsistencies and contradictions that give the text over to confusion and misunderstanding" (145). Not entirely disagreeing with Muldoon, aspects of time are not Merleau-Ponty's strongest contributions within phenomenology, but like Muldoon I agree that Merleau-Ponty contributes to the understanding that the experiential requires the body, even in regard to time.
69. Muldoon 153.
70. Wiles 8; Carman 209.

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71. In my utilization of Michael Chekhov's psychological gestures in acting classes, students have been continually surprised how certain archetypes (the mother, the beggar, the joker) continue to create the same physical stances and gestures even though I specially direct it so students are not watching each other to create these PGs.
72. Merleau-Ponty 90.
73. Merleau-Ponty 239-240.
74. Hubert L. Dreyfus and Stuart E. Dreyfus, "The Challenge of Merleau-Ponty's Phenomenology of Embodiment for Cognitive Science," *Perspectives of Embodiment: The Intersection of Nature and Culture*, eds. Gail Weiss and Honi Ferb Haber (New York: Routledge, 1999) 104.
75. The growth of disability studies demonstrates that the body is too often treated as able-bodied and ignores how cultural/social influences have heavily shaped how we have catered the world to those who are able-bodied. Carrie Sandhahl explains, "Facets of the experience of disability from the insiders' perspective though the disability rights movement grew up alongside other identity-based movements in the 1960s and '70s, the particular forms of discrimination disabled people have suffered—attitudinal, employment and architectural barriers; educational and social segregation; institutionalization; even forced sterilization—kept many isolated from one another" ("7 Plays About Physical Difference," *American Theatre* 18.4 [Apr. 2001]: 22). The attitudinal and social barriers she mentions are cultural constructs. In stating that culture's effect on bodies may be more important than viewing physical limitations, is not to dismiss such studies and critiques or the realities of those who are not able-bodied. Rather, it is in consideration that "disability [is] both a lived reality in which the experiences of people with disabilities are central to interpreting their place in the world, and [is] a social and political definition based on societal power relations" (Geoffrey Reaume, "Understanding Critical Disability Studies," *CMAJ* 186.16 [Nov. 4]: 1248).
76. Morris.
77. Nick Crossley, "Habit and Habitus," *Body & Society* 19.2 & 3 (2013): 147. This article is a concise read connecting habit to habitus through the work of Bourdieu and Merleau-Ponty via Mauss and Durkheim. Crossley credits Merleau-Ponty for understanding that habits are "structures of behavior...which take shape and reshaped...in the dynamic and always ongoing process of interaction between actor and world" (147). The give and take of habits as evolving and dynamic, Crossley says, is not as fully explained in Bourdieu's work.
78. Sandra B. Rosenthal and Patrick L. Bourgeois, *Mead and Merleau-Ponty: Toward a Common Vision* (Albany: State University of New York Press, 1991) 38.
79. Morris.
80. Morris.
81. Thomas J. Csordas, "Embodiment as a Paradigm for Anthropology," *Ethos* 18.1 (Mar. 1990): 5.
82. Csordas 8.
83. Pierre Bourdieu, *Outline of a Theory of Practice*, trans. Richard Nice (Cambridge: Cambridge UP, 2013) 79.
84. Bourdieu, *Outline* 79-82.
85. Pierre Bourdieu, "Distinction," in *Literary Theory: An Anthology, Second Edition*, ed. Julie Rivkin and Michael Ryan (Malden, MA: Blackwell Publishing Ltd., 2004) 243.
86. For those of us in the theatre who have spent time in actor training, we know how often we have spoken to actors about movement, physicality, and how even the use of one's fingers may illustrate a character's background to a degree we need to be intentional about such choices.

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87. Susan Kozel, *Closer: Performance, Technologies, Phenomenology* (Cambridge: MIT Press, 2007) xvi.
 88. Colin Counsell, "Introduction," in *Performance, Embodiment and Cultural Memory*, ed. Colin Counsell and Roberta Mock (Newcastle: Cambridge Scholars Publishing, 2009) 6.
 89. Counsell 8.
 90. Garner 5 and 12.
 91. F. Elizabeth Hart, "Performance, phenomenology, and the cognitive turn," in *Performance and Cognition: Theatre Studies and the Cognitive Turn*, ed. Bruce McConachie and F. Elizabeth Hart (New York: Routledge, 2007) 30.
 92. Mark Fortier, *Theory/Theatre: An Introduction* (New York: Routledge, 2002) 38.
 93. Garner 4.
 94. Garner 4.
 95. Garner 3.
 96. Geoff Proehl, "Rehearsing Dramaturgy: 'Time is Passing,'" *Journal of Dramatic Theory and Criticism* 23.1 (Fall 1998): 105 and 106.
 97. Rayner 31.
 98. States quotes Peter Handke, *Kaspar and Other Plays*, trans. Michael Roloff. (New York: Hill & Wang, 1970) on page 20; 119.
 99. Hence the title of this dissertation: examining cultural implications of time in science plays means understanding that members of culture already come to the theatre with preconceptions of science and a learned behavior of how to treat time.
 100. James R. Hamilton, "Understanding Plays," in *Staging Philosophy: Intersections of Theater, Performance, and Philosophy*, eds. David Krasner and David Z. Saltz (Ann Arbor: U of Michigan P, 2009) 222 and 235.
 101. Erika Fischer-Lichte, *The Transformative Power of Performance*, trans. Saskya Iris Jain (New York: Taylor & Francis, 2008) 75.
 102. Rayner xvii.
 103. Garner 43.
 104. Garner 43-44.
 105. Rayner 19.
 106. Rayner 21.
 107. Rayner 29.
 108. Rayner 31.
 109. States 50.
 110. States 48.
 111. Shepherd-Barr, *Stage* 48 and 3.
 112. States 205.

Chapter 2.1: How Culture, Time, and Science Intersect

Stephen Kern writes in the introduction to *The Culture of Time and Space*: “Since all experience takes place in time and space, the two categories provide a comprehensive framework that can include such wide-ranging cultural developments as Cubism, simultaneous poetry, and ragtime music along with the steamship, skyscraper, and machine gun.”¹ He describes that while kings, big cities, and churches are not found in every society in every generation, “Time and space are. All people, everywhere, in all ages, have a distinctive experience of time and space and, however, unconscious, some conception of it.”² This conception is part of the essence of time; time is a part of all cultures, always. We may seldom think about time as an objective reality, shaping our lives or even as a personal experience we confront daily; and yet it, along with space, is always present. Throughout this dissertation I refer to how time and culture and science influence each other, and do so by comparing and clarifying this relationship through the plays I analyze, along with theories of time related to science and philosophy. In this section, I consider science as a cultural entity and time as related to culture. My next section closely examines a series of plays that demonstrate how science is part of our culture, demonstrative in part by how the plays utilize time. As I noted in my introduction, science is very much a predominant cultural force—affecting government, politics, economics, business, and as evident in this dissertation, the arts too—even though we do not always view science in this way. What does it mean, then, to treat science and time as a part of culture?

Science as Culture

In exploring the experiences of perception, Merleau-Ponty describes the question is not whether we really “perceive a world, we must instead say: the world is what we

perceive,” or that “The world is not what I think, but what I live through.”³ These thoughts correlate to thinking about how time and science materialize (or do not) within our experiential world, and why we as a culture may be reluctant to accept the realities of knowledge that we cannot directly experience. While not disagreeing with the theoretical meaning of Merleau-Ponty’s words, we may also see how such ideas are problematic to scientific knowledge. This is a longstanding problem, as many a non-scientific-believer doubted earth’s roundness given that our horizontal perspective only sees flatness ahead. In the nineteenth century through to today, people doubt evolution because of its inability to be evident in the span of our own lifetimes. This scientific disbelief is also apparent in the disputations of global warming when someone points out supposed counter-evidence of a particular cold winter or heavy snowfalls. Perceptions can be misleading, and this can be the case when it comes to the power of perceptions in light of scientific knowledge or policies. I reference Merleau-Ponty because how we perceive is directly related to the culture we are raised within and are accustomed to. If we view science in a particular way, it has a lot to do with our culture.

When writing about science being a part of our culture, it is hard to avoid the ideas from C. P. Snow’s “the Two Cultures,” which often appears when scholars discuss ways in which the humanities/arts and science intermingle. It has resurfaced in both Shepherd-Barr’s and Zehelein’s books. In 1959 Snow gave a lecture, which was later published as *The Two Cultures and the Scientific Revolution*. In it, he stated, “I believe the intellectual life of the whole of western society is increasingly being split into two polar groups [...] at one pole we have the literary intellectuals [...] at the other scientists, and as the most representative, the physical scientist.”⁴ He discussed the dissension between the two groups, emphasizing that nonscientists believe scientists are “unaware of man’s conditions,” that the “pole of total incomprehension of science radiates its influence on all the rest,” and described an

“unscientific flavor” influencing “‘traditional’ culture,” which also tended toward the anti-scientific.⁵ He suggested, “There seems then to be no place where the cultures meet,” and by his lecture’s conclusion—after discussing how the gaps between cultures is illustrative in the views of the Industrial Revolution, education, and disparities between the rich and poor—writes, “Closing the gap between our cultures is a necessity.”⁶ To do so, we need to reexamine our education system, concluding: “Isn’t it time we began? The danger is, we have been brought up to think as though we had all the time in the world. We have very little time. So little that I dare not guess at it.”⁷ The way in which Snow has framed his argument does less to describe science as culture, and more to illustrate that science as a part of culture is often dismissed by those in the arts/humanities and larger society as a whole. As will materialize countless ways in this dissertation, time, of course, makes a difference in his final evaluation.

Many scholars continue to debate Snow’s words—arguing for and against their validity as time has pushed forward, some even suggesting a third culture of various definitions or one culture that encompasses all.⁸ In his preface to *The Three Cultures*, psychologist Jerome Kagan succinctly describes the ebb and flow of the cultures, noting that since 1959 the funding discrepancies between natural sciences, social sciences, and humanities have been considerable. His book offers valuable purposes of each culture, critiquing why Snow’s positioning of science does not stand up now as “the largesse available to natural scientists [...] created status differentials that eroded collegiality and provoked defensive strategies by the two less advantaged cultures [social science and humanities].”⁹ He concludes his book by outlining that Snow did not describe the usefulness of these different disciplines; and Kagan instead suggests they are like “branches of American government, represent[ing] a potential source of restraint when one, in a move to dominate the others, advocates ideological excesses that stray too far from evidence or

violates the community's ethical sense.”¹⁰ Rens Bod and Julia Kursell in “Introduction: The Humanities and the Sciences,” write that historians of science have softened the cultural divide by positioning the history of science as part of the history of culture, and thus, “related the sciences to the arts, crafts, scientific education, and popular cultures of knowledge.”¹¹ Zehelein too argues that rather than thinking that the gap has widened between the cultures, the reverse is true, writing, “never has science been so close to the general public, never have the attempt to communicate scientific issues to the informed public been greater and more versatile.”¹² Zehelein adds that some, like John Brockman in *The Third Culture*, have offered the idea that “communicators, who translate the complex scientific contexts into a more comprehensible language for the general audience” have bridged the gap between these two cultures.¹³ Zehelein further describes that while “Science is part and parcel of culture,” and interdisciplinary crossovers continue between the two cultures, there are “bridges [that] are established. And sometimes, these bridges materialize on stage,” which she continuously demonstrates in her science play survey analysis.¹⁴ Additionally, Shepherd-Barr addresses that “the marriage of the resources of the stage and the ideas and issues of science does indeed bring about unprecedented creative chances.”¹⁵ I have stated earlier how she thinks that theatre may serve as a sort of third culture. It is evident this idea of two cultures will continue to find articulation and redefinition, and I tend to agree that theatre can offer a bridge of communication and knowledge. In our current age, the more we can share between the disciplines in all forms, the better off our culture will be.

I refer to Snow's work, because the way he writes about these two cultures is largely divisive and mostly has to do with groups of people treating other groups of people and their respective knowledge with dismissal or disdain. He creates a polemic for a particular reason, but as the text is returned to time and again, it should be emphasized that what he describes is done with generalities; he makes it hard to see the gray areas of overlap in the black and

white world he creates of separation. He writes in the plural about the people within these disciplines, intellectuals and friends of his, but offers few concrete examples of either. This is not a criticism of the lecture, per se, but as his points are positioned within other ideas and arguments, it raises the question of the work's influence as a measuring stick that has been used so often. The term "two cultures" became so ubiquitous that it has fostered a litany of titles the subject, and authors have built their books utilizing this term and modifying it over the decades. And while his book does go beyond the pitting of the two cultures to consider what should be done for our future, little in Snow's writing explicates what it means to think of science *as part* of our culture rather than a culture of its own. This is not to say the same is not true for the humanities according to Snow; but it would seem less obvious to ignore that scholars in the humanities engage with culture as their objects of study are often about the human experience via history, philosophy, literature, religion, and sometimes including the arts.

To consider science as a cultural entity means to investigate the ways in which it impacts us as a culture rather than simply as an intellectual process or basis of knowledge. This is not made any easier by the fact that defining culture itself is difficult. To do so is about as difficult as defining time—it is reportedly the "second or third most complex word in the English language."¹⁶ Raymond Williams writes, "Culture is ordinary: that is the first fact. Every human society has its own shape, its own purposes, its own meanings. Every human society expresses these, in institutions, and in arts and learning."¹⁷ This reads broadly, but it does encompass the hazy boundaries of culture well. Having attended popular culture and American culture conferences, with interdisciplinary panels that cover everything from history, dance, literature, food, fat studies, and graphic novels, it seems easier to suggest what is not culture. Terry Eagleton describes culture as a "kind of social unconscious," considering it as an "aesthetic or utopian critique of industrial capitalism [...] the search for a substitute

for religion.”¹⁸ This clarification illuminates that culture is almost impossible to see or know. Eagleton cites Williams, who observed that the idea of culture has “inflationary tendencies,” to the point that what is not culture is indiscernible.¹⁹ It is an amorphous category: even when scholars say that they do cultural studies, it is hard to know what that might entail.

I rely on a reflexive act: defining culture means looking at what defines our culture. Taking inspiration from the writers I have cited above and my own observations into the world of cultural studies, the definition of culture can be seen in the question: What are the practices, the acts, the movements, the moments, and ideas that are shaping our world and perception of it? For example, why do we value certain foods or tastes over others, why do we seem agree to treat time the way we do, and why do we assume we know what a scientist is like? Some of this taps into the behaviors I spoke of in the last chapter regarding Bourdieu and habitus. By asking what we do—looking at our actions—I circumvent depending on a descriptive or definitional exploration of these complexities, and offer something else to the conversation: the performative. Taking this a step further, I ask how do we perform culture? Science plays perform culture, and they perform science as culture. They articulate many of our cultural responses to science, first envisaged by the playwright, then interpreted by the director, performers, and designers. Reviewers and the public finally evaluate and critique the productions, securing the work’s critical acclaim, economic return, popularity, and longevity of a play/production. Thus, in the ensuing section and the chapters ahead, I discuss plays, assessing what they reflect about science as culture through these maneuvers of analyzing the text, talking about a production when possible, and including reviewers’ comments. Inevitably, time is integral to this assessment, as playwrights craft their narrative involving time or demonstrate a scientific point by utilizing time within their plays.

As I have suggested above about Merleau-Ponty, science plays do two things in enlightening us how science is a part of culture. First, it does away with the unclear

generalities of the unknown scientists that Snow refers to in his work or in the way we speak often of science. Playwrights position scientists in the foreground rather than the background, reminding us of the fact that this knowledge is known and researched by people who are also a part of the culture they find themselves in. Steven Shapin describes that early in the “twentieth century, scientists themselves were repeatedly stipulating that they ought to be regarded as human,” and that the purposes for these wishes, “was to understand that neither poison gas nor the atomic bomb was produced by bad people;” scientists were made of “moral ordinariness.”²⁰ As I will demonstrate in the plays I analyze in the next section, through this art, we may grasp how relatable scientists can be presented as people, and people constituted of differing opinions, opportunities, and experiences. By seeing scientists as such, we are reshaping the world we perceive and how we perceive scientists in that world. Secondly, it makes us reconsider the formation of scientific knowledge. Science is not an objective enterprise devoid of questioning its purposes or meanings; while the knowledge science reveals is neutral, the implications of and practices of pursuing that knowledge are not. It is struggled over, pondered over, and fought over. If Merleau-Ponty is correct, and the world is what we perceive, then by seeing scientists as people like ourselves and understanding that scientific knowledge is still a pursuit of struggle, uncertainty, and sacrifice, perhaps our cultural perception of science can be one of more understanding.

Time as Culture

In plays we can experience science as such because of the phenomenological experience of how we view embodiment. It becomes more difficult to dismiss a scientist who is before us, three dimensional and empathetically performed. The other element here at play, phenomenologically speaking, is time. Time in these plays often heightens the dramatic stakes and/or underlines a major theme in the play that deserves more of our cultural

attention. To give context to what it means to think of time and science and culture as fluid and inter-reactive, it is worthy to consider how time can be cultural—as I have so far explored what it means to think of it as physical, philosophical, and phenomenological. To do so, I return to Adam Frank’s book. If the first narrative in Frank’s book is about cosmology, in his words, “the second story tells what might be called the social history of time—a history of lived time.”²¹ Frank, throughout his book, investigates how the evolutions of time, often progressed by science, are correlated with the human and cultural conceptions of how we treat time. Consider the GPS capabilities we have, enabled by Einstein’s discoveries. Global positioning systems have completely revolutionized how we travel, transport goods, and track a multitude of civilian, economic, and military needs. Many of these activities previously were impossible to do or took considerable more time; and GPS is only possible because of the precision of the “atom clock, whose ticks must be known to an accuracy of 20 to 30 nanoseconds.”²² The GPS has changed a cultural experience and management of time, and it required a more accurate measurement of time to exist and to do so. This example illustrates how the understanding the universe and human time have “always been intertwined, and there was never an age when they could be cleanly separated.”²³ My analysis in thinking about science plays as both scientific and cultural inquiries into time is inspired by ideas like Frank’s. Fittingly, Frank writes:

But cultures (with their invented institutions) need justification and support. They need to set themselves against a cosmic background to give individual and collective lives meaning [...] It is crucial to recognize that each grand change in human history has shifted more than merely ideas about time. Instead, it is the experience of time, its felt contours, that have been transformed.²⁴

He hints at many of the ideas I addressed in my last chapter regarding the phenomenology of time and its experiential qualities of time. It is a vibrant relationship: we not only respond to changes in time—we ourselves, as a culture—change how time operates for us. Barbara Adam, a sociologist, looks at time similarly through this lens, examining the cultural practices that are related to time in her succinctly titled book *Time*. Like Frank, she looks at how our lives and our practices of time continue to change as philosophies of thought, economics, belief systems, and technology encroach on our cultural and individual lives and consciousness. She describes time as “lived, experienced, known, theorized, created, regulated, sold and controlled.”²⁵ Her book covers diverse topics, evident by that description, but when we think of time in this cultural sense we can see how interconnected time is to the very fabric of our societal and individual lives (and to science).

For example, in thinking about the seasons of the year, we gather how our agricultural productivity is essentially linked to time. As I write now, it has been an unseasonably warm spring, and plants are growing that I usually do not see any evidence of until April. As I edit this, the fall has also been warmer than normal. This changes a sense of time I experience. This also changed how farmers in the Midwest prepared the soil and planted crops this spring. The unseasonably warm temperatures raises questions of whether our cultural practices have changed the weather, inciting debates if such temperatures are a matter of fluctuating patterns or climate change. Is this the new February? Is spring now an earlier season on our calendars? The *Farmer’s Almanac* since 1818 has been used to predict weather patterns for the following year, demonstrating that we want to predict the future of weather to ensure the best preparation for our food resources. I will illustrate in my chapter ahead that in light of climate change, this has been increasingly difficult.²⁶ Perhaps our actions have not directly changed time, as it is still February and February will possess a “Februaryness,” regardless if it has typical February weather or not. But how we respond to the weather,

which we may in fact have influenced as a species, and how we rely on food production, related to seasonal habits, illustrates that our societal and cultural lives are integrated with time—in this case the time of the year. February may still be February, but climate change models tell us with the increase of global temperatures that seasons will change. Our activities of what we do in February will likely change as its qualities change. February may not continue to feel like February for much longer. Our sense of time—in this case, the calendar year—will inevitably change if that happens.

Adam writes about another example of how we culturally interact with and shape time: how we deal with the finiteness of our lives. In a general sense, we can easily deduce how this forms our sense of time. Religious beliefs about an afterlife or what happens when we die are intrinsically linked to cultural beliefs regarding the temporal realities of our life. Adam looks at ancient mythologies about death and afterlife, articulating, “with the deification of time, archaic cultures have acknowledged the key role of time for all existence.”²⁷ If such ideas about afterlife seem like relics of a bygone era of Ancient Greek, Babylonian, and Aztec ideations of renewal and regeneration, take into consideration that 72% of Americans believe in heaven and, in a similar non-religiously inspired line of belief, current theories are being debated about digital immortality—living on forever through a digital avatar or computer.²⁸ These are cultural responses to our life, shaped by realizations of a beginning and end to our own temporal existence and trying to potentially think our way past this ending.

I could continue with such examples, investigating the culturally informed ways we think of seconds, minutes, hours, days, years, seasons, lifetimes, history, social progress, the dawn of mankind, and the beginning of the universe that have something innately to do with time. As I stated many pages ago: time is an extraordinarily difficult concept to describe or know. A “problem” with time is that time is embedded in nearly everything we do, in the

questions we ask about our past, present, and future, and in the individual thoughts we have and the cultural practices we subscribe to. Time is everywhere, which makes it that much harder to observe, to know, and to know when we are experiencing it. It is also essential in art, as even the idea for time to be explored in this dissertation came from an art exhibit and corresponding book about atemporal works: *The Forever Now: Contemporary Painting in an Atemporal World*.²⁹ Barbara Adam does not leave art out of her examination about time and culture. She writes about how to “make time stand still” that requires representation to externalize knowledge, stating that “To hold in unchanging form what is moving, changing, and interconnected is an achievement that has been realized by our earliest ancestors through their art.”³⁰ Art thus preserves for future generations what a previous culture valued and gives insight into experiences that may otherwise have been lost over time. In theatre, time and culture can be relived through re-performances of the past, demonstrating cultural beliefs from a past society. Yet, in theatre, time is also unpredictable and unreliable. Even as we reread scripts and re-stage plays that are centuries old, we cannot exactly replicate the experience of watching a live play that has been performed, never to be seen again. Theatre is a part of our culture, and has continued to reflect how our culture has perceived itself and its beliefs and practices for thousands of years. Science plays are no exception.

In my next section of this chapter, I examine four science plays that present possibilities for theatre in depicting science as a part of culture, exemplified by the ways in which these plays use time. These plays introduce broad considerations, such as raising questions about science and science ethics, how scientists are presented, what has changed or is open for examination regarding the practice of science as a byproduct and part of culture, and finally, what might these plays suggest for further cultural reflection. Frank reminds us that scientists too are born of the culture that surrounds them, and they build “imaginative responses” to the knowledge and ideas they encounter through their work’s pursuits,

informed by their cultural background.³¹ Science plays embody this notion, as the science depicted may be seen as part of a cultural moment or response, and ultimately integral to our cultural behavior toward time.

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1. Stephen Kern, *The Culture of Time and Space, 1880-1918* (Cambridge: Harvard UP, 2003)
 - 2.
 2. Kern 4.
 3. Maurice Merleau-Ponty, *Phenomenology of Perceptions*, trans. Colin Smith (New York: Routledge, 1994) xvi.
 4. C. P. Snow, *The Two Cultures and the Scientific Revolution* (New York: Cambridge UP, 1959) 4.
 5. Snow 5, 10.
 6. Snow 53.
 7. Snow 54.
 8. Many of the authors I cite in this analysis are more contemporary, illustrating that the conversations now had with and against Snow's views are more recent evaluations. Culture and time are interrelated into the dynamics of this changing conversation. For example on the one culture conversation, see *The One Culture?: A Conversation About Science*, ed. Jay A. Labinger and Harry Collins (Chicago: Chicago UP, 2001). Zehelein 33-34.
 9. Jerome Kagan, *The Three Cultures: Natural Sciences, Social Sciences, and the Humanities in the 21st Century* (Cambridge: Harvard UP, 2009) ix.
 10. Kagan 265.
 11. Rens Bod and Julia Kursell, "Introduction: The Humanities and the Sciences," *Isis* 106.2 (June 2015): 337.
 12. Zehelein 20.
 13. Zehelein 35.
 14. Zehelein 45, 47.
 15. Shepherd-Barr, *Stage* 10.
 16. Terry Eagleton, *Culture* (New Haven: Yale UP, 2016) 1.
 17. Raymond Williams, "Culture is Ordinary," *Resources of Hope: Culture, Democracy, Socialism* (London: Verso, 1989) 4.
 18. Eagleton viii and xi.
 19. Eagleton 3.
 20. Steven Shapin, *Never Pure* (Baltimore: John Hopkins UP, 2010) 12. Recently while attending the American Society for Theatre Research conference and participating in a working group about science and performance/theatre, I overheard someone say Einstein and Hawking do enough normalizing of scientists. While this is arguable, and surely, that list could also include other scientists, the idea that a couple of scientists should be the face of an

entire discipline or group is extraordinarily limiting and an insufficient argument one would likely make for other types of people or roles.

21. Frank xv.

22. Richard Gray and Alexandra Genova, "How Einstein changed the world with his theory of general relativity...and why you would literally be lost without it," *Daily Mail*, 26 Nov. 2015, <<http://www.dailymail.co.uk/sciencetech/article-3333250/How-Einstein-changed-world-theory-general-relativity-literally-LOST-without-it.html#ixzz42epyiQp4>> (accessed 10 Mar. 2016).

23. Frank xv.

24. Frank xxi.

25. Barbara Adam, *Time* (Cambridge: Polity Press, 2004) 1.

26. Barry Witham in "Theater, Environment, and the Thirties," writes about plays in the 1930s that portrayed the drought. He describes that while the economic crisis received much attention, the "onslaught of draughts, dust storms, and unregulated pollution that assaulted an already desperate United States" received far less examination in plays (13). I mention this because our artistic response to this time specific/natural phenomena/weather occurrence is not a new thing that climate change plays are the first to undertake. The plays he refers to are less scientific than politically aimed, such as Hallie Flanagan's *Can You Hear Their Voices?*, but such plays mark the first works to give increased attention to the ecological and environmental consciousness tied to a hybrid of science/culture/time/theatre we will likely see more of in the years ahead. See, Witham in *Readings in Performance and Ecology*, ed. Wendy Arons and Theresa May, (New York: Palgrave, 2012): 13-22.

27. Adam 18.

28. See Carlyle Murphy, "Most Americans believe in heaven ... and hell," *Pew Research*, 10 Nov. 2015, <<http://www.pewresearch.org/fact-tank/2015/11/10/most-americans-believe-in-heaven-and-hell/>> (accessed 3 Mar. 2016); and Simon Parkin, "Back-up Brains: The era of digital immortality," *BBC.com*, 23 Jan. 2015, <<http://www.bbc.com/future/story/20150122-the-secret-to-immortality>> (accessed 3 Mar. 2016).

29. Laura Hoptman, *The Forever Now: Contemporary Painting in an Atemporal World* (New York: Museum of Modern Art, 2015).

30. Adam 79.

31. Frank 332.

Chapter 2.2: Contemporary Science Plays and Time: The Possibilities Never Before Possible

Our culture's relationship to science is a particular one, and one in which the edges are still not clearly defined. In their book, *Science in Public: Communication, Culture, and Credibility*, Jane Gregory and Steven Miller describe the push for the public to know more about science, and whether that means the public has "understanding," "knowledge," or "appreciation" of science.¹ Using the words of Isaac Asimov, who described that understanding science is not only essential "to preventing growing public hostility," they add that public knowledge about science benefits research funding, national power, and influence.² Taking this consideration further, Gregory and Miller also suggest, "Little has been done that would really turn greater public understanding of science directly into democratic political and economic power."³ While this is a line of thought I continue to explore in future chapters regarding atomic science and climate change, in this chapter I am examining a more general observation about what science plays may offer science: they may help us understand science as a cultural entity that is about humans and for humans. How I posit these plays do so, both ingeniously and simply, is through utilizing the concept of time, which illustrates that science is something that has affected us societally and personally, and will continue to for years ahead.

In this chapter, I examine contemporary science plays and their deployment of time to see what they offer for our cultural perceptions of scientists, scientific knowledge, and science itself, which thereby sheds more light on science's role in our culture. Analyses of Tom Stoppard's *Arcadia* (1993), Shelagh Stephenson's *An Experiment with an Air Pump* (2000), Anna Ziegler's *Photograph 51* (2011), and Nick Payne's *Constellations* (2012), illuminate such possibilities. In Stoppard's *Arcadia*, the audience can see how entropy and

the second law of thermodynamics materialize within the young, brilliant Thomasina's ideas in 1809, and in comprehending the inevitability of past events, even as the researchers in 1993 study Thomasina and her adult peers. This dynamic back-and-forth illustrates how the arrow of time (time always moves directionally through past, present, and into the future) is interrelated to these scientific theories, to these characters, and to their conclusions—all of which come to life in Stoppard's acclaimed work. In the play, we see also a display of ethics in research demonstrated by scholars, as a certain character's shortcut for a good research narrative momentarily trumps historical veracity. The plays by Stephenson and Ziegler, like *Arcadia*, also present time in an enlightening manner. Both works demonstrate an awareness that passed time does not mean an event or its consequences remain sealed in the past, and the plays, while never explicitly so, highlight theories of a block universe and Minkowski's spacetime by showing how past/present/future are contiguous. Stephenson's play focuses on how ethical concerns of science are always a part of scientific inquiry, no matter the time period. It also underlines the tensions of gender affecting scientific lives, then and now. This is more strongly emphasized in *Photograph 51*. Ziegler's play reveals a glimpse of the scientist Rosalind Franklin and her overlooked contributions, depicting a necessary critique of how women have been treated in the sciences. The play is set in an ambiguous present as past events are represented, and characters have future knowledge of this past that they then use to critique what happened. Franklin's treatment by her colleagues is that much more salient given Ziegler's resistance to make the work a strict period play, hinting how women in the sciences are treated is still a problem today. Payne's *Constellations* explores multiverse theory and how time is finite, even if life's choices and consequences are limitless within a multiverse conception of the universe. The science in the play emerges through this play of time, and through it, the physicist Marianne realizes a puzzle of time. She learns that that which is experienced is not the same as the actual science behind it: "Time is irrelevant

at the level of atoms and molecules.”⁴ The play also underscores ethics surrounding the choice of death when facing terminal illness.

The ideas in these plays are notably complicated and diverse in topic, but what they share are the playwrights’ meticulous use of time as a structural element and theoretical exploration. Therefore, I confine my analysis to a specific deliberation about what time does as related to the larger themes within each play. To maintain a larger exploration of how time and science interact in other cultural mediums—as I do throughout this dissertation—I compare theatre to film phenomenologically by looking at the movie *Interstellar* (2014). The movie portrays the possibilities of climate change destruction, space travel to another inhabitable planet, and time dilation, while also depicting scientists as central protagonists who save the day. In many ways the movie typifies, like the plays in this chapter, how scientific knowledge, coupled with the playing of time, can create new narratives. I chose the film because “it sticks pretty close to established science and any speculation remains in the realm of plausibility,” due to the contribution of renowned theoretical physicist and *Interstellar* consultant, Kip Thorne.⁵ I also reference a *StarTalk* radio episode, hosted by astrophysicist Neil deGrasse Tyson, that discusses the movie with director Christopher Nolan and his interest in nonlinear movie storytelling with scientific themes. This useful conversation and the film indicate the current popular interest in collapsing binaries of high and low culture, science and arts, and the potential of engaging in interdisciplinary dialogue to create art. Having seen *Constellations* on Broadway this spring, I also compare the experience of watching the play to reading it in relation to time and phenomenology.

Through these cultural representations we see the interplay potentials between science and theatre, and how science can offer theatre “whole new territories of subject matter for playwrights to address, beyond the stale and melodramatic material of dysfunctional families.”⁶ In return, theatre elucidates how science is part of our cultural milieu,

exemplifying it can affect how we tell stories and what stories we can and should keep performing. In exploring this idea there is a tendency to explicate that theatre humanizes science, but this argument can be limiting to what theatre is doing or can do, rendering it as a “mere handmaiden to science,” as I cited Shepherd-Barr in arguing against earlier.⁷ This is a point those of us studying science plays appear to go back and forth on.⁸ Insisting that this capability to humanize is a powerful asset theatre provides to all human experiences, science included, in my dissertation I argue the empathetic and humanizing ability theatre offers science is significant for our culture, particularly given our current cultural moment. Moreover, as “many science plays demonstrate, the role of science within contemporary culture is a tense one, as new discoveries constantly create new ethical dilemmas,” writes Kirsten Shepherd-Barr.⁹ The ethical dilemmas portrayed in these plays are complex and varied, and depict the practices within science and the practice *of* science that can invite further consideration, particularly when viewed with the lens of time.

The intersectionality of theatre and science bears forth many different paths for inquiry. The contemporary plays examined in this chapter allow us to see how science can come to life on stage often through a captivating use and expression of time. Moreover, these four plays prove that while science’s role in our culture may often be viewed as distant, it can also be a thought-provoking enterprise because of what it can help us rethink about our existence, in large part to how these plays plot and display time. Through these science plays we can see that science can be inspiring, poignant, and beautiful, as well as a pursuit followed by humans who are relatable. It is a significant feat for science plays to personify science in our culture as it may help us better understand science, which I argue these plays provide through their thoughtful engagement with time. This is no truer than in one of the pioneer plays of the science play genre, Tom Stoppard’s *Arcadia*.

Arcadian Rhythms

It is hard to write anything new about *Arcadia*. Tom Stoppard's 1993 play is so rich with complexity that it has offered considerable angles for scholars to analyze in the past two decades since its premiere. Shepherd-Barr, for example, pronounces that the play "contains an astonishing multiplicity of themes, ideas, and fields of knowledge, including physics, landscape architecture, and literary biography and criticism."¹⁰ This being so, I focus primarily on how time operates in the play. The play is set in a country house in Derbyshire, Sidley Park, and jumps back and forth between events in 1809 and 1993, and ends with a scene in 1812. In 1809, we meet an extraordinarily bright young girl, Thomasina Coverly, tutored by Septimus Hodge. Thomasina's mathematical and cognitive abilities are well beyond her age and her time, and her curious questions to Septimus show a unique bond between the two that deepens throughout the play. She remarks early, "When you stir your rice pudding, Septimus, the spoonful of jam spreads itself round making red trails like the picture of a meteor [...] But if you stir backward, the jam will not come together again" and Septimus responds, "we must stir our way onward mixing as we go, disorder out of disorder into disorder."¹¹ Shepherd-Barr cites this moment as the introduction of entropy and the second law of thermodynamics in the play. Stephen Abbott in "Turning Theorems into Plays" writes, "Stoppard is setting the stage for what is to be a provocative exploration of the human implications inherent in the confrontation of classical Euclidean geometry and Newtonian physics with chaos theory and the second law of thermodynamics."¹² As many scholars, both in theatre and the sciences, have explicated, Stoppard is not merely using science to make a point or as a throwaway, but rather the theories of science he utilizes are discussed often by the characters *and* integral to the very formation of his plot.

The second law of thermodynamics is "The tendency of physical systems to evolve toward states of higher entropy" explains Brian Greene, understanding that this evolution

increases over time. Greene explains that there “are more ways for a system to have higher entropy, and ‘more ways’ means it is more likely that a system will evolve into one of these high-entropy configurations.” Furthermore, it is also most likely that a state of high entropy will not move toward a state of low entropy.¹³ Adam Frank clarifies, “Entropy can be thought of as the disorder in a system. All energy transformations that do work also create disorder;” thus he gives the example of breaking eggs to make an omelet, which necessitates disorder and entropy.¹⁴ Sean Carroll offers the historic context of the emergence of this theory by describing the studies of heat and its properties by Léonard Sadi Carnot in 1824 and Rudolf Clausius in 1865. Carnot realized that in looking at steam engine technology, “the operation of a steam engine is an irreversible process,” and Clausius deduced that “heat does not spontaneously flow from cold bodies to warm ones.”¹⁵ This phenomenon can be explained, again, with an egg example. In the case of an egg splattering:

“there are *so* many ways to splatter. It’s difficult for an egg to unsplatter, because an enormous number of splattered constituents must move in perfect coordination to produce the single, unique result of a pristine egg resting on the counter. For things with many constituents, going from lower to high entropy—from order to disorder—is easy, so it happens all the time.”¹⁶

This is the same as the rice pudding Thomasina stirs; it cannot be unstirred—it cannot go from such disorder and higher entropy back to the clean separation of jam and pudding. With this theory, there emerges an entropic understanding of the arrow of time; the forward direction of time is evident because “you cannot reduce a system’s entropy [...] The transformation can only flow in one direction, and that direction appears to separate the past (low entropy) from the future (high entropy).”¹⁷ Carroll even refers to *Arcadia* in his book

From Eternity to Here, saying Stoppard “uses the arrow of time as a central organizing metaphor,” which Carroll calls “a brute fact about our universe.”¹⁸ It becomes a brute fact in the play too.¹⁹ What has sprung forth from these theories are many more theories about different types of universe beginnings and endings to account for what may have happened and will happen in the future due to this entropic conundrum. This is a matter I will leave to the physicists.²⁰ However, in laying out this terrain, the simple statements in Stoppard’s play indicate they have worlds of scientific meaning behind them. And as will prove to be the case in looking at the many science plays ahead, demonstrative of how time/science/culture and even our universe are interwoven into ways we know and experience the world.

In the play, Septimus has been having an affair with Mrs. Chater. Mr. Noakes, the garden landscaper, notifies Mr. Ezra Chater of this. Mr. Chater approaches Septimus about it, and Septimus riles him up with jokes about his wife’s demands for “satisfaction” (11). Chater is calmed, however, when Septimus tells him he has received an early copy of his book, *The Couch of Eros*, and that he will write a favorable review of it. Chater deduces his wife must have known Septimus was expected to write a review for him, exclaiming, “There is nothing that woman would not do for me!” (13). As Zehelein summarizes, “In 1809 life is about sex, sexy literature and literature.”²¹ Stoppard sets up a colorful world in 1809, which is not surprising then that the scholars in 1993 are trying to piece it together for their individual research interests. The play moves to 1993 (present day at the play’s premiere) at the start of scene two to focus on Hannah Jarvis. Stoppard explains in the stage directions that Hannah’s research is on the table in scene one, despite her not being a part of that temporal world. He clarifies, “*During the course of the play the table collects this and that, and where an object from one scene would be an anachronism in another (say a coffee mug) it is simply deemed to have become invisible*” (19). It is as if those characters in the past have no way to see the future (present for the audience), and the characters in the present—including Hannah—

cannot clearly see the points of evidence from the past that are right there in front of them. Hannah is writing a book about the house's vast gardens, which we have learned that Thomasina's mother, Lady Croom, is preoccupied with redesigning in the former scene. Bernard Nightingale, an arrogant literary scholar and professor, is also at the property, trying to figure out a Sidley Park connection regarding Ezra Chater, and later he admits, Lord Byron. There is also Valentine Coverly, a scientist/mathematical biologist studying grouse. "All three are engaged in their individual attempts to reconstruct past events," thus creating a contrasting play of motives as what they *think* happened is juxtaposed with that which the audience *sees* happen in the nineteenth century.²² Hannah is trying to figure out more about a potential hermit who lived in the gardens, but is uncertain of his identity despite him living there like "a pottery gnome" (31). In the cottage where the hermit lived were "Hundreds of pages. Thousands [...] he was suspected of genius" and was also perhaps not mentally sound, as Hannah refers to him as "A mind in chaos" (31).

Nightingale pursues the Byron connection, knowing Byron's fame could give Bernard himself notoriety writing about him. He thinks Chater's book was reviewed by a young Lord Byron and has found a connection that he believes proves this—despite the inscription of the book from Chater to Septimus, and Hannah saying as much herself. She even states, "The book had seven years to find its way into Byron's possession. It doesn't connect Byron with Chater, or with Sidley Park. Or with Hodge for that matter" (35). Nightingale instead retorts that Byron "killed Chater!" (35). He concludes that the disappearance of Chater after 1809 and Byron's travels to live abroad shortly thereafter mean there is a undeniable connection of some foul play. Through her own research, she later discovers a journal of Thomasina's with mathematical algorithms that appear to demonstrate advanced iterations. Valentine looks at them and assesses what she is doing in the journal "hasn't been around for much longer than, well, call it twenty years" (48). Valentine dismisses it as a child just playing with numbers,

and explains more about his own research trying to figure out the grouse population by the hunting logs that detailed how many were shot. While Hannah and Valentine are concerned about their research verified by proof, Bernard wants to pursue his Byron theory with little more than a hunch and his instincts. He insists that there was a duel and justifies this belief as beyond reason: “The certainty for which there is no back-reference. Because time is reversed. Tock, tick goes the universe” (54). His rationale apparently defies how time operates; it should be no wonder, given the temporal layout of this plot, this will not bode well for him.

Time hangs over the play, and creeps in and out of each scene. In a tutoring session, Thomasina mourns all that was lost in the fire of the great library of Alexandria, and Septimus lectures her that all that was lost in the march of time will either “turn up piece by piece, or be written again in another language [...] Mathematical discoveries glimpsed and lost to view will have their time again” (42). Both Bernard and Septimus’s arguments illustrate an uncertainty of time—that there are experiences that might evade time’s logic and that we can never entirely grieve what is lost in time, for what is lost may have its day yet again. These are only feelings about time, however, as neither can know these things. In the present, Valentine confirms that Bryon was at the estate, shown in the game books and records that he shot a hare. Bernard is now relentless in solidifying his theory, telling Hannah she has helped him with “probably the most sensational literary discover of the century” (62). Despite Hannah and Valentine warning him otherwise, even calling him “arrogant, greedy, and reckless” and that “your theory is incomplete,” he does not heed their advice (63). No time can be wasted; “He publishes his harried results, and instead of writing an article in a scholarly magazine or journal, he sends off a press release.”²³

The play’s time frame switches to 1812, when the house butler tells Septimus that Captain Brice, Mr. and Mrs. Chater, and Lord Byron have all left the estate. Lady Croom, Thomasina’s mother, confronts Septimus, telling him that she found a letter addressed to her

daughter from him that is “full of rice pudding” and another love letter addressed to her, in case he died in a duel (73). While Lady Croom explains that Brice sent Chater to investigate botany in the West Indies so he can further seduce his wife, she also agrees to an affair with Septimus. It is only a fleeting conversation in the past, but the fate of Chater is established by his dispersal to study botany, something that will be critical to Nightingale’s research. We can never know how “present” events will matter to the future. Back in the 1993 present, the release of Bernard’s theory has found its way to press: “‘in Arcadia—Sex, Literature, and Death at Sidley Park.’ Picture of Byron” (77). Valentine and Hannah discuss their research in light of Bernard’s moment in the sun, and she sees on his computer an astonishing set of work, which Valentine states is the “Coverly set”—Thomasina’s math” (80). He explains that he could use his computer to finish her work in a fraction of the time than she ever could have, and now he has a publishable project on his hands. While Valentine admits that had Thomasina finished, she would be famous, Hannah corrects him that she had died prematurely. She had “burned to death [...] The night before her seventeenth birthday” (80).

This statement is set against Thomasina and Septimus in 1812 discussing that he had promised to teach her how to waltz, “Sealed with a kiss” (84). The two remain playful and full of admiration and respect for one another, and Thomasina teases him about her fanciful ideas of marrying Lord Byron. The differences in timelines are no longer bifurcated by scene, instead now shifting back and forth faster—like the objects on the table from both temporal worlds. The characters from the different timelines fill the stage, lines overlapping one another. Lady Croom enters the room and discusses the steam engine, once again hinting at the history of the second law of thermodynamics that is embedded in the play. Bernard appears and asks Hannah how incorrect he was about Lord Byron, and she reports, “Ezra Chater of the Sidley Park connection is the same Chater who described a dwarf dahlia in Martinique in 1810 and died there, of a monkey bite” (93). There has been no sensationalized

duel where Byron killed Chater, like Bernard claimed. Bernard has already made a round of publicity stops and has now learned what his shoddy research has cost him. Hannah says she will write a statement to *The Times* about this finding, and Bernard will graciously concede he was wrong. Bernard has learned the necessity of taking his time to do his research thoroughly.

In the last scene, Thomasina and Septimus are alone, and it is the night before her seventeenth birthday. She kisses him, and though she wants to dance, he instead is reading her essay. It is a “diagram of heat exchange,” and while he looks at it, Valentine in the present is simultaneously doing so, or as Stoppard writes, together they “*study the diagram doubled by time*” (97). Valentine notes that she “didn’t have the maths, not remotely. She saw what things meant, way ahead, like seeing a picture” (97). Thomasina could see the possibilities of the second law and the science behind it, even if she could not yet prove them. She knew that “you can’t run the film backwards. Heat was the first thing which didn’t work that way” (97). Hannah concludes she has a good idea who the hermit was, “but I can’t prove it,” and we concurrently watch Septimus and Thomasina waltzing freely. Thomasina takes the candle from the room, and Septimus, presciently tells her, “Be careful with the flame” (100). We already know what happens to her, soon. While Thomasina asks for Septimus to come to her room, and he says he will not, she stays, stating, “Then I will not go. Once more, for my birthday” (101). We watch as Thomasina and Septimus show sparks of a romantic future, and Thomasina shows promise of being a scientific genius. Only none of this will come to pass. Despite these hints of potential, we already know that time only moves forward and that this past event is already set in Hannah’s present. Instead of what could be, Thomasina perishes in a fire and Septimus retreats to the garden as the hermit. The rice could not be unstirred, even though we in the audience did not piece all this together until the final bittersweet moments.

N.M. Hoffman for *Theatre Journal* reviewed the 1995 production at the Lincoln Center, directed by Trevor Nunn. Nunn also directed the 1993 premiere at the Royal National Theatre. Hoffman writes, “In Thomasina’s conception, the random order of the natural world should be demonstrable in an algebraic equation,” but even her equations could not account for the randomness of her own fateful death.²⁴ He describes the transitions between the temporal settings as executed in a way that was “magical,” and that “Every thing is made to participate, increasing the urgency of the closest observation.” While the play suffered from poor articulation from its performers, including Billy Crudup playing Septimus, he and the actor playing Thomasiana created “a distinguished palette of varying passions.” Crudup would later return to play Bernard in a 2011 production at the Ethel Barrymore Theatre. Ben Brantley writing of the production stated, “But see it you should, in part to experience the ingenuity and seamlessness of Mr. Stoppard’s time-traveling craftsmanship, but also to feel the empathic imagination brought to characters you may wind up realizing you never fully grasped before.”²⁵ At the grand reopening of the Writer’s Theatre in Chicago in a new space, *Arcadia* was chosen as the premiere play. Chris Jones for the *Chicago Tribune* called the play a “formidably intellectual drama” that “flits through genres,” and wrote “Stoppard structures the play so that sometimes we know more than those characters, for we have seen that which they have not.”²⁶ It is an astute and simple observation: we in the audience experience this as only we know exactly what happened in the past that the present researchers grapple with, and we know what will come to be, in ways that those in the past can never foresee. Jones credited the actors with keeping emotional weight to the characters instead of devolving them into dryly intelligent stereotypes, stating further that that the balance of feeling and thinking comprises the “core of this great drama that’s really all about the limitations of art and science without the leavening properties of the other.” Enoch Brater discussing the play, writes that Stoppard has always had a “fascination with the choreography of stage time,” and that “the

dual time structure is carefully manipulated to show cause *after* effect” in *Arcadia*.²⁷ Brater adds that the “dual time frames” are pursued with “authority, clarity, and a great deal of stylistic direction and precision.”²⁸

Arcadia has had many productions since its 1993 premiere, which is not unexpected given its critical and commercial success. Stoppard clearly crafted a work of high intelligence, which did not cheapen the science *or* the artistry of the play in balancing the two in a skillfully shaped narrative. The play demonstrates that our culture has an enthusiasm for such work. It also reveals, even though we may not know it, that the second law of thermodynamics plays a hand in our own lives; we cannot change the arrow of time. As we look back on the past and wonder what might have happened, time moves forward. The play also shows that literary scholars, brilliant mathematicians and scientists, writers, and garden scholars could be compelling characters to watch, and that science utilized in a play’s narrative could offer an appealing night of theatre. As Shepherd-Barr writes:

The impact of *Arcadia* on subsequent drama and theater has been extensive. The play showed how successfully one could incorporate sophisticated scientific ideas into the theater, and it spawned a rash of look-alikes in its wake—plays that use the same juxtaposition of different time periods (usually using the same actors doubling), with varying degrees of success.²⁹

This is true for the other plays in this dissertation, particularly for Stephenson’s *An Experiment with an Air Pump*.

Time Fluctuations: Ethics and Gender in *An Experiment with an Air Pump* and *Photograph 51*

Much like *Arcadia*, Shelagh Stephenson's *An Experiment with an Air Pump* balances two timelines, shared by space. Yet, in Stephenson's work this temporal device highlights how questions about the ethics of science continue to reverberate, despite two centuries between the points in time. Claudia Barnett describes the time difference in the play as a "simultaneous staging of similarity and difference, past and present, result[ing] in a drama that grapples with issues of ethics and interpretation and requires its audience to do the same."³⁰ The play juxtaposes scientists in 1799 England with a geneticist and her husband in 1999. The play's setting is in the same house, as the characters in 1999 discover the remains of a body that is connected to the events unfolding in 1799. The play pivots between the two times, and the audience is privy to seeing the parallels and contrasts between scientists, questions of scientific ethics, and gender expectations and marital relationships between then and now. Zehelein succinctly summarizes the play as one that uses "a number of polarities and alleged dichotomies," but it "does not treat these contrasted concepts as static entities."³¹ The playwright offers ambiguities in the very questions she posits.

In the play we also see differences of opinion in the point of science, and that scientific discoveries are often marred by one's ambitions without possessing foresight. The play uses Joseph Wright's 1768 painting, "An Experiment on a Bird in the Air Pump," as a starting point, which simultaneously illustrates the intriguing possibilities of science, and that science undermines the concern of the life of the bird inside the air vacuum. Such experiments were not uncommon in the day.³² In Wright's painting, there in a darkened room lit only by a candle we see the natural philosopher show off his experiment: "The choice of a live animal – a rare and exotic cockatoo – adds a dramatic dimension to what otherwise might be viewed as a pedestrian scientific demonstration."³³ The others in the painting, both men and women and of various ages, watch with "mixed emotions. The two young girls show signs of obvious anxiety and distress, while the gentleman and boy at left

follow the lecturer's explanation with interest.”³⁴ Paul Duro, exploring Wright's many paintings, also references Susan L. Siegfried in his analysis of Wright's work. She describes how women were seen as the “carriers of the emotional and imaginative import of scientific discovery” in the eighteenth century, which Wright's painting highlights and in many ways Stephenson's play probes.³⁵

The play begins with actors in a tableau of Wright's painting, with the character of Fenwick in the role of the central scientist/natural philosopher. Ellen, the modern geneticist, states her love for the painting, because “it has a scientist at the heart of it, a scientist where you usually find god.”³⁶ As Ellen discusses her own interest in this painting, Stephenson then shifts our view to Maria asking her father, Fenwick, if the bird will die—making the painting come to life. Susannah, Maria's mother, scolds her daughter for being so sensitive. Harriet, Maria's sister, muses that the bird is Maria's pet, while Armstrong (another natural philosopher) states she can get another, and Roget, the physician and lexicographer of the famed thesaurus, offers that they perhaps they could find another bird. In this introduction of clashing responses, the dynamics are established that will reappear in the rest of the plot. Armstrong tells Fenwick he is late to attend a lecture regarding an anatomical anomaly, something not uncommon in the day as means of scientific discovery and education, much like what occurred with Joseph Merrick (as also presented in the 1977 science play, Bernard Pomerance's *The Elephant Man*). Fenwick espouses that such scientific lectures are far too sporadic in quality and antiquated in approach. He argues, “We want something worthy of the past and fired by visions of the future. We want to excite the audience” (10). The two daughters discuss a play that Harriet has written, which Roget quizzes the young women about. When Fenwick tells his daughters he cannot watch it now, Harriet responds, “How many times have we sat through your experiments, your visiting speakers droning endlessly about combustible gasses and electricity” (17). She knows a play can be as enlightening as

his science, which exemplifies one of the play's "general banner[s] of 'art vs. science.'"37 Stephenson, while focusing on the science, keeps these female characters central in the play, most of whom in 1799 struggle with their limited roles due to their gender identity. Isobel, the house servant, defies stereotype as she is highly literate and dazzles all three men with her wit. As is made clear in the play, "Words are what interest [her]" (20). Upon Fenwick's exit, Armstrong flirts with Isobel despite the physical malformation of her back, but Roget reprimands him for doing so. Both Armstrong and Roget show romantic interest in Isobel. However, Fenwick will warn Roget to leave her be, because he thinks of her like family. Armstrong finds her fascinating and wonders what caused her spinal misalignment, revealing his precise interest in her that will develop within the play.

The next scene takes place in the same room, but it is now 1999. Ellen and Tom are moving out of their large home that will be used for a commercialized bed and breakfast. Speculating on the storied past of the house, Ellen says, "The history of this house is the history of radicalism and dissent and intellectual inquiry and they're going to turn it into a tin of souvenir biscuits" (26). Mirroring the relationship between Susannah and Fenwick, Ellen and Tom as husband and wife are on different sides of the Humanities-Sciences discipline divide. Ellen is a research scientist, specifically in genetics, and Tom is an unemployed English lecturer. Ellen tells Phil, a building surveyor, that her friend Kate has offered her a job in specialized genetic research, but Tom has problems with aspects of the work. Ellen has perfected a technique that allows scientists to detect early signs of Alzheimer's and other diseases, and the embryos being tested are left over from in-vitro fertilization. Ellen knows that with the work she is doing some people might want "to terminate the pregnancy" upon discovery of genetic diseases, and thus she has an "ethical crisis" (31-32). While Kate and Ellen discuss the implications of this research, Tom appears and states what will become the

mystery to solve in the play: he has found a box of bones underneath one of the kitchen cupboards.

The play jumps back to 1799, and while Kate and Ellen have just discussed the future of genetic science in the twenty-first century, Fenwick tells Roget about what he sees for the future of his country. He says to Roget, “one hundred years from now, there will be no monarchy in England,” continuing:

Logic demands it. Science is inextricably linked with democracy. Once people are released from their ignorance, they will demand universal suffrage, and once we have it, it follows as night follows day that we will vote the monarchy out of existence.

(37)

Like Kate, Fenwick believes that science will push the world and people into a better, more progressive existence—elucidating his sense of idealism that reality can likely never match. Earlier in the play, his sympathies for rioters protesting the cost of fish was evident; he believes people need science to improve society and their lot. Through Fenwick’s beliefs, we see how tense is interlaced within the play, and how both those in the past and the present (of 1999) look anxiously and expectantly ahead to what the future holds. Fenwick truly believes that once people have reason and knowledge, they will do and act better, which we still know not to be true to the degree Fenwick wants to believe, and to which Roget disagrees: “People like the monarchy because it’s got nothing to do with reality” (38). Fenwick debates Roget on this point, stating, “We’re scientists because we want to change the world,” after which Roget retorts, “We’re scientists because we want to understand the world.” Fenwick concludes, “We’re scientists because we want to change the conditions under which people live” (39). This exchange emphasizes a driving question within Stephenson’s play: what is

the purpose of science? Is it merely for the pursuit of knowledge, or is it to make life and our world better—and if so, how? Fenwick proposes that being a good scientist requires a warm heart, and that we understand “pure objectivity is a fallacy” (40). This is reminiscent of Steven Shapin’s argument in his book, fully titled, *Never Pure: Historical Studies of Science as if It was Produced by People with Bodies, Situated in Time, Space, and Culture, and Society, and Struggling for Credibility and Authority*. In his introduction, Shapin discusses how the sacred attitude and cultural authority given to religion was passed on to science in the twentieth century. There is a belief that science drives “history forward, in which science represents humankind’s highest achievement, and in which science ultimately frees humankind from its historical shackles.”³⁸ With such grandiose notions, Shapin counters that historians of science are not only researching the past and the great scientists of yesteryear, but also conveying more information about the actual lives of scientists, depicting them as embodied and real persons. His book clarifies that as people perform science, it can never be entirely objective. This is an important clarification as historians of science aim to figure out, “What were the boundaries of science, separating it from other forms of human endeavor, when it had become so bound up with the institutions of business, politics, and war.”³⁹ Stephenson’s dramatic character, Fenwick, instead, keeps science on a pedestal. In the play, this conversation about the purpose of science alluded to between Fenwick and Roget primes the one that unfolds with Ellen and Tom.

Tom and Ellen in the “present” discuss the dead body, and Tom feels guilt over not knowing anything about this female. This leads all too easily into criticism of Ellen’s work. Tom questions her how many times she has been pregnant, and reminds her every time, since the moment of conception, she thought that was life—interrogating the implications of her work again. Ellen argues with Tom’s line of reasoning, saying if they did not use the pre-embryos in her research they would have been discarded, which is not the same as the

personal conception she experienced. Tom further interrogates, asking for whose benefit this research is accomplished as it is a “totally commercial operation” (44). When Ellen replies that this is the world we live in, Tom reasons that with genetic codes it is potential that health insurers and other insurance companies will use that information to deny coverage for people.⁴⁰ In the play, Ellen exclaims, “Every scientist is aware of the implications, but we all live in the market place [...] It’s easy to have rarefied ethics if all our job involves is decoding bits of Shakespeare,” taking a harsh jab at Tom (45).

Susannah and Fenwick parallel this argument Tom and Ellen have, which encircles the inner workings and personal experiences they have endured in their marriage. Susannah tells her husband that he only liked her beauty, “that [she] knew nothing of politics or sciences seemed a matter of supreme indifference” (64). Fenwick admits he mistook her beauty for wisdom, her frequent silence as contemplation. Susannah feels lonely in her marriage, given that her husband has dedicated his whole life to his work. In response to his brazen honesty, his wife retorts, “You must talk to me in a language that does not exclude me” (65). It is a salient criticism to make against her husband/scientist as she demands her equality. In 1799, the women in the house struggle to assert their worth. Armstrong continuously pursues Isobel, both “*fascinated and bewitched*” by her back, but she keeps a distance given her disbelief of his interest (46). Maria, Harriet, and Isobel perform Harriet’s play but as the audience laughs, Harriet admits with frustration she does not want to write plays, and as she storms out of the room cries she “want[s] to be a physician, like papa” (52). Women of course were not allowed to follow such a profession at this time in England.⁴¹ Interwoven throughout the play are these two strong threads regarding gender and the ethics of science, often in ways that highlight how personal lives can affect one’s professional work. This is also true with Isobel and how Armstrong uses her out of his own scientific curiosity. Armstrong gives Isobel a gift, and Roget catches Armstrong kissing Isobel afterwards.

Armstrong briefly keeps up the charade, but confesses to Roget in privacy that he is only interested in Isobel's back and understanding its malformation. Isobel has overheard him, and while he speaks about the medical intricacy of the distortion of her rib cage, she runs off.

Ellen tells Tom she has taken the genetics job, not out of material needs alone but rather out of "passion [...] To me it's a form of rapture" (71). Her words conjure the face of wonder of the scientist in Wright's painting. As the two further discuss the topic, Kate interjects with her thoughts that are akin to Fenwick's ideas of the future; she wants science to discover the undiscovered and progress society for the future. Yet, Tom remains reluctant: "We've seen things come and go. And one of the things we know is the messiah's not coming" (72). He will simply not acquiesce to the idea that science is the only path for and toward the future. They toast the New Year, as the twenty-first century is merely moments away. Barnett writes that the continual "inter-spliced scenes" in the play that fluctuate back and forth between 1799 and 1999 "lead[s] the audience to ponder how the present becomes history and how much control we have over what we come to mean."⁴² Barnett has made a significant point here. Fenwick's concern over the legacy he and his scientific peers have, which will lead others into the future, is partly about control. He wants to believe that the impact of his work will have meaning. As the future is nearly celebrated in 1799, Isobel, alone, opens her gift, which is inevitably the same gold chain found on the body in 1999. She puts a rope around her neck, and Armstrong finds her body hanging in the next scene. Tom and Ellen never learn of her identity; meanwhile, back in 1799, as the family says their sorrowful goodbyes to Isobel, the New Year rings in. As midnight chimes, Fenwick states, "Here's to a future we dream about but cannot know [...] here's to the new century" (77). The juxtaposition of hope for the future and the sad reality of Isobel's death taints the idealism Fenwick once had. Eva-Sabine Zehelein astutely summarizes, "the characters in 1799 as well as in 1999 look with apprehension towards the future, the new century of hope

and promise, and are entangled in their own lives and emotional hang-ups.”⁴³ Throughout the play, time has been deployed to showcase that our questions about the purpose of science and the future of society are not separate, and that both are affected by the fact that humans are the driving force behind each.

Irene Backalenick reviewed the play as it premiered at the Manhattan Theatre Club—one of the two New York theatres affiliated with the Alfred P. Sloan Foundation, which promotes representations of science through multiple avenues—and wrote the production was a “literate, intelligent piece,” and that the play was “alive with vibrant characters and confrontational relationships.” She described that the past and present are capably woven together, concluding it is “gratifying that serious plays with panache” are still staged.⁴⁴ Charles Isherwood for *Variety* was less kind. He called the play not “particularly satisfactory.” He described that the play paled compared to its clear predecessor, *Arcadia*, and that it was “packed with debates about the moral dimensions of genetic research and the perorations on the values of science vs. those of art and literature,” leaving the play tedious and too talky.⁴⁵ Peter Marks for the *New York Times* wrote that the play was ambitious, and addressed “provocative concerns [...] passion versus love, the evolving role of women and the aims of science at the dawning of eras 200 years apart.” He explained that even though Stephenson, “sends more marbles rolling than she can ever retrieve,” the play benefitted greatly from the production’s staging.⁴⁶ Jeffrey Wainwright similarly wrote of the 1998 production at the Royal Exchange Theatre in Manchester (UK). He outlined how the play “crosses back and forth between Fenwick’s world and our own.” He said that the work was “teeming with interest, humour, eloquence, and above all, ideas.” Regardless of the time period, Wainwright assessed that the play emphasized “the inappropriateness of applying scientific disinterest to the tumble of variables that constitute the human affections.”⁴⁷ The success of Stephenson’s play, even as performed, balances past and present, presenting how

our questions about science and ethics and their role in our future *and* personal and cultural lives are still a matter of great concern.

The play is at times less fair in its depiction of scientists, which Shepherd-Barr's earlier sentiment grazed upon, particularly in the creation of the heartless Armstrong. Yet, depending on the direction of the character and performance of the actor the melodramatic villainy could be downplayed, instead emphasizing a calculated approach to science that sees the discovery first and the person second. The heart of the play lies in the ways in which science is interwoven into the lives of the scientists and their family members. In 1799, Fenwick's wife and daughters have no space in his ideal vision of the future. His wife feels shut out by his inability to communicate with her, intellectually and emotionally. His daughter Harriet feels sorrow that she must follow the arts rather than the sciences because she is a woman. Even in 1999, the gender politics still come to play, as Tom reminds Ellen of her personal experience as an expectant mother that he thinks she should consider in her genetic research. Both in Susannah and Fenwick's marriage and Tom and Ellen's the scientist's passion is a central issue that needs to be mitigated and dealt with as it affects the path of their relationship. This coupled with the larger moral and ethical consideration Stephenson teases out about the role of science in society (a great democratic liberator or potential commercial commodity) illustrates a vast world on stage. This world is possible through the parallel timelines, where we see our questions and quandaries of science have and will continue to be those of societal, political, economic, and personal concern for our culture. Time will not abate this fact.

In *Photograph 51* we encounter another pertinent example of how gender materializes within science. This time it is with the dramatic portrayal of the real life scientist, Rosalind Franklin, whose work with x-rays and photography enabled the understanding of molecular structures of DNA. Sarah Rapoport reminds us about the unknown scientist, describing, "Few

people outside of the scientific community know of Rosalind Franklin [...] Fewer still are aware that it was Rosalind Franklin's clear X-ray photographs that established unequivocally the structure of DNA."⁴⁸ This has changed, hopefully to some degree, with Anna Ziegler's play. Ziegler describes her play's structure as composed of a "choral aspect, in which the men narrate historical events from a future perspective."⁴⁹ This is much like Michael Frayn's *Copenhagen*, which I analyze later in this dissertation; and like Frayn's work, this play also has a "contested narrative," in which characters dispute and argue over what truly happened. There is also a "present moment" to be played naturally and a "dream space" of what ifs (5). Ziegler has established through this description the melding of many temporal and performance modes of the play. This description indicates that tense matters in the play: what is known in the future can be used to analyze the past. However, it also shows that tenses will overlap without the clear delineation made in *Arcadia* or in *Experiment with an Air Pump*. Premiering in 2010 at the Ensemble Studio Theatre (the other theatre that has a strong relationship with the Sloan Foundation), Ziegler's play consists of only six characters, including the other famed, male scientists Maurice Wilkins, Don Caspar, James Watson, Ray Gosling, and Francis Crick. It should be noted that Franklin is the only woman, and as indicated by Ziegler's framing descriptions, will not be a part of the narrative that looks back on history from a future perspective.

At the play's beginning, the men squabble over how this story will be told and that the focus will be put on Rosalind, or as James Watson refers to: "someone who barely made a dent" (11). In early 1951 in London, Rosalind is partnered with Maurice Wilkins, but the partnership quickly sours. From the onset, the battles Franklin faces are obvious, including acquiring her desired laboratory materials at King's College under Wilkins, with him telling her that instead of analyzing proteins, her work will focus on nucleic acid. He explains this is necessary because she will be assisting him, and his doctoral student—Gosling—will be

assisting her. Rosalind clarifies that she was told, “I’d be heading up the study. That I’d be in charge of my own work here,” and that “I will not be anyone’s assistant [...] I don’t like others to analyze *my* data, *my* work” (13). Her firm, rigid nature is palpable. Wilkins swiftly rebukes her, “Circumstances changed,” and that they must work on X-ray photos of DNA (13).

The men continue to argue over the details of this history, particularly how Rosalind misunderstood the terms of her work, and that the race for discovering the genetic structure was lost in that moment by Franklin setting herself apart from Wilkins. Rosalind begins working in the lab, asking Maurice about his time working on the Manhattan Project and stating, “Maybe you’re aware of the fact that not a single female scientist from Britain was given a research position during wartime,” and that “nuclear force is not something of which I approve.” Maurice retorts, “Then I suppose it’s good no one asked you to work on it” (14). The parameters of their often-contentious relationship are solidified in these brief exchanges sprinkled throughout the play. Franklin tries to handle the situation as best as she can, but she is excluded from the senior common room to eat lunch like the other scientists because it is a room for men only; she cannot be a part of the old boys’ club. Rosalind recognizes such exclusion sets her back professionally, as she does not get to network or have the important conversations with other scientists. Later Rosalind and Maurice try to connect with lighter social conversation. She tells him she saw Peter Brook’s *The Winter’s Tale*, and he states he almost went the same day, walked right past, their paths nearly crossing. The two discuss the play with some mutual interest, but the exchange runs its course.

It is hard to know what is happening in any specificity of time as the conversations flow into one another without any breaks. Rosalind gets a letter from Don Caspar, a doctoral student in biophysics. The two trade work and flatteries, and eventually he works at King’s and romantically pursues her. Rosalind will refute his first attempt, saying, “I’m afraid there

just isn't time, Dr. Caspar" (47). She knows that the race for the DNA structure is on. Time in this play is often about the looming stopwatch to be first—a plot conflict that also appears in other science plays, such as Peter Parnell's 2007 *Trumpety*, which is about Darwin and Alfred Wallace racing to write about natural selection. Zehelein writes, "Priority, fame and recognition are thus part and parcel of the scientific endeavor," so it is not surprising that these themes become driving forces in many science plays.⁵⁰ In Rosalind's exchanges with Ray, we sense how hardworking she is by staying late and working all hours and how much she wants to succeed. Maurice, failing to grasp how he continues to slight Franklin, gives her a box of chocolates because "Kindness always works with women" (26). Franklin rejects it, admonishing Wilkins for thinking such a gesture would mean something to her. Their relationship only sours more when Maurice takes the credit for their work and speaks of a helix pattern of DNA, which Rosalind cautions him about since they are not yet certain.

James Watson, who is also working on discovering the structure of DNA offers to partner with Maurice on their research but is turned down. The two characters step outside this moment as it is acted in the present and reflect. Maurice says, "maybe the two of *us* would have... Maybe later *my* name would have..." (24). He cannot help but wonder if Wilkins and Watson could have been what Watson and Crick became. James answers, "Was it the biggest mistake of his life? Without question," only to see him partnered with Crick shortly thereafter. Rosalind discovers the A and B form of DNA; history is in the making, if history had been just. While Maurice wants to collaborate, Rosalind refuses. Working alone, which the two conclusively did, James assesses, "Rosalind didn't hypothesize the way Crick and I did; she proved things, and proving things... well for one thing it isn't fast" (30). The second time we watch Maurice and James meet, they discuss Franklin's unpleasant manner, her Jewish religion, and whether she is "quite overweight" (31). It is a stereotypical way of diminishing women to their qualities of likability and appearance as markers of their value. It

is evident that the men want to reduce Franklin to descriptions that have nothing to do with her scientific importance. Franklin continues to work, but she is not interested in making a DNA model, whereas Francis tells the audience, “to Rosalind, making a model was tantamount to negligence [...] So what ended up happening was that she and Wilkins both sat in separate dimly lit rooms, doing maths (31). The last half of the play goes back and forth between Rosalind working as hard as she can, but outnumbered by the advantages of Watson, Crick, and Wilkins. As Ziegler portrays, this is particularly true due to the teamwork Crick and Watson had that Wilkins and Franklin never forged.

The historic image, photographed by Ray Gosling under Franklin’s supervision and project direction, clearly identifies the structure of DNA. Gosling tells her, and Rosalind sees, “It’s a perfect X. It’s a helix” (35). Confirmation has occurred. Rosalind chooses to hide the photo from Maurice, which Ray later shows him thinking it is only fair. As history goes on to show and as the play demonstrates, Watson and Crick ask Maurice what Rosalind is working on, and he willingly tells them after they bonded over their dislike for her. The two procure her work, which Watson failed to do with Rosalind previously; and without her knowledge, they see Photograph 51. Don recounts to the audience, “In *The Double Helix*, Watson later wrote ‘The instant I saw the picture my mouth fell open and my pulse began to race’” (41). In looking at the real history, Anne Sayre tells us that Watson’s book was “read with great interest and much pleasure by a large number of people,” only further problematizing the historical memory of Franklin as Watson portrayed her in his account.⁵¹ Watson raced to tell Crick, because their earlier incorrect formation of the DNA structure showed the DNA molecule “with its backbone on the *inside*.” He later received more information from Wilkins about Franklin’s progress and research after Wilkins secretly copied her work.⁵² In the play and in reality, Watson and Crick got a hold of Rosalind’s unpublished work and “her latest calculations, confirmation that the B-form was helical, and the diameter of the helix” (46).

The unethical alliance between Wilkins and Watson contrasts the complete lack of relationship between himself and Franklin.

Watson, Crick, and Wilkins were awarded the Nobel Prize in 1962 for their work on the DNA molecular structure, with Franklin unable to receive the award due to her death four years prior.⁵³ Had Watson, Crick, and Wilkins properly acknowledged Franklin's contribution, "Rosalind Franklin would have shared the enormous public recognition."⁵⁴ Franklin's work was instrumental to understanding the DNA model that Watson and Crick deduced, but her name is rarely evoked when discussing its discovery. When Don and Rosalind go out in the play, he tells her about how women physicists have to sneak in to labs late at night to do work at Princeton and how women are not even allowed in the physics buildings at Harvard. Rosalind knows these realities all too well. The loneliness she has felt as a woman scientist frames the ending of the play, her's being particular in the strained partnership she had with Wilkins. Maurice adds, "It's the loneliest pursuit in the world. Science. Because there either are answers or there aren't" (54). Rosalind confesses she has two tumors and ovarian cancer. Maurice writes her a letter wishing her well; and on stage, the two talk about Watson and Crick:

ROSALIND: So they really got it, did they?

MAURICE: Yes.

ROSALIND: Is the model . . . is it just beautiful?

MAURICE: Yes.

ROSALIND: Well. We were close, weren't we? By god, we were close.

MAURICE: But we lost.

ROSALIND: Lost? No... We all won. The world won, didn't it?

MAURICE: But aren't you at all . . .

ROSALIND: Yes, but... It's not that they got it first...It really isn't...It's that I didn't see it. I wish I'd be able to see it (57).

The cast of characters consider the "if onlys": if only Rosalind had been more self protective, less self protective, collaborated, been a better scientist, taken more risks, been friendlier, born another era, been born a man (57). Maurice feels guilt. He wants to relive the past, only this time to do it differently. This time he will go inside and watch *The Winter's Tale* and catch Franklin's eye. Afterwards they will discuss Gielgud. They can discuss whether Hermione comes to life at the end or if she is just a projection so Leontes can feel forgiveness: the metaphor is easy to see. Rosalind agrees that perhaps they might have gone to the play together or had lunch together, simple acts that never happened. Whether that would have changed history, "We'll never know, will we" (59). Time does not allow a redo.

At the play's end we learn of Rosalind's death; and in this last surreal moment Rosalind and Maurice, two scientists who never could harmoniously work together, realize their relationship bitterly affected their work and legacy. The play demonstrates the human element that is a part of science as practice, where biases and relationships can affect the research, discovery, and recognition. When Don writes to Rosalind to tell her of his doctorate conferral, she congratulates him, but she also identifies that at the time she received her doctorate she thought it "would have the same value for me, but of course you and I well know this is not the case" (37). As a woman it would not be, and the reality is that there is still work to be done to right this. As Eileen Polack for *New York Time Magazine* writes in "Why Are There Still So Few Women in Science?," male scientists are often viewed more favorably than women by both genders, male scientists earn higher salaries and more resource allotments, only one-fifth of physicists are women (there are even lower statistics for African Americans or Latinos of either gender), and that "The most powerful determinant

of whether a woman goes on in science might be whether anyone encourages her to go on.”⁵⁵ Her memoir, *The Only Woman in the Room: Why Science is Still a Boys’ Club*, and her article demonstrate the many hurdles in science women face. This include feeling inadequate in failing to succeed in ways their male counterparts do, and the many real instances of sexism, such as not being supported or mentored the same way males are, not given opportunities, being told to pursue something else, and even sexual harassment. Ziegler’s play captures these sentiments, and in the refusal to cement the play in its time period provides insight that the sexism Franklin endured is still a problem in the sciences for far too many women.⁵⁶

The play premiered in 2010 at Ensemble Studio Theatre, but had a recent revival that drew much attention in England. Writing of the West End production in London in 2015 starring Nicole Kidman, Michael Trueman called the play “a science play that sticks to the formula,” and that “Kidman nails [Franklin’s] air of cool superiority exactly—as well as being tentative and uncompromising.”⁵⁷ He said the play, with its “momentum of a race to discovery, all the step-by-step deductions, competition, and backhanded betrayals” is almost “too perfect.”⁵⁸ He is correct that sometimes Crick and Watson slip “into super-villainy,” which the script runs the risk of, production aside, but Trueman concludes it is Kidman in the lead role that shined. Ben Brantley for the *New York Times* wrote that while the play opened five years prior to little fanfare, in this production, “Ms. Kidman grabs onto such details of character without wringing them dry. And she deftly pulls off the trick of letting Franklin reveal to us an underlying wistfulness [...] without ever allowing us to think that the others onstage have sensed the same vulnerability.”⁵⁹ Brantley stated the play reminded him in structure of *Copenhagen*, but it “sustains a crisp dramatic tension even when it skirts banality or expository tedium.”⁶⁰ Susannah Clapp for *The Guardian* gave the production only three out of five stars, and that despite the other characters not given enough depth and the play

being “sketchy,” the work still “transmits excitement and a real sense of discovery” due to Kidman’s performance.⁶¹ Kidman won the London Evening Standard theatre award for best actress for the performance.

Putting aside the question of ethics in *Experiment* and the race to being first in *Photograph*, phenomenologically speaking both plays offer something important to the genre of science plays and as cultural reflection. They demonstrate that gender still plays a part in how science affects and impacts our culture. Michael Billington wrote of *Photograph 51*, “What the play does do is correct a historical injustice and ask, by implication, whether women are still sidelined in the scientific world.”⁶² It is easy to speak of science in monolithic strokes, reflecting such sentiments like those of Fenwick’s about its possibilities for humanity or the future of our societies. Yet, such generalities can elide the fact that people experience the world differently. Of note, finding science plays with either females or minorities as the central protagonists is not easy, as many portray white male European scientists, echoing the history of science which has been about the notable scientists—mostly white, male Europeans. Ziegler’s and Stephenson’s plays, one through juxtaposing timelines and the other through making time and tense indefinable, indicate that the impact of gender on science and by science is not settled.

Moreover, on stage, these are characters inhabited by real bodies in a shared space. “The body is that by which I come to know the world,” writes Stanton Garner, adding, “On the fictional level, theater emphasizes the variable of embodiedness in the stories it chooses to tell, since these stories are grounded in the physical insertion of character in environment and in the often competing operations of perception, habitation, and intersubjectivity.”⁶³ These plays display that scientists have bodies, and particular bodies that are viewed and treated differently. Franklin is not a disconnected head with thoughts. Her colleagues scrutinize her body, and her gendered body becomes an assessment through which they

evaluate her. Her body also shows limitations in her illness. In *Experiment*, the women's bodies shape their lives—Susannah's value was attributed due to her attractiveness in earlier years, Harriet is encumbered by her gendered body in her professional aspirations, Ellen's body is spoken about in what reproductive functions it has performed that are viewed in contrast by her husband to her future work, and Isobel's by its physical distortion. It is not their work or intrinsic qualities that matter, but their gender, essentialized and visible, is evaluated by society and their peers/family members/spouses. Rosalind being the only female body on stage stands out against the cast of male characters. We sense her isolation not only from the narrative but also by the sheer uniqueness of her being the only woman on the stage. The body of Isobel becomes the “thing” that drives the play's action in *Experiment*. In 1999, the house residents want to know where this body comes from, but never learn much more about its origins because as a lowly house servant, it was forgettable. Having women on stage matters, and more importantly, having a woman portray a scientist on stage is powerful. It reminds the public of the adversity women still face and that women in such roles should not be considered an aberration. This matters for our culture and our cultural expectations of who a scientist was, is, and may be in the future.

Phenomenologies of Film and Theatre: *Interstellar*

Representations of science go from the microscopic—to the particular experiences of a scientist like Franklin—to the macroscopic, how we may all experience something as vast as the universe. Such stories are told on stage, but they also make appearances in other cultural mediums, like on the screen. The medium arguably most like theatre is film. Both utilize performers, directors, and designers, and both tell stories of all kinds through a performative interpretation. Shepherd-Barr tackles the theatre and film comparison in her science play survey. She writes that while there have been films about science, few rely on

“real” or “hard” science, and argues that many films can be classified more as science fiction. In considering what makes the two art forms different, Shepherd-Barr writes that the audience in dialogue is an essential ingredient in theatre, offering a “multidimensional conversation” which may allow a sort of “Third Culture” to emerge. She also contends that the “less being more” limitations might actually help theatre, including its simplicity, and that it allows fewer viewers, thereby creating more intimacy amongst audience members. By comparison, while she says she is not placing one medium above the other, the “emphasis on the visual, the tendency to excess, the lack of experimental or innovative forms” within films may be some of the reasons why science is more embraced within the theatre than in film. She also does not ignore the “socioeconomic factors” where a theatre audience is more likely higher educated and affluent than one at a film showing, and may therefore be familiar “with the ideas and events depicted.”⁶⁴

I disagree with some of Shepherd-Barr’s conclusions. Many films are addressing science in ways that should not be ignored or dismissed as neither “real” nor “hard,” even if they tackle science fiction-like stories. Since her book’s publication, there are increasingly more films about scientists and science coming out that are not blockbuster-designed. This includes 2014’s *The Theory of Everything* which featured an Oscar winning performance by Eddie Redmayne as Stephen Hawking, and 2014’s *The Imitation Game*, which told the story of Alan Turing’s Nazi code-cracking machine. 2016’s *Hidden Figures* tells the story of African American physicist and mathematician, Katherine Johnson, who helped calculate the math for John Glenn’s orbit, and her two colleagues—Dorothy Vaughan and Mary Jackson—who became instrumental in their work at NASA and pioneers as black females in white, male dominated fields. There are many other movies not based on historical science, but that still offer something relevant to the conversation about how our society and culture thinks of and should perhaps consider the future of science. Movies like *Gattaca*, the recent *Planet of*

the Apes, Her, Ex Machina, and Interstellar exemplify the range of movies that have scientific themes within them, covering an assortment of topics about possibilities of the future of science and technology.

Phenomenologically, theatre, unlike film, has the “shared mortality of an actor and spectator together” in a communal space and time.⁶⁵ Mark Pizzato cites Herbert Blau, who wrote about the mortality of theatre, and comparing film to theatre, described “a crucial distinction in the experience of time, regarding the mortal human body.” Considering the human on stage as a mortal body conjures many of the phenomenological theories I discussed in the previous chapter regarding Heidegger. Pizzato adds that the “movie or television viewer seems to leave his or her body like a ghost, flying through space and time in the various camera angles, tracking shots, quick cuts, and flashbacks.”⁶⁶ In the theatre, we do not get these same feelings of escape given the confines of the seating arrangement, the fact that the production running time is something out of our individual control, and by the apparatus of the stage that is limited by its physical parameters. Garner states that unlike film, when an actor steps on stage “a fundamental shift takes place with phenomenological consequences” because the body makes an appearance. As the audience watches, “the gaze is now oriented in relation to the body that inhabits its boundaries;” and moreover, it is not a one-sided gaze. The audience does “not eliminate the disruptive potential of the performer’s own gaze.” While Garner deliberates what it means to actually be seen as an audience member, “in the absence of a live performer such a gaze is never in any genuine sense reciprocal” in film.⁶⁷ For all the technical abilities, editing assists, and narrative possibilities in film, this lack of reciprocity will always differentiate the medium from theatre. Film will never show the live body before us, with eyes to see us in return. And as I argue, while I think all mediums addressing science offer something significant and worthwhile, it is this ability of theatre to not only humanize scientists, but also to embody them in a shared space and time which

makes it so inimitable and necessary for our culture. Theatre plays with such multiplicities of phenomenological uniqueness: a science play can span time, but the time of the performance is structured; an actor can play multiple characters with the mere suggestion of a costume, but the actor's body is never reducible given its overt corporeality; and while a play can have many settings within it, it is always confined by the performance space in which it is produced and where we as an audience watch. With the actor performing the character in front of us—crying tears, smiling, or just breathing—we cannot differentiate in our minds the performance from the very humanness of what is before us: we observe a live and three-dimensional human in our shared time and space. Film cannot replicate these experiences.

Nevertheless, film can present stunning possibilities of science storytelling through its unrivaled technologies. This is true in Christopher Nolan's *Interstellar*, which encapsulates many of the ideas that several of the science plays I evaluate also address. The 2014 film tells the story of a not so distant future, and Cooper, performed by Matthew McConaughey, a former engineer and pilot, who farms in the Midwest that is blighted by a constant barrage of dust storms. Climate change is threatening the entire planet's survival: there are no armies, implying a smaller world population, and the last crop to be eaten is corn. Cooper's daughter, Murphy, is a bright girl, but causes troubles at school when she denies the textbook lesson that man never landed on the moon. Nolan uses the denial of the moon landing as an analogy about the ways in which current society denies the effects of climate change. Murphy tells her father about a ghost in her bedroom when books start to fall off her bookshelf. When she leaves her window open and dust fills her room after one storm, the dust aligns itself on the floor, providing coordinates due to some inexplicable gravitational pull. Following them, Cooper and Murphy arrive at a hidden research lab for NASA that is pursuing how to save the human race. The two-prong mission consists of a space crew following leads from an earlier mission of astronauts that traveled to several earth-like planets for our next potential

residence. The second part means saving the Earth's current inhabitants by creating a launchable space station that is currently being constructed—but it has yet to be determined how to launch it given its extremely large size and the unfound equation to figure out the gravity problem with making such a station feasible.

Cooper ends up agreeing to pilot the mission to search for the first crewmembers and the potentially habitable planets they are on, and is able to use a wormhole that has been placed by a mysterious “They” as a pathway into these other galaxies.⁶⁸ Along with the physicist Amelia Brand, performed by Anne Hathaway, and two others, he hopes to find which planet to transport the survivors of Earth to, or in a last case scenario, re-colonize the planet with fertilized embryos. Time quickly comes into play in the movie. Cooper knows that Earth is running out of time and that this mission is critical to human survival; this is a theme that reappears in the climate change plays I discuss in Chapter Four. Professor Brand, Amelia's father, even proclaims the destiny of humankind as such: “We're not meant to save the world. We're meant to leave it.” As Cooper says his final goodbye to his daughter, he tells her he is coming back, and she tearfully asks when. He gives her a watch and says, “Time's gonna change for me. It's gonna move more slowly... I love you forever. And I'm coming back.” This offers little solace to his young daughter.

Once in space and through the wormhole, the mission can only investigate a small number of exoplanets where signals have been received due to their limited resources. Time itself is a commodity, a limited resource, Dr. Brand reminds the crew. The choice of which planets to visit is extremely difficult. For example, on the first planet they visit, each hour on the surface is equivalent to seven years passing on Earth—time moves much slower on that planet due to its proximity to a black hole and time dilation (the difference of elapsed time between two events). They will need to move quickly given the time differences. Cooper, Brand, and crewmember Doyle head down to find a water world. Doyle does not survive as

a giant tidal wave crashes the ship in what is a spectacular film visual. Once Brand and Cooper make it back to the central ship orbiting and re-encounter their other crewmate, Romily, they realize this costly mistake has cost them twenty-three years on Earth. Brand tells a perplexed Cooper that the astronaut who sent the signal had likely only been dead for a few minutes before they landed; the time dilation had made the signal appear as if it had been sent years prior. As Cooper watches footage of his children from Earth, he weeps seeing how much he has missed, and that they now appear as adults. Murphy states on her bittersweet film, “Today I’m the age you were when you left.”

Back on Earth, Murphy has surrendered to the abandonment she feels her father has subjected her to. Amelia’s father has taken her under his wing, and she is a bright physicist who is attempting to figure out how to propel the large space center off of Earth. In space, Cooper and Brand, along with crewmate Romily, argue where they should head next. Brand’s romantic interests motivate her to head to the planet where the astronaut she is in love with landed, which leads to a conversation about love as an integral component to the human experience. Cooper instead insists on the planet inhabited by the former mission’s captain. Cooper wins, but it turns out his choice is an inhospitable planet that the mission captain falsified the data on to be rescued from. After a harrowing escape and the ultimate demise of said captain, Brand and Cooper realize their choices are severely limited due to the state of their spacecraft. Cooper will use the gravitational pull of the black hole to catapult Brand to the last remaining exoplanet—the one she originally wanted to travel to. Cooper and the mission robot, TARS, instead “fall” into the black hole. We see a visual representation of a black hole that is nothing short of dazzling and something theatre could never attempt. Cooper slips past the event horizon and into some anomaly of space and time that “They created.” Cooper finds himself in an unreal space where he sees the bookshelves in Murphy’s bedroom. Cooper realizes the beings that brought them here were not some alien

species, but humans, in a different moment in time, from the future. He is able to communicate with Murphy at different points in time in her life, revisit her past, because all space and time equally co-exist. His love for his daughter is connected to this moment and ability. The arrow of time is not rigid. He was the ghost that haunted her, pushing her books off the shelf, and placing the coordinates in the dust when she was a child. He sees that time is but a physical dimension, and that gravity can cross dimensions, including time. Cooper states, “They didn’t bring us here to change the past,” as it is the present that is ongoing that needs desperate help. As cosmologist Dr. Janna Levin reasons about this scene, “There are mathematical proofs, if Einstein’s relativity is the whole story... then there are certain situations in which you can absolutely go back in time.”⁶⁹ “They” were not trying to get Cooper to save Earth; they were using him to parlay to his daughter how to save everyone. And now, watching her in the present in her old bedroom, he uses the watch he gave her, communicating to her the necessary information to calculate the gravitational theory to save those still inhabiting Earth. Miraculously or magically, he survives the black hole. It is years later—only moments for him—and he is now on the space station that Murphy founded. He meets his daughter again, only she is near death in her old age, and he is a mere few years older. They say a last tearful goodbye, and she tells him he should go find Brand, for she made it to the habitable planet they will all one day call home.

The film was received with mixed reviews. Joe Morgenstern for the *Wall Street Journal* wrote, “The last thing I expected was a space adventure burdened by turgid discussions of abstruse physics, a wavering tone, visual effects of variable quality and a time-traveling structure that turns on bloodless abstractions.”⁷⁰ Scott Foundas countered that seldom have mainstream films “successfully translated complex mathematical and scientific ideas to a lay audience,” which Neil Degraesse Tyson also confirmed with his tweets on the movie that described no other film has presented Einstein’s theory of relativity or the

curvature of space before in the same way.⁷¹ David Denby for the *New Yorker* chafed, “The film was stunning but meaningless—a postmodern machine, with many moving parts, dedicated to its own workings and little else,” even equivocating that the movie likely separated the geeks from the civilians.⁷² Robbie Collin for *The Telegraph* has written that the film is Nolan’s best, and “Nolan’s glimmering cosmic ballet” sharply portrays time, clarifying that as the action unfolds in this epic film “all the while, time passes, life vanishes, and the loss gnaws at Cooper like frostbite.”⁷³ The film is long and I admit perhaps not for everyone, but its intelligence and execution of ideas are rare and exciting to see on film. Moreover, while Shepherd-Barr contends that film does not offer a dialogue the same way theatre can, the abundance of articles online about the science in this particular movie proves otherwise. The questions it left audience members with—including the mechanisms of the science involved—and the debates over what is real or not, which many physicists joined online, illustrates that science performed, in any medium, can offer moments for public engagement.

Fueling this interest by scientists are the contributions Astrophysicist Rip Thorne made to the film. His work helped create “the most accurate simulation ever of what a black hole would look like [...] It’s the product of a year of work by 30 people and thousands of computers.”⁷⁴ Thorne had also suggested to Carl Sagan for his book and later movie of the same title, *Contact*, that a “wormhole, a hypothetical tear in the universe connecting two distant points via dimensions beyond the four we experience as space and time” would be the most reasonable way to explain different species on different planets connecting across space and time.⁷⁵ Thus, the wormhole idea is also central to *Interstellar*’s “planet hopping,” even though it is a highly speculative theory. Interviewing the film’s director, Nolan, and discussing the film’s science with cosmologist Dr. Levin, famed astrophysicist Neil deGrasse Tyson hosted an episode of his radio show *StarTalk* (which is also available as a podcast)

about the movie. The focus on the film comes from Tyson's concerted efforts on his show to find connections between science and various facets of popular culture, and usually doing so by explicating scientific ideas and the utilization of humor.⁷⁶ Speaking about the film in particular, he made clear that "One of my big things is to get more artists interested in science, so they can fold the science into their art and take us new places."⁷⁷ Tyson argues that *Interstellar* does this, and even more so, presented scientists as people rather than as the crazy person or the Dr. Frankenstein. He clarifies that normally, "You don't care if they're in love, if they have kids," but in *Interstellar* we see the inner lives of scientists, and that "scientists save the day" due to their bravery and their scientific knowledge. Speaking with Nolan, he asked about the film's intriguing use of time. Nolan spoke that in real life we "don't do beginning, middle, and end" in this perfect chronology, assessing that how we think of life is much more fragmented than the linearity of objective life; he posits, why do films in "linear form" when that is not how we experience life. It is a phenomenological/philosophical question. In comparison to Nolan's other films that are not about science, the director has often depicted narratives that distort chronology and the phenomenology of experiencing the world.⁷⁸ Yet in *Interstellar*, most of the science is real or at least possible, aside from the black hole ending, about which physicist Brian Greene quipped, "Most people would agree that a person who jumps into a black hole is doomed."⁷⁹ What makes *Interstellar* so promising is that it balances this phenomenological experience of time that is relative and fleeting while exploring scientific concepts that real scientists are excited to see presented, evident by Tyson's enthusiasm and his interest in seeing scientists as relatable characters and their work portrayed as significant.⁸⁰ Seldom have ideas like this been presented through a mainstream film. Science plays often do the same.

Multiverses of Timelines and *Constellations*

Like *Interstellar*, Nick Payne's play, *Constellations*, also addresses the topic of love, but does so through a theoretical exploration of the universe that is linked to how we experience life and time. The play consists of only two characters: Marianne, the physicist, and Roland, the beekeeper. Payne in the script's introduction cites John Gray, "Science continues to be a channel for magic—the belief that for the human will [...] nothing is impossible."⁸¹ In the play, the storytelling could read as magical or fantastical, given that it repeats a love story through many incarnations. The couple meets and breaks up several different ways and does so repetitively. Yet, as Payne specifies also at the play's start, each shift that occurs in the scenes is a shift in universe, borrowing the idea of multiverse theory. Here the magic is scientific.

Multiverse theory has many of its own tangents. Bernard Carr describes how "cosmologists have come to realize that there are many contexts in which our universe could be just one of a (possibly infinite) ensemble of 'parallel' universes in which the physical constants vary."⁸² Science writer Sarah Scoles details that with the Big Bang, the universe expanded "faster than the speed of light in a growth spurt called 'inflation.'"⁸³ One theory in the idea of the "interflationary multiverse" is that the expansion continues, "just not in our universe where we could see it. And as it does, it spawns other universes." She writes that while cosmologists study this idea, it can take other forms and versions—including that if the "cosmos is infinite" then what we can see could just be one of many other universes.⁸⁴ Yet, the catch is that by definition a universe is observable and if a multiverse is not, what does that mean and how is it testable? Such questions, once again, depict the convergence of physics into philosophy, Scoles argues. Sean Carroll has also written about the potential multiverse theory. He mentions that understanding inflation at the beginning of the universe makes "a theory of initial conditions much more pressing," particularly in regard to the low entropy at its start, which I mentioned earlier.⁸⁵ Carroll concludes that given the complex

‘problems’ in explaining our early universe, it is difficult to “try to embed our observable universe into a bigger picture.”⁸⁶ To solve some of these problems the theory of the multiverse emerges, which he admits is “deep into speculative territory.”⁸⁷ To this point, Carr explains that if there are many universes, it weakens the idea of a “strong anthropic principle”—that how we know the universe is interrelated to our very existence, which raises other difficulties about how we come to know and understand the universe as it may be severely limited to how we know what we know through our instruments and abilities.⁸⁸

Astrophysicist Martin Rees complicates this further by stating that “he’s confident there is far more to physical reality than the vast domain that we see through our telescopes,” suggesting that maybe even “different physical laws govern the other universes.”⁸⁹ In turn, physicists are left to strategize and contemplate what possibly explains the universe best, and multiverse theories are one potential answer. Of the many multiverse theories, the daughter universe theory arguably most closely resembles the idea in *Constellations*, explained as each time we “reach a crossroad [...] the present universe gives rise to two daughter universes: one in which you go right, and one in which you go left.”⁹⁰ Carroll summarizes that multiverse theory is one possible rationalization for the “the problem of the arrow of time,” and it is “hard to tell whether baby universes and the multiverse will ultimately play a role in understanding the arrow of time.”⁹¹ What multiverse theories ultimately illustrate for the purposes of this dissertation is that our universe and time are interwoven—a similar refrain—and in more ways than just how time might operate. In trying to understand time, it is not only about the question of how time has functioned since the beginning of our universe, but how all of these components are interlaced, including entropy, inflation, a universe model, and the arrow of time.

In Payne’s play, we see this theory come to the life in the many incarnations of love possible between Roland and Marianne, or as Ben Brantley has described it, “It’s boy meets

girl, girl meets boy, boy (or girl) gets and loses and gets girl (or boy) over and over again.”⁹² Payne describes in the play’s directions, “*An indented rule indicates a change in universe*” (8). We first encounter the pair meeting at a party. Marianne tries to spark a conversation with Roland in many versions of this scene. One time Roland is not interested, but at other times he is in a relationship or married. Payne, the performers, and director through their choices demonstrate how the differences of these scenes manifest in the reciprocation, communication, and reactions between these two. Finally, in the last incarnation, the audience watches as Roland and Marianne proceed with their conversation with hints of romantic chemistry. They are both single in this universe; Roland is just out of a relationship and available for Marianne’s conversational advances. In many ways the play suggests a general romantic truth about the importance of timing. Only in this play timing relates to the idea that each of these twists and turns is not a matter of fate, but rather of the potential of an “infinite number of universes.”⁹³

In the scene where Roland and Marianne get to know each other we sense their connection despite the disparity of their professions. Suddenly, there is a jump in time. On page fifteen, Marianne tells Roland that she does not think she can go back to work. Marianne's speech is fragmented, and she has a difficult time stating her thoughts fluidly: "Either I'm walking or I'm...Either I'm... walker...I either do it or I don't. Scares me" (16). This scene portraying Marianne’s fading health is returned to again and again between the scenes we watch of Marianne and Roland meeting, potentially falling for each other (or not), of progressing their relationship (or not), of cheating on one another, and of eventually becoming engaged. In this recurring scene, Marianne struggles with her health, telling Roland she can hardly read or type even though she knows the words. There is an obvious familiarity in their relationship in this returned-to-scene that is not there in the scenes where the relationship blossoms. Watching the production in New York at the Samuel J. Friedman

Theatre in March 2015, once the characters appeared to progress to a moment of understanding with one another as people and within their relationship, Marianne's illness comes to the forefront again—throwing the pair back into confusion about what would be next for them as a couple.

Returning to the present (or is it the past? are the health scenes part of the future?), we advance in time with Marianne and Roland. They are back at her apartment after a first date. Roland asks Marianne if she wants him to leave. In one version, we sense her hesitation, "as soon as we stepped inside, I started thinking—I mean I just started thinking—" (17). In the next, Marianne is curt and Roland is offended by her behavior, "This was your idea [...] It's rude" (18). In the next account we sense the awkwardness as Roland says he has an early start to the day and Marianne makes a poor joke about staying the night, but he still leaves. When I watched the play on Broadway performed by Jake Gyllenhaal and Ruth Wilson, each of these shifts of scenes increasingly drew responses of laughter from the audience. Whereas at first the audience was trying to gather what these "do-overs" meant and why we were watching these scenes restart, the audience was now used to the convention. In watching the scenes, there was a palpable craving to see the ways the romance works *and* does not work; we were entertained in watching what ways the relationship came together and fell apart.

In seeing the many multiverse incarnations of the couple's first night together, the audience watches in one version as Marianne drunkenly tells Roland about quantum mechanics and theoretical physics. Roland, listening to her, tells her how attractive this is to him, and asks if he can stay the night. It is an exchange that is both highly abstract on one level, and on the next, unassuming. The two kiss, and she states, "A by-product of every single one of these theories—almost entirely by accident—is the possibility that we're part of a multiverse [...] one way of explaining this is to draw the conclusion that, at any given moment, several outcomes can co-exist simultaneously" (22-23). Finally, the audience gains

insight into what is happening in the play that has yet gone unexplained in the many “re-dos.” Marianne continues explaining that in a quantum multiverse, “every choice, every decision you’ve ever and never made exists in an unimaginably vast ensemble of parallel universes” (23). She tells Roland that it means that every possible future is determined by all the decisions we make, and that maybe we do not have free will if we are in fact just particles and equations do not prove more than that (24). Payne has done many things through this scene exquisitely: he has explained the scientific theory that underpins his entire play, and he has made the character of Marianne appealing *as* a scientist—not despite it—through the attraction Roland feels as she explains her work and this concept. Moreover, Payne has shown that it is this moment of scientific wonder where Roland and Marianne best connect. It is a moment both explanatory of the science and mutually humanizing of it, which the play succeeded in conveying

As the play evolves, we see scenes between the pair as they quarrel over cheating, with Roland moving out in several versions after Marianne cheats on him, exploring various levels of guilt and discovery. There is yet another version where Roland cheats on her, and one version where they break up and Roland tells her he was going to propose. The play then segues back to Marianne discussing her health problems, and the scene is both fragmented by Marianne’s inability to clearly communicate and the phenomenological disruption of our trying to make sense of why we are thrown back to this temporal space and time. We do not see the scene yet played in full. Instead, the play returns to the couple re-meeting, outside of a ballroom dance class. In the first version, Marianne tells Roland she bought his honey, and Roland tells her he tried to read one of her papers. Only Marianne appears truly interested in the conversation. In the second multiverse, Marianne tells Roland she is getting married and learning ballroom dancing for her wedding; and Marianne asks Roland: “did you know that I was going to be here?” (41). In the third version of this exchange the conversation goes

further, but Roland is engaged. Roland struggles to apologize in one incarnation, and Marianne wants to take him out for a drink in another. Watching the play, I was impressed by the virtuosity of both performers as their varied choices for each scene captured a multitude of intricate feelings of love and remorse, all the while remaining true to the nature of both characters.

We gather from the ensuing scene that some version of this ballroom reencounter worked, because the two get back together, and Roland attempts to propose marriage. The sweetness of the proposal is that in each version Roland prepares essentially the same speech. He will tell Marianne about different kind of bees and their “quiet elegance,” and that “If only we could understand why it is we that we’re here and what it is that we’re meant to spend our lives doing. I am uncertain when it comes to a great many things. But there is now one thing I am definitely certain of” (49). Marianne in the first two versions is dismissive, albeit in different ways. In one version, Roland forgets his speech paper and does not propose. And finally, he does, and she says “okay” (52). Watching the play unfold live, this moment escapes the clichés of romantic stories with the fact the audience knows in many versions that they do not end up together—we have already seen the couple never work out. Yet, we also know, given the play’s structure, that a more heartbreaking path exists where they remain in love and engaged, yet still are torn apart by her illness.

We watch the scenes where Marianne discovers she is ill. Her illness, apparently a brain tumor, is in her frontal lobe, affecting her speech and thinking, and it will make it difficult for her to select words and more apt for seizures—explaining the scenes before where Marianne struggled to put a sentence together. In another version, the tumor is benign and the potential for full recovery is there. In the fourth, we hear that it is called a “glioblastoma multiforme” and a grade four tumor (59). As Marianne researches her illness, she becomes angry reading forums where people discuss death: “‘When your time’s up’ [...]

'Time,' I mean what on earth are they even talking about?" (61). On these forums people upload pictures, one even with a woman "surrounded by these garish fucking balloons" (61). She warns Roland not to give her any balloons. The set, designed by Tom Scutt, and the production, directed by Michael Longhurst, created a set that was open for the actors to fully utilize, aside from a central heightened platform where all the scenes took place. There was no furniture. Above the set were sphere shapes, which I did not realize until this scene were balloon-like with strings hanging down. The shapes changed with the various colors from the lighting design. The lights were blue when the couple first meets, purple when they reencounter, and starker when she speaks of her illness. At times there were flickers in these spherical/balloons that hung low over the stage, almost like her brain's synapses were firing. As Marianne comes closer to choosing a path of euthanasia, balloons began to fall from above, on to the stage, filling the floor space. The balloons became a symbolic reminder that Marianne's death, in any version of her life, was ultimately always there and inescapable, evident as the stage becomes flooded with balloons.

By the play's end we watch the full scene between Roland and Marianne we had only seen glimpses of before; Marianne faces her terminal illness as the tumor has altered her ability to think and speak. Marianne chooses to go abroad and pursue euthanasia. In the third multiverse strand of this scene, Roland asks her, "I am starting to wonder if now is the right time. Because if it were me and I were you I think that I would want as much time as possible" (73). Marianne agrees, and they go home. Yet, in the fourth version, after Roland states this, Marianne asks him the fundamental question: "what do you mean by time?" to which he responds, "Time, I mean time, I'd want more time with you" (74). Marianne the physicist emerges saying, "There's an arrow from p-past to present [...] But that's really all we can say. Asymmetrical" (74). Roland tries to pacify her with saying he should not have brought it up. But she continues:

The b-b-basic laws of physics don't have a past and present, Time is irrelevant at the level of a-atoms and molecules. It's symmetrical.

We have all the time we've always had.

You'll still have all our time

Once I

Once

Once

There's not going to be any more or less of it.

Once I'm gone. (74).

With this conclusion, that so beautifully encapsulates Marianne and Roland's love story, we watch her explain their bittersweet parting through the physical theories of time. Time cannot be negotiated with. Yet, rather than this being the play's end, Payne returns to the scene where Marianne and Roland reencounter after breaking up, meeting outside of a ballroom class. Marianne tells Roland she bought his honey, and Roland tells Marianne he downloaded her paper. They are both taking dance lessons, and they are both single. At the end of their exchange, Roland suggests that they get a drink. "But if we get there, if we're there, if we're there and you, you change your mind [...] then we'll just call it a day. We'll just call it a day and you'll never have to see me again" (76). Unlike all the previous versions of this run-in, this time it is not Marianne who asks to meet later. This time it is Roland, and the scene feels like maybe that alone will make a difference, a fork in the road—or in this case the universe—where their path may be changed. There, somewhere, in some other line of time, maybe they have a different ending.

Watching the play was a powerful experience. Marilyn Stasio for *Variety* wrote of the production, “the devilishly clever scribe is not playing games with either his characters or his audience, because with each iteration Roland and Marianne grow closer to one another — and become more important to us. And by the end of the play (has it really been only an hour?), we’re fully invested in their lives. All of them.”⁹⁴ She also accurately assesses that the play would be a hit in the regional theatre circuit due to its minimal performance requirements, which is true, because the play has been staged across the country in the years following its premiere. In many ways, as grandiose as a film like *Interstellar* is, *Constellations* proves the ability of theatre to present large, scientific ideas through more basic means. Watching the play, it felt like it flew by, and yet I also felt like I fully knew these characters despite not reading the script beforehand. Brantley described how he loved the British production he watched three years prior, but that the Broadway production matched its success. He explained, “*Constellations* assesses the variables of such moments, factoring in the unreliability of memory, and suggests how even a change in tone of voice can alter the course of events,” adding further that, “Time, it turns out, is a more effective breaker of hearts than human beings, with all their conflicted intentions, can ever be. This story of parallel universes is universal in every sense of the word.”⁹⁵

Sitting in the busy auditorium, I waited impatiently for the play to begin. As late play-goers entered, I contemplated why they did not budget their time better. Audience members around me discussed how they read or heard this play was going to be good, but did not know what it was really about. The performances by Gyllenhaal and Wilson were executed with talented precision and warmth; Wilson would later be nominated for a Tony for Best Actress. The direction kept the play lively and engaging, using the minimum set in ways that still made the space feel full of life and vitality. The design, both in lighting and set, added a scientific feel with its balloons/spheres, use of color in lighting, and overall

minimalism. I found myself midway through the play wishing it was all taking longer; knowing the play only had a run time of seventy minutes and sensing it was speeding by. By the end of the play, I could sense a communal moment of realization amongst the audience as we watched Roland and Marianne meet again in the last scene, despite her telling him moments earlier, heartbreakingly, that they did not have any more time together. Somewhere in the universe, or another multiverse, they did. I am not sure if what we felt as an audience was relief or bittersweet sadness about this fact. As the enthusiastic applause died down after curtain call, I heard audience members leaving the theatre praising the play and performers, saying things like, “I’ve never seen a play like that,” or “That was so different.” It is a play that has stuck with me, that has made me rethink my own choices and paths in life. This feeling recurs even as I rewrite its synopsis. What if this is really how time and the universe work, I cannot help but consider each time I think about *Constellations*. This scientific theory, one of which I never knew about before reading the play, has opened my eyes to seeing the world differently, and has made me research more about the science of multiverses. I contend it did the same for others in the audience that night, or for the many other audiences watching it tonight or tomorrow.

Conclusion

Despite the many intricate theories involved, science and time can still be something rendered in the most relatable of ideas: this is a matter of human concern. In this chapter I have provided a glimpse of the ways in which some science plays utilize time, and what doing so illustrates in thinking about science as a part of our culture. This included thinking about how the second law of thermodynamics dictates that time always moves forward, and that we cannot change the past or see the historical past with the details in plain sight as *Arcadia* demonstrates. This has meant that throughout time, science has begged questions

about its purpose and ethics, evident in *An Experiment With An Air Pump*. This also includes interrogations of how science affects us personally, including in regard to gender and the identity of those impacted by science and practicing science, which *Photograph 51* depicts. In performing science, film approaches storytelling quite differently than theatre with its special effects and narrative scope. The epic movie *Interstellar* exhibited this with its depiction of time dilation and Cooper's encounter with the past through a new dimensional space. Finally, with a simplicity of staging and of cast size of *Constellations*, we see a presentation of multiverse theory through a relatable love story, where a physicist scientifically conveys to her lover that there is no more time for them to be together.

Despite the range of the topics and the vast implications of the science broached in each of these representations of science, each one shows us something about who we are. We too get to see that the scientific concepts on stage, in some way, affect human relationships. We get to see science as culture—as it impacts the things we think, the way we feel, how we act, and what we may value—even in ways we may not have always understood before. The plays I have analyzed not only point to questions we have about ethics, concerns about gender, or how time might be interwoven into our societal and personal lives through the realities of how time works in the universe, but they all conclusively address the human experience to which time inevitably belongs. Simply, these plays help us rethink science in a shared cultural time and space.

In my next chapter, I take a closer look at the monumental scientific moment of the twentieth century related to the atomic bomb, which yet again demonstrates the interconnectedness of science, culture, and time that may be scripted for the theatre. While we already know the impact of this historical moment, how we remember the atomic bomb and portray it will continue to affect the human story we tell about it now and in our future.

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1. Jane Gregory and Steven Miller, *Science in Public: Communication, Culture, and Credibility* (Cambridge: Basic Books, 2000) 8.
 2. Gregory and Miller 10.
 3. Gregory and Miller 14.
 4. Nick Payne, *Constellations* (New York: Faber and Faber, 2012) 74.
 5. Daniel Clery, “Physicist who inspired *Interstellar* spills the backstory—and the scene that makes him cringe,” *Science*, 6 November 2014, <<http://news.sciencemag.org/people-events/2014/11/physicist-who-inspired-interstellar-spills-backstory-and-scene-makes-him>> (accessed 29 August 2015).
 6. Shepherd-Barr, *Stage* 12.
 7. Kirsten Shepherd-Barr, *Theatre and Evolution from Ibsen to Beckett* (New York: Columbia UP, 2015) 4.
 8. In my recent participation at the American Society for Theatre Research this was a question in my working group about science and theatre/performance. There was a strong desire to not reduce theatre to being a humanizing counterpart to science. I can certainly understand the hesitation, especially given the power of STEM disciplines on college campuses. However, this has been a point that I have returned to in my writing with shifting degrees of agreement and disagreement. In writing this in 2017, I think humanizing sciences or any discipline is a power of theatre, but not its only. I also think the exchanges between theatre and sciences are two-way streets, where theatre-utilizing science also opens new storytelling terrain—evident in this chapter.
 9. Shepherd-Barr, *Stage* 48.
 10. Shepherd-Barr, *Stage* 132.
 11. Tom Stoppard, *Arcadia* (New York: Faber and Faber, Inc., 1993) 9. All future citations will be parenthetical.
 12. Stephen Abbott, “Turning Theorems into Plays,” *Math Horizons* 7.1 (September 1999): 5. As described by Peter Dizkes, chaos theory was discovered by meteorology professor Edward Lorenz when doing a computer program simulating weather patterns. He discovered that a small change in a variable “drastically transformed the whole pattern produced, over two months of stimulated weather.” This finding challenges determinism, which “might give you short-term predictability, but in the long run, things could be unpredictable. That’s what we associate with the word ‘chaos.’” Chaos theory has since taken off, and is mostly used to explain complex systems that have nonlinearity fundamental to them, such as weather. Peter Dizikes, “When the Butterfly Effect Took Flight,” *MIT Technology Review*, 22 Feb. 2011, <<https://www.technologyreview.com/s/422809/when-the-butterfly-effect-took-flight/>> (accessed 26 Nov. 2016).
 13. Greene 156.
 14. Frank 112.
 15. Carroll 33-34.
 16. Greene 158.
 17. Frank 112.
 18. Carroll 29.
 19. Greene equivocates that the arrow is not “completely rigid; there is no claim that this definition of time’s direction is 100 percent foolproof”—which may be an exciting idea for the many storytellers wanting to do more with time travel. The idea of entropy and time asymmetry opens up many more questions about the Big Bang and the start of the universe, including: “Why was the entropy of our observable universe low at early times?” (Greene 158, Frank 339). I address more of this in discussing *Constellations*.

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20. See Carroll's Chapter "The Past Through Tomorrow" in *From Eternity to Here*, pages 339-365.
 21. Zehelein 279.
 22. Zehelein 281.
 23. Zehelein 282
 24. N. M. Hoffman, "Arcadia (review)," *Theatre Journal* 48.2 (1996): 215-216.
 25. Ben Brantley, "Theater Review: 'Arcadia,' The 180-Year Itch, Metaphysically Speaking," *New York Times*, 17 Mar. 2011, <<http://www.nytimes.com/2011/03/18/theater/reviews/arcadia-by-tom-stoppard-on-broadway-review.html?pagewanted=all>> (accessed 23 Nov. 2016).
 26. Chris Jones, "'Arcadia' brims with intelligence in Writers' bright new house," *Chicago Tribune*, 24 Mar. 2016, <<http://www.chicagotribune.com/entertainment/theater/reviews/ct-arcadia-writers-theatre-review-ent-0325-20160324-column.html>> (accessed 23 Nov. 2016).
 27. Enoch Brater, "Playing for time (and Playing with Time) in Stoppard's *Arcadia*," *Comparative Drama* 39.2 (Summer 2005): 161.
 28. Brater 163.
 29. Shepherd-Barr, *Stage* 140.
 30. Claudia Barnett, "A Moral Dialectic: Shelagh Stephenson's *An Experiment with an Air Pump*," *Modern Drama* 49.2 (Summer 2006): 206.
 31. Zehelein 147.
 32. Paul Duro cites the historic scientific studies of James Ferguson, who wrote that any bird, cat, rat, or mouse placed in such an air pump would convulse and then die. Paul Duro, "'Great and Noble Ideas of the Moral Kind': Wright of Derby and the Scientific Sublime," *Art History* 33.4 (September 2010): 670.
 33. Duro 671.
 34. Duro 671.
 35. Duro 672. See also, Susan L. Siegfried, "Engaging the audience: sexual economies of vision in Joseph Wright," *Representations*, 68 (1999): 34-58.
 36. Shelagh Stephenson, *An Experiment with An Air Pump* (New York: Dramatist Play Service, 1999) 5. Future citations will be parenthetical.
 37. Zehelein 147.
 38. Shapin, *Never Pure* 3.
 39. Shapin, *Never Pure* 13.
 40. As of 2014 in the U.S., the *New York Times* reported about people not wanting to undergo genetic testing because the 2008 Genetic Information Nondiscrimination Act (GINA) does not apply to three types of insurance: "life, disability, and long-term care." For those with inherited diseases falling under these insurance coverage types, many are "fearful that a positive result could be used against them." See Kira Peikoff, "Fearing Punishment for Bad Genes," *New York Times*, 7 Apr. 2014, <http://www.nytimes.com/2014/04/08/science/fearing-punishment-for-bad-genes.html?_r=0> (accessed 18 Sept. 2016).
 41. The first female physician is listed as Elizabeth Garrett Anderson on the Royal Society website. "Female physicians were unheard of in the 19th century Britain and her attempts to study at a number of medical schools was denied," but Anderson persisted and the Society of Apothecaries changed their rules. On the site there are other earlier scientists listed, including paleontologist Mary Anning (1799-1847), Mary Somerville, who experimented on magnetism (1780-1872), and Caroline Herschel (1750-1848), who helped her brother with his astronomical work and discovered comets on her own. See, "Most Influential British Women in Science," *The Royal Society*, 21 Mar. 2010, <<https://royalsociety.org/news/2010/influential-british-women/>> (accessed 9 Oct. 2016).

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42. Barnett 209.
43. Zehelein 161.
44. Irene Backalenick, "Review: Theatre: 'An Experiment With an Air Pump,'" *Back Stage-The Performing Arts Weekly*, 5-11 Nov. 1999, 36.
45. Christopher Isherwood, "An Experiment with an Air Pump," *Variety*, 1 Nov. 1999, 376.
46. Peter Marks, "Theater Review; Cutting Ethical Corners in the Name of Science, Then and Now," *New York Times*, 1 Nov. 1999, <<http://www.nytimes.com/1999/11/01/theater/theater-review-cutting-ethical-corners-in-the-name-of-science-then-and-now.html>> (accessed 20 Nov. 2016).
47. Jeffrey Wainwright, "Theatre: An Experiment With An Airpump, The Royal Exchange, Manchester - What's the big idea?," *The Independent*, 18 Feb. 1999, <<http://www.independent.co.uk/life-style/theatre-an-experiment-with-an-airpump-the-royal-exchange-manchester-whats-the-big-idea-1145615.html>> (accessed 12 Nov. 2016).
48. Sarah Rapoport, "Rosalind Franklin: Unsung Hero of the DNA Revolution," *New York History* 84.3 (Summer 2003): 316.
49. Anna Ziegler, *Photograph 51* (New York: Dramatists Play Service, 2011) 5. Future citations will be parenthetical.
50. Zehelein 146.
51. Anne Sayre, *Rosalind Franklin and DNA* (New York: W.W. Norton & Company, Inc., 1978) 15. As Sayre explains, Watson characterized Franklin as Wilkins's assistant, which was not true and "she never was, nor was she ever meant to be" because she was originally hired by Professor John Randall (20). Watson's description of her is akin to how he describes her in Ziegler's play—overemphasizing her appearance and his judgment of a lack of femininity.
52. Rapoport 322-324
53. There has been the suggestion that Rosalind's work with x-rays made her more susceptible to cancer, but of course, this is hard to verify.
54. Rapoport 317.
55. Eileen Polack, "Why are there Still So Few Women in Science?," *New York Times Magazine*, 3 Oct. 2013, <<http://www.nytimes.com/2013/10/06/magazine/why-are-there-still-so-few-women-in-science.html>> (accessed 4 Nov. 2016). See also Polack's memoir that elaborates on her experiences, *The Only Woman in the Room: Why Science is Still a Boys Club* (Boston: Beacon Press, 2015).
56. At a panel discussion of the play, *New York Times* science reporter, Nicolas Wade, and Franklin scholar and biologist, Lynne Osman Elkin, discussed differing opinions on Franklin's treatment. Watson was scheduled to come, but then did not due to another conference. Wade argued that Crick saw the photograph in an "annual report," and "he came by it partly legitimately." He also says the mythology of Franklin was perpetuated by Anne Sayre (whom I have cited myself). He adds, "[Franklin] spent most of her time focusing on the one form, as we now know. She failed to understand many things about the structure." Elkin countered Wade, "you do not hand unpublished data to a competitor," and the two then argued about whether Rosalind was ill-treated, and if she herself recognized this. Such contentiousness over science plays is not an anomaly. Moreover, I think the real point is even if Franklin was not treated exactly as Ziegler has portrayed, many women in the sciences have struggled for recognition, equality, and support. For more on the interview, see Robin Lloyd, "Rosalind Franklin and DNA: How wronged was she?," *Scientific American*, 3 Nov. 2010, <<https://blogs.scientificamerican.com/observations/rosalind-franklin-and-dna-how-wronged-was-she/>> (accessed 28 Nov. 2016).

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57. Of note, Trueman says that Ziegler refuses “merely to blame a sexist (anti-Semitic) academy that wouldn’t take female scientists seriously [...] Franklin was frosty and uncollaborative.” See Matt Trueman, “West End Review: Nicole Kidman in ‘Photograph 51,’” *Variety*, 15 Sept. 2015, <variety.com/2015/legit/reviews/photograph-51-review-nicole-kidman-1201593374/> (accessed 14 Oct. 2016).
58. Trueman, “Photograph 51.”
59. Ben Brantley, “Review: In ‘Photograph 51,’ Nicole Kidman Is a Steely DNA Scientist,” *New York Times*, 14 Sept. 2015, <<http://www.nytimes.com/2015/09/15/theater/review-in-photograph-51-nicole-kidman-is-a-steely-dna-scientist.html>> (28 Oct. 2016).
60. Brantley, “Photograph 51.”
61. Susannah Clapp, “Photograph 51 review-‘Kidman moves like a laser beam through the action,’” *The Guardian*, 20 Sept. 2015, <<https://www.theguardian.com/stage/2015/sep/20/photograph-51-review-eureka-moment-nicole-kidman-rosalind-franklin-theatre>> (accessed 29 Nov. 2016).
62. Michael Billington, “Photograph 51 review-Nicole Kidman captures the ecstasy of scientific discovery,” *The Guardian*, 14 Sept. 2014, <<https://www.theguardian.com/stage/2015/sep/14/nicole-kidman-photograph-51-noel-coward-theatre-rosalind-franklin-review>> (accessed 29 Nov. 2016).
63. Garner 50 and 51.
64. Shepherd Barr, *Stage* 44-46. Certainly, I tend to think of this as a weakness of theatre rather than a strength; and the suggestion of the affluence and education of theatregoers understanding science in science plays better, while perhaps plausible, is not a statement one wants to make with the same casualness in 2017. If there is something both theatre and science and all disciplines need to do a better job of, it is reaching out to and engaging wider swaths of the public.
65. Mark Pizzato, *Ghosts of Theatre and Cinema in the Brain*, (New York: Palgrave, 2006) 2.
66. Pizzato 6-7. See also Herbert Blau, *Blooded Thought: Occasions of Theatre* (New York: Performing Arts Journal Publications, 1982).
67. Garner 46-48.
68. It should be noted that while wormholes are popularly discussed, particularly in science fiction, “nobody knows whether or not they actually exist. According to Einstein's theory of general relativity, they are possible, but no sign of them has ever been spotted.” See Mike Wall, “The Science of ‘Interstellar’: Black Holes, Wormholes and Space Travel,” *NASA.com*, 10 Nov. 2014, <<http://www.space.com/27701-interstellar-movie-science-black-holes.html>> (accessed 22 Nov. 2016).
69. Neil deGrasse Tyson, Interview with Christopher Nolan and Janna Levin, “The Science of Interstellar with Christopher Nolan,” *StarTalk Radio Show*, podcast audio, 3 May 2015.
70. Joe Morgenstern, “‘Interstellar’ Review: Too Many Faults in Its Stars,” *Wall Street Journal*, 6 Nov. 2014, <<http://www.wsj.com/articles/interstellar-review-too-many-faults-in-its-stars-1415303687>> (accessed 24 Nov. 2016).
71. Scott Foundas, “Film Review: ‘Interstellar’” *Variety*, 27 Oct. 2014, <<http://variety.com/2014/film/reviews/film-review-interstellar-1201338475/>> (accessed 24 Nov. 2016); Nellie Andreeva, “Neil DeGrasse Tyson’s ‘Review’ Of ‘Interstellar,’” *Deadline.com*, 10 Nov. 2014, <<http://deadline.com/2014/11/neil-degrasse-tyson-interstellar-twitter-comments-1201280567/>> (accessed 17 Nov. 2016).
72. David Denby, “Love and Physics: ‘Interstellar’ and ‘The Theory of Everything,’” *The New Yorker*, 10 Nov. 2014, <<http://www.newyorker.com/magazine/2014/11/10/love-physics>> (accessed 24 Nov. 2016).

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73. Robbie Collin, "Interstellar review: Christopher Nolan's best film," *The Telegraph*, 23 June 2015, <<http://www.telegraph.co.uk/film/interstellar/review/>> (accessed 24 Nov. 2016).
74. Adam Rogers, "Wrinkles in Spacetime: The Warped Astrophysics of *Interstellar*," *Wired*, 24 Oct. 2014, <<https://www.wired.com/2014/10/astrophysics-interstellar-black-hole/>> (accessed 18 Nov. 2016).
75. Rogers "Wrinkle." The black hole in the film is supposedly "10 billion light years from Earth," and required the understanding that "time passes slower in higher gravity fields. So on a planet orbiting close to a black hole, a clock ticks much more slowly than on a spaceship orbiting farther away"—hence explaining what happens with time on the water planet (Tate). Karl Tate, "The Science of 'Interstellar' Explained (Infographic)," *Space.com*, 7 Oct. 2014, <<http://www.space.com/27692-science-of-interstellar-infographic.html>> (accessed 18 Nov. 2016).
76. "About Us," *StarTalk Radio Show*, <<https://www.startalkradio.net/about-us/>> (accessed 24 Nov. 2016).
77. Tyson, interview.
78. One can look at Nolan's films as either writer/director or both, like *Memento*, *Insomnia*, *The Prestige*, and *Inception*, to see how often he presents characters who are not certain of reality or the certainty of events as they experience it—which is arguably throwing into question a phenomenological question of how do we know what we know/how do we know what we are actually experiencing or witnessing. While his films are often not doing so through the explicit use of time theory like *Interstellar*, the temporality of experience is still interwoven through these character perceptions.
79. Jeffrey Kluger, "What *Interstellar* Got Right and Wrong About Science," *Time*, 7 Nov. 2014, <<http://time.com/3572988/interstellar-science-fact-check/>> (accessed 23 Nov. 2016).
80. The late 2016 film *Arrival* is another promising entry into this genre, this time featuring a linguistics expert and professor who is utilized by the U.S. government to communicate with an alien species. A physicist, who will play a significant role in her life, accompanies her. The use of time in the film is critical to the plot's meaning and structure, and presents an exciting theoretical idea of how time may function.
81. Nick Payne, "Preface," in *Constellations* (New York: Faber and Faber, Inc., 2012). Future citations will be parenthetical.
82. Bernard Carr, *Multiverse or Universe?* (Cambridge: Cambridge UP, 2007) 3-4.
83. Sarah Scoles, "Can Physicists Ever Prove the Multiverse Is Real?," *Smithsonian.com*, 19 Apr. 2016, <<http://www.smithsonianmag.com/science-nature/can-physicists-ever-prove-multiverse-real-180958813>> (accessed 12 Oct. 2016).
84. Scoles.
85. Carroll 337.
86. Carroll 338.
87. Carroll 338.
88. Nick Bostrom explains this clearer in his book *Anthropic Bias*. He writes, "Our data is filtered not only by limitations in our instrumentation but also by the precondition that somebody be there to 'have' the data yielded by the instruments" (2). Bostrom includes an example: in the idea of looking for intelligent life on other Earth-like planets, which has spurred many a scientific article that look at other solar systems and similar Earth-like distances of planets from their sun. Those who argue that there might be life on such planets base it on the fact that intelligent life started on our planet with our given circumstances, illustrating problems with "observation selection" that is based on a "single data point" – Earth. See Bostrom, *Anthropic Bias: Observation Selection Effects in Science and Philosophy* (New York: Routledge, 2002) 1-4.

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89. Robert Lawrence Kuhn, "Confronting the Multiverse: What 'Infinite Universes' Would Mean," *Space.com*, 23 Dec. 2015, <<http://www.space.com/31465-is-our-universe-just-one-of-many-in-a-multiverse.html>> (accessed 5 Oct. 2016).
90. Clara Moskowitz, "5 Reasons We May Live in a Multiverse," *Space.com*, 7 Dec. 2012, <<http://www.space.com/18811-multiple-universes-5-theories.html>> (accessed 7 Oct. 2016).
91. Carroll 364. Craig Callendar summarizes Carroll's point well, writing, "entropy is highly likely to increase towards the future and the past - the latter contrary to thermodynamics. The mystery, then, is not why entropy increases with time, but why it was lower in the past." Yet, Carroll thinks the odds of a universe beginning in low entropy is minimal, suggesting instead "until he arrives at his destination: an eternal 'mother space-time' from which a multiverse of baby universes are continually bubbling up and pinching off. The mother space-time is a high entropy vacuum that gives birth to universes like our own, some of which we can expect to begin with low entropy." See Callendar, "Can the multiverse explain time's arrow?," *New Scientist*, 21 Jan. 2010, <<https://www.newscientist.com/blogs/culturelab/2010/01/a-leap-too-far-in-this-multiverse-explanation-of-time.html>> (accessed 27 Jan. 2017).
92. Ben Brantley, "Theater Review: Nerds in Love, Rewriting Destinies; 'Constellations,' With Jake Gyllenhaal and Ruth Wilson, Opens on Broadway," *New York Times*, 13 Jan. 2015, <http://www.nytimes.com/2015/01/14/theater/constellations-with-jake-gyllenhaal-and-ruth-wilson-opens-on-broadway.html?_r=0> (accessed 9 Sept. 2016).
93. Moskowitz.
94. Marilyn Stasio, "Broadway Review: 'Constellations' Starring Jake Gyllenhaal, Ruth Wilson," *Variety*, 13 Jan. 2015, <<http://variety.com/2015/legit/reviews/broadway-review-constellations-starring-jake-gyllenhaal-ruth-wilson-1201403797/>> (accessed 10 Oct. 2016).
95. Brantley, "Constellations."

Chapter 3.1: Tensed Time and the Atomic Bomb

“Yet in the image of a mushroom cloud that rose into these skies, we are most starkly reminded of humanity’s core contradiction; how the very spark that marks us as a species—our thoughts, our imagination, our language, our tool-making, our ability to set ourselves apart from nature and bend it to our will—those very things also give us the capacity for unmatched destruction.”

--President Barack Obama, at Hiroshima Peace Memorial on May 27, 2016

Seventy-one years after the bombs dropped on Hiroshima and Nagasaki, Obama’s words illustrate the ways in which atomic science led to both an astonishing scientific breakthrough and devastating consequences. This chapter looks at ways that the atomic bomb has been presented in dramatic form and in exhibitions at two museums dedicated to the Manhattan Project and the history of the atomic bomb. I extrapolate how these representations illustrate the atomic bomb’s complex relationship with time and temporality that exists in our culture. The atomic bomb was one of the defining moments of the twentieth century. We speak of it occurring decades ago, happening before many Americans were born.¹ Yet, despite the many ways that time is manifested within these representations about atomic science and the bomb, the overarching thought that persists is that the bomb is a part of our past, a historical event. In consideration of this statement, a fundamental question emerges in relation to time: what is the past?

Treating the bomb as part of our cultural past is complicated for reasons that will be further explored in the following section. First, however, I briefly analyze why it is a contested notion because of the concept of tensed time. Phenomenologically it makes sense why we look at our nation’s history or even our personal lives and regard the past as being

different from the present, assuming that the future will be different from both. We can observe changes that may delineate these tenses, such as transformations in society or our individual progression of age. The past and future can thus feel distant or unfamiliar from our present experiences. The atomic bomb is not a lived experience in my personal life history—I do not have any memories of fearing a nuclear war. I do not remember learning much of the specifics involving the atomic bomb in history classes, nor do I recall many memories of my grandparents or parents discussing the experience of living through the atomic age. The atomic bomb belongs to a hermetically sealed past with which I have little firsthand experience.

Visiting the Pearl Harbor site in Oahu years ago and seeing the sunken hull of the USS Arizona, a ship visible but corroded by the salt water, did not close the phenomenological/temporal distance I feel toward the events surrounding World War II. In the black and white photographs of the atomic bomb's infamous mushroom cloud over Hiroshima, the temporal disassociation I have with the image relates to the fact that this event evokes an iconic image of another age, perhaps in ways that Americans born today will one day look at images from 9/11. Spencer Weart in writing about the cloud describes its “unforgettable impression” that became a folk symbol for “overwhelming and numinous power.”² Seeing the images today, I do not share these same impressions—viewing them instead with some sort of cognitive disbelief as it is beyond my temporal existence. It may be a part of *our* past but it is not *my* past. This phenomenological perception is tied to the notion of time flowing; the past is comprised of moments that we have flowed and moved past, individually or culturally.

The problem is that the past may not quite work this way. Tense and time are more intricate than our personal experiences and our phenomenological perceptions. The tense of an event changes: its anticipated future becomes a present now that recedes into a past

moment—illustrating that tense is relative. Scientifically, tense is usually described in terms of spacetime and block theories of the universe. As Adrian Bardon writes, “the most plausible model of space-time is the block model, which includes a timelessly existing span of events.”³ Many physicists argue that tense is a construct when viewed from a block universe theory of time, which has raised theoretical questions about whether free will is real, the openness of both past and future, the possibilities of time travel, and the idea that time, like space, does not pass. Physicist Sean Carroll argues that according to block time, if one saw the universe in its totality one could observe how the past, present, and future coexist.⁴ Further, Carroll suggests that if people could perceive time from this perspective, they would not think of themselves and their experience as central to the universe; rather, they would think of the universe as a “distinct entity, as if we were observing it from an external perspective.”⁵ Of course, we do not get to have this experience or perceive the world outside of ourselves.

Instead, as Brian Greene writes, our experiences “teach us, overwhelmingly so, that the past is different from the future” and that time flows. However, countering this experience “is convincing evidence that spacetime [...] is real,” and that a “less than widely appreciated implication of Einstein’s work is that special relativistic reality treats all time equally.”⁶ From this acknowledgment, the past may *not* be different from the future because “the totality of spacetime” points toward its conceivable actuality, and “every moment” in time is consequently “as real as any other.”⁷ Therefore, the past is still “there,” as is this present moment, as well as a future moment we have not yet experienced. In a *Scientific American* special edition dedicated to time, Craig Callendar elaborates about how strange this concept is for us to grasp: “The gap between the scientific understanding of time and our everyday understanding of time has troubled thinkers throughout history.”⁸ He describes that many of the ways that we perceive time may feel natural to our human experience, but our

experiences are not actually “reflected in science.”⁹ Callendar even goes so far to suggest that “the future is no more open than the past” and proposes that we live in a “timeless reality.”¹⁰ This is quite a provocative idea, and invites philosophical questions about what it may truly mean if the future is no more open than the past. Theoretical physicist Hrvoje Nikolić adds to this larger conversation that physics cannot imply that time does *or* does not lapse, but we commonly assess that it does because of how we experience time. When we consider that time may not lapse, we may concede then that “nothing in physical equations that deal with time says that the past is more certain the future.”¹¹

These are some of the recurring ideas in contemporary writing by some key physicists: that our experiences, or how we phenomenologically come to know time, may not have much correlation to how time and tense operate scientifically. These physicists are assessing a spectrum of possibilities regarding the past, present, and future. Such theoretical considerations are not absolute or definite. Yet for the purposes of this dissertation, they illustrate that the certainty with which we as a culture treat tense is not something always verifiable by science. The belief that we have transcended our past and the atomic bombing is fraught with complications, and it might not be a very accurate way to scientifically view the past. If we cannot speak scientifically about tense with certainty, what exactly is it? We know that events in time have already happened and that other events will happen, but when is the past the past or the future the present? Even considering the minutiae of time, every moment that is no longer present is now past.

Looking at articles about the atomic bomb, it is common to refer to the bombing event as part of the past. Headlines and news stories about Obama’s recent Hiroshima visit demonstrate the ways in which this construction of the past is slippery and indefinable. One headline reads, “Obama Makes History, Confronts Past in Hiroshima,” giving the past an appearance that it is something interwoven with space and geography—that it can be

confronted means it has some semblance of an existence where that is possible.¹² *The Atlantic* counters that Obama at Hiroshima will “recognize the painful past, but he won’t revisit it.” Uri Friedman in the article posits that recognizing the past does not mean Obama is apologizing for America dropping the bomb. Instead, Friedman writes, “The logic, it seems, is that Hiroshima’s dark, disputed history is a dead end. So you pivot from the past to the future—and find a way to tell a different story.”¹³ Friedman’s words indicate that the history and past of the bomb is like a memory, something one can recognize but somewhat meaningless without pointing this memory toward future application. Contrastingly, an editorial for the U.S. edition of *The Guardian* titled, “The Guardian view on Obama in Hiroshima: facing a nuclear past, not fixing a post-nuclear future,” concedes that while Obama’s visit was historic and acknowledged the horrors of the bombing at Hiroshima, we will continue to live in age of atomic weapons for many years after Obama leaves office.¹⁴ These acts of recognizing, confronting, and facing the past all give different qualities to what the past is or can be—akin to the ways Vyvyan Evans has discussed our semantic ways of writing and talking about time. Also evident from the newspaper headlines is that the gravity and significance of the bomb and this moment in the past often correlates with what it might mean for the future, evident with such headlines like, “Obama’s Hiroshima visit looks to future amid charges of selective amnesia.”¹⁵ The dramatic representations analyzed in the next section will also demonstrate how the bomb evokes such temporal contemplations.

The atomic bomb can conjure our tense dichotomies, underlining that as much as we as a culture may want to say the bomb is a part of our past, its ramifications nonetheless continue through our present and into our future. Moreover, it highlights the fragility of tense demarcations that both physicists and philosophers have often debated. One philosopher who has written extensively about tense and time is D.H. Mellor. He claims that “time can be real though tense is not.”¹⁶ His work in *Real Time* and *Real Time II* articulates why dates are fixed

but tenses are not given how tenses constantly change, i.e. what is the future will soon be present and then be past.¹⁷ Mellor contends that there are “inescapable objective truths about what is past, present, and future, even though nothing really is past, present, or future in itself,” continuing that “tense is not an aspect of reality” but it is “an inescapable mode of perceiving, thinking and speaking about reality.”¹⁸ For Mellor, things happen earlier or later but this does not explain tense. Tense, for Mellor, is merely a relation between a person and an event, and tense is not a property of the event itself.¹⁹ He argues that relations are not properties of the things that are being related; in this case the person and/or the event. Hence, an event on its own cannot become ‘more past’—i.e., it makes no sense to say the French Revolution is more past than World War II because events do not change. They only appear to because of the way we humans think of and discuss tense, as well as how we relate to events in time. Thinking about the bomb, this makes sense. For my grandparents in 1952, the bomb was not the distant past that it is for me given my relationship to this event versus theirs. Yet, for both my grandparents and myself the bomb occurred in 1945, regardless of whether it seems *more* past now. The event has not changed temporally, but rather the evolving relationship for our culture to the event has as we become more temporally distanced from this event.

Another interesting aspect Mellor explicates is that when we have a painful experience, we say with relief when the moment has passed, “Thank goodness that’s over.”²⁰ It seems from such sentiments that we are glad the “pain is past” and that the pain is gone. Mellor clarifies that “the fact that what makes me glad that my pain is over is not that it *is* over but that I *believe* it is over.”²¹ He illuminates this in his chapter on “The presence of experience,” stating that for us to be aware that our pain is past we “must not only believe that I *was* in pain, I must also be aware that *now* I am not in pain, or at least not in as much pain as I was.”²² Mellor, aware that “all experience takes place in the present,” writes that we

take our present circumstances to look back on events that are no longer currently part of our present experience.²³ Mellor stresses that it does not matter whether it is factual we are no longer in pain (as often we may even forget that we were in pain and are no longer), but instead that it is our *belief* that we once were and our experience presently is that we no longer are.

Considering this idea of how we treat past pain, I cannot help but deduce similarities between the idea and how we treat the past event of the atomic bomb and the cultural fears it perpetuated. The bomb was culturally painful. We presently regard it with this sort of “thank goodness that’s over” attitude. This appears in the continual refrain I read in criticism and reviews that describe the merits of a play about the atomic bomb, but dismiss any present danger of atomic weapons or bombs. I have also experienced this mentality when I mention to people I am writing a chapter about atomic bomb plays. Their questions illustrate how little many of us learned about the bomb and how often we think of it as a historical footnote. We no longer practice nuclear bomb drills because those days of threat seem to be over. Yet, a striking contrast exists in literature written by scientists that still deems the challenges and potential hazards of atomic weapons, nuclear energy, and nuclear waste as a real and present concern.²⁴ We want to believe our present no longer has this pain, but that does not appear to be unequivocally true. So, is our cultural response today of treating the bomb as part of our past a way of dealing with the pain? Is it because we have too many other dire concerns to address presently? Is this catastrophic event too long ago for it to seem like anything other than a past we can say, perhaps, thank goodness, is over?²⁵ Perhaps the bigger question is how Americans address that concern, aside from hoping this is a past that will never repeat itself.

As I have attempted to demonstrate, in relegating an event as part of the past, we often ignore that the past is not scientifically or philosophically something as stable or

definite as we culturally have constructed it or phenomenologically have experienced it. More importantly, by thinking of the bomb as something that existed only in our past, we also ignore many consequences from this scientific moment that continue to influence science and its relationship to our culture.²⁶ Even if we cannot agree in scientific or philosophical terms as to what exactly the past is, the bomb's past is still one that has shaped the landscape of the relationship between science and government, and also thereby the public. This is a relationship our culture should concern itself with. It is hard not to perceive that the general fears or concerns that once appeared in our cultural zeitgeist diminished considerably since the end of an "atomic era." This is evident in the museum exhibit that portrays atomic fears in America ending in 1965, a scholar who looks at plays depicting the atomic age and bomb era ends his survey at 1964, and sociologist Robert Wuthnow in his book *Be Very Afraid* designates the Nuclear-Haunted Era as peaking "during the Cuban missile crisis of 1962, but waned before emerging again on a wide scale in the 1980s."²⁷ Now that the Cold War is over, the age of nuclear threat feels distant despite resurges of threats from Iran and North Korea and the persistent headlines of politicians having control of nuclear codes.

In my next section, I explore through theatre why the age of the atomic bomb and science is a phase we have not yet transcended, nor is it a past we can afford to forget. Playwrights use theatre, with its phenomenological particularities, to return to the time period of the bomb and re-present this past. Given how we treat this particular past, I argue theatre's intervention as a critically important way for this past to become a pressing present consideration. At Hiroshima, President Obama stated, "Science allows us to communicate across the seas and fly above the clouds; to cure disease and understand the cosmos. But those same discoveries can be turned into ever-more efficient killing machines."²⁸ These are strongly suggestive words about science that are hard to argue against at the memorial site at

Hiroshima. Yet, the President further expressed, “Technological progress without an equivalent progress in human institutions can doom us. The scientific revolution that led to the splitting of an atom requires a moral revolution, as well.” These words are a fitting introduction to a group of playwrights whose concerns about the ethical decisions made by scientists and politicians and the consequences of the bomb led them to craft stories for the stage that depicted atomic anxieties. These dramatic representations about atomic science and the bomb engagingly characterize the thorny and pertinent moral quandaries that the development and use of the bomb evoked. After all, it is in theatre where the past never remains inactive for long.

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1. The median age of Americans is 37.8 years. “The World Factbook,” *Central Intelligence Agency*, <<https://www.cia.gov/library/publications/the-world-factbook/fields/2177.html>> (accessed 5 May 2016).
 2. Spencer Weart, *Nuclear Fear: A History of Image* (Cambridge: Harvard UP, 1988) 402-403.
 3. Bardon 128.
 4. Carroll 24.
 5. Carroll 23.
 6. Greene 131-132.
 7. Greene 131-132.
 8. Craig Callendar, “Is Time an Illusion?,” *Scientific American* 21.2 (Spring 2012): 16.
 9. Callendar 15.
 10. Last two statements are from Callendar 16.
 11. Hrvoje Nikolić, “Block Time: Why Many Physicists Still Don’t Accept it?,” 24 Sept. 2008, <<http://fqxi.org/community/forum/topic/259>> (accessed 25 June 2015): 2.
 12. Cindy Saine, “Obama Makes History, Confronts Past in Hiroshima,” *Voices of America*, 27 May 2016, <<http://www.voanews.com/content/obama-hiroshima-visit/3348343.html>> (accessed 11 July 2016).
 13. Uri Friedman, “Hiroshima and the Politics of Apologizing,” *The Atlantic*, 26 May 2016, <<http://www.theatlantic.com/international/archive/2016/05/obama-hiroshima-apology-nuclear/483617/>> (accessed 11 July 2016).
 14. “Editorial: The Guardian view on Obama in Hiroshima: facing a nuclear past, not fixing a post-nuclear future,” *The Guardian*, 26 May 2016, <<https://www.theguardian.com/commentisfree/2016/may/26/the-guardian-view-on-obama-in-hiroshima-facing-a-nuclear-past-not-fixing-a-post-nuclear-future>> (accessed 11 July 2016).

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- 15 Linda Seig and Matt Spetalnick, "Obama's Hiroshima visit looks to future and charges of selective amnesia," *Reuters*, 20 May 2016, <www.reuters.com/article/us-japan-obama-hiroshima-idUSKCN0YB0FB> (accessed 17 Dec. 2016).
16. D.H. Mellor, *Real Time* (Cambridge: Cambridge UP, 1981) 5. Many of Mellor's arguments refer to McTaggart's A-series and B-series ideas of time. A-series is a view that holds the distinctions of past, present, and future and B-series theorists instead deny the objectivity of tense in this way, positing that things are earlier than, later than, or simultaneous with. See Dean W. Zimmerman, "The A-Theory of Time, The B-Theory of Time, and 'Taking Tense Seriously,'" *Dialectica* 59.4 (2005): 401-402.
17. D. H. Mellor, *Real Time II* (New York: Routledge, 1998) 22.
17. Mellor, *Time* 6.
19. D. H. Mellor, "Hugh Mellor on Time," interview by Nigel Warburton, *Philosophy Bites*, podcast audio, 15 Feb. 2008.
20. Mellor, *Time II* 40.
21. Mellor, *Time II* 41.
22. Mellor, *Time II* 42.
23. Mellor, *Time* 6.
24. One such example of this is evident in Lisbeth Grolund's "Obama to Hiroshima: Actions, Not Words," *Union of Concerned Scientists*, 10 May 2016, <http://blog.ucsusa.org/lisbeth-grolund/obama-to-hiroshima-actions-notwords?_ga=1.176033442.124839949.1464318313> (accessed 15 June 2016). Grolund, a physicist, writes that Obama should "Scale back his plans to spend more than \$1 trillion building a new generation of nuclear warheads, missiles, bombers, and submarines and cancel the new nuclear-armed cruise missile, which is destabilizing and unneeded." Grolund's essay illustrates that even though Obama spoke of a world without nuclear weapons, U.S. weapon developments continue to demonstrate otherwise. What will precisely happen in the new presidency is something I touch on in my Conclusion.
25. This is not to say that Americans are entirely unconcerned about nuclear weapons. A 2013 Gallup poll suggests that 83% of Americans deemed nuclear weapon development in Iran and North Korea as critical threats. Jeffrey M. Jones, "In U.S., 83% say North Korean Nukes Are a Threat," *Gallup*, 18 Feb. 2013, <<http://www.gallup.com/poll/160541/say-north-korean-nukes-critical-threat.aspx>> (accessed 14 June 2016).
26. Steven Shapin writes about how the industry of science changed after World War II. Post war, scientists could earn considerably more in government jobs and in industry jobs than they could in academia, Shapin noting how one Manhattan Project scientist could earn four times the salary he was offered before the war. *The Scientific Life* (Chicago: U of Chicago P, 2008) 105-106.
27. Robert Wuthnow, *Be Very Afraid: The Cultural Response to Terror, Pandemics, Environmental Devastation, Nuclear Annihilation, and Other Threats* (Oxford: Oxford UP, 2010) 25.
28. "Remarks by President Obama and Prime Minister Abe of Japan at Hiroshima Peace Memorial," *The White House: Briefing Room*, 27 May 2016, <<https://www.whitehouse.gov/the-press-office/2016/05/27/remarks-president-obama-and-prime-minister-abe-japan-hiroshima-peace>> (accessed 28 June 2016).

Chapter 3.2: The Atomic Bomb: A Past that Persists

Evaluating the nuclear age, physicist Adam Frank writes about the radioactive fallout from the U.S. Castle Bravo hydrogen bomb test at Bikini Atoll in 1954. He says it illustrated that “For many, the end of human time was feeling like a distinct possibility.”¹ Inherent in this fear was the consequential reality of the bomb, which many Americans had not yet faced in the decade after World War II. Whereas many Americans viewed Nagasaki and Hiroshima as “successful,” the test-bombing explosion at Bikini Atoll yielded the equivalent to fifteen megatons of TNT and not the five megatons predicted by Los Alamos scientists.² The explosion and fallout radiation not only quickly affected the crew of a nearby Japanese fishing boat, Marshall Islanders, and invoked fears in Japan about the radioactivity levels in tuna, but one month after the miscalculated bombing, Seattle residents complained about strange “pits in the windshields of their car” resulting from radiation.³ Even though these reports proved to be false, new fears accumulated. The Atomic Energy Commission received reports from concerned Americans about shifting weather patterns, birth defects, and other unusual potential side effects many thought could be attributed to radiation. Spencer Weart, physicist and historian of science, writes that Bikini Atoll sparked a fear of “contamination,” and that “Scientists and nuclear officials made particularly apt targets for suspicions” because “there was a long tradition of accusing science and technology of violating the order of things.”⁴ Bikini Atoll was not the first marker that times had changed in the nuclear era, but it did cement the fact that nuclear science and its consequences were a concern in our western cultural horizon.

Accordingly, this chapter examines how American and British plays spanning the twentieth century represented atomic science and the atomic bomb. I look at Robert Nichols and Maurice Browne’s *Wings Over Europe* (1927), Arch Oboler’s *Night of the Auk* (1956), Lorraine Hansberry’s *What Use Are Flowers?* (1969), Arthur Kopit’s *The End of the World*

(1984), and Michael Frayn's *Copenhagen* (1998). Reappearing in each of the plays examined are temporal apprehensions about atomic science and the bomb, many like the ones I have mentioned above. Moreover, it is apparent in evaluating these plays that representing the atomic science/bomb on stage and the subsequent fears and contemplations it elicited was no easy task. After all, how does one represent a science so vast and monumental through the dramatic form? The sample of plays I have selected depicts and embodies an assortment of characters, including fictional and real scientists, government officials, and civilians. They also present time in unique ways that illustrate that the bomb has always been interwoven with concerns regarding time. As Frank writes, these concerns could be about the end of human time, or the end of an era, proving that life as we knew it will never be the same as it was before the bombs dropped.

In exploring these plays, I investigate how time in each work manifests itself in the structure or setting, and how characters within the play experience time or discuss their apprehensions about time. This includes a seeming recurring inability to reflect the bombing and evolving science in the present (the playwright's day). Instead, playwrights writing about atomic science and the atomic bomb often set their plays in a different tense/time, with the exception of Kopit's work, which is set in "a recognizable and probable present," yet still highlights a future in potential peril.⁵ Nichols and Browne's, Oboler's, and Hansberry's plays are set in the future. The former two are dramatizations of an envisioned potential near future, while the latter is a departure into a post-nuclear apocalypse where civilization is ostensibly absent. Frayn's play, one of the most successful and renowned science plays, is set in a distorted past/present hybrid—much like *Photograph 51*—depicting a conversation exchanged between notable physicists Niels Bohr and Werner Heisenberg. The play is not a period play as the characters both reenact and speak of the past in an undetermined present.

The considerable aspect of time in relation to the atomic bomb that emerges in nearly every play (and every book I have thus far encountered about the bomb) is a cultural ideation that was never shaken off: the bomb could provide the means through which human time ended.⁶ The bomb challenged our perceptions of time as finite for humans, which can be a difficult premise to fully comprehend without anxiety, such as I evaluated in my chapter of phenomenology that considered Heidegger's thoughts on being and death. As a cultural entity, the bomb comprises an intertwined, heightened tension between time and consequences, and thus inhabits a cognitive and perceptual space often beyond our typical phenomenological experiences. This feeling is pervasive in many of the plays in this chapter as "what if" tends to be a repeated question that playwrights cannot help but portray in various ways.

In contrasting these plays and the phenomenological and temporal particularities they potentially demonstrate, in this chapter I also evaluate two museums: the Bradbury Science Museum, part of the Los Alamos National Laboratory in New Mexico, and the National Museum of Nuclear Science and History in Albuquerque. Museums operate differently in a variety of ways from theatre, but the principal difference in this case is how they shape and characterize the narrative of the atomic bomb in relation to time and history. In examining the museums, I consider my experience visiting each, assessing how they present the science about the bomb and its history and providing a general deliberation about the ways that museums perform differently than theatre. When looking at a topic as complex as the atomic bomb, it is worth noting how both museums frame the event, particularly as the Bradbury Science Museum is located where the Manhattan Project was established. Moreover, both museums are affiliated with national organizations and top-tier laboratories that continue to monitor and secure our nuclear weaponry. Significantly, the Sandia National Laboratory in Albuquerque, next door to the National Museum, states on their website that their work on

nuclear weapons and devices is so that they “*always* work when commanded and authorized by the president of the United States, and must *never* detonate otherwise.”⁷ The bomb is clearly not a bygone issue. The museums are presenting a controversial topic, evident by the ways United States government officials and institutions have an invested interest in how the bomb is framed within these public exhibits.

In examining representations of the bomb, I draw on pertinent examples and theories when they illuminate ideas and themes within these plays and or museum exhibits. As I mentioned previously in this dissertation, tense is complicated; and while playwrights from the earlier part of the century depicted what the bomb may mean for our future, playwrights in the later part of the century depicted the bombing and its many consequences as a past we should perhaps reconsider. This counters some of the displays in museums that often frame the bomb as a singular historical event rather than as a watershed moment that altered how science, government, and industry have worked together since. As we have reached a cultural moment when technological and scientific experts ponder where the future of other scientific advancements may be heading, we as a culture might take a serious interest in reexamining a major moment in our recent scientific past that illuminates how these advancements will likely change our culture. With science plays, the consequences of such advancements are performed through embodied characters we can relate to through the phenomenological experiences that theatre enables. I evaluate whether science plays about the atomic bomb were successful by this measure in correlation to the responses of critics; and if they were not, consider why that may be related to our cultural relationship to the bomb and time. Despite the bomb seeming like part of an often-dormant past, it is also part of a past that persists in new nuclear treaties and weapons developments, in the continued calls for the disarmament of all nuclear weapons or in the call for its continued use, and in representational form that can challenge public perception. As these dramatic and museum

representations will demonstrate, the bomb—despite being a part of our past—can still stoke passionate feelings about how this past is remembered in our cultural memory and reenacted on stage.

A Defining Science Play: *Copenhagen*

Responding to the strong reactions his play *Copenhagen* garnered, Michael Frayn describes, “When I wrote the play I thought it unlikely that anyone would want to produce it. Even if I sometimes hoped I might find some small theater somewhere that would take it on, I can’t remember ever thinking that anyone would come to see it, much less have strong views about it.”⁸ Frayn’s concerns are not entirely unfounded, as many plays about the atomic bomb had short runs and were not positively received. The emergence of science plays in the last twenty years can be seen as beginning, in part, with Frayn’s genre-defining play. As Margaret Araneo describes Frayn’s success: “The science in *Copenhagen* is clear and accurate while also being essential to the plot. The play received praise from theatre critics as well as the physics community.”⁹ In *Copenhagen*, the character Werner Heisenberg defends his choice to stay in Germany, working under the Nazi’s atomic science program as one of its principal scientists. Based on the historically-questioned meeting between Heisenberg and Niels Bohr, Frayn’s play often shifts back and forth between their conversation revealed in the present that is full of reflections of the past. The exchange in the play dodges and darts between two men who share a mutual love of physics, who respect each other, but are irreparably divided given their current status and alignments. The play also includes the character Margrethe, Bohr’s wife. The play’s uniqueness lies in its richness and depth of conversation; in some regards nothing truly happens within the play. Instead, the play’s significance stems from deriving what it is that *might* be happening, i.e. is Heisenberg testing Bohr’s knowledge about what the Allies are doing, is he asking Bohr what he should

do under the Nazis, or is he really asking whether atomic weapons are possible? Heisenberg at one moment clarifies, asking Bohr to contemplate the broader question of whether a scientist should *ever* work on such discoveries. He states, “sooner or later governments will have to turn to scientists and ask whether it’s worth committing those resources—whether there’s any hope of producing the weapons in time for them to be used [...] the government is going to come to *me*! They will ask *me* whether to continue or not!”¹⁰

The play reaches a dramatic moment when Heisenberg quizzes Bohr about whether the Allies are making a bomb, to which Bohr replies:

BOHR: But, my dear Heisenberg, there’s nothing I can tell you. I’ve no idea whether there’s an Allied nuclear program.

HEISENBERG: It’s just getting under way even as you and I are talking. It’s just getting under way even as you and I are talking [...] Because the bomb they’re building is to be used on us. On the evening of Hiroshima Oppenheimer said it was his one regret. That they hadn’t produced the bomb in time to use on Germany (43).

In this dialogue two temporal particularities unfold. One, Frayn has made the character Heisenberg talk about the bomb as part of his present—that the bomb is being made by the Allies during the very moments he speaks. Then he shifts within the same passage of dialogue, speaking about the bomb with retrospective knowledge. He peers into his future, which is a part of the audience’s past. He states that it was Oppenheimer directing the Allied project. He identifies comments Oppenheimer made after the bombs had already been used. Two, evident in this moment and many others like it throughout, the play creates a phenomenological dissonance for the audience as what is present for these characters is in constant flux, exacerbating the uncertainty as to what actually happened. Frayn creates his

play to have “three ‘drafts,’ as the characters call them, each with different outcomes, and the audience essentially has to choose which draft it prefers, since no concrete answers are explicitly given.”¹¹ In these drafts, time and tense waver, and the truth becomes indiscernible.

The play is infused with influences from Heisenberg’s Uncertainty Principle, a fundamental principle in quantum mechanics that explains, “the act of measurement always disturbs the object measured.”¹² Alok Jha specifies scientifically: “The uncertainty principle says that we cannot measure the position (x) and the momentum (p) of a particle with absolute precision. The more accurately we know one of these values, the less accurately we know the other.”¹³ Frayn himself writes that what the “uncertainty of thoughts does have in common with the uncertainty of particles” is “a systematic limitation which cannot even in theory be circumvented.”¹⁴ We are always limited in one way or another by our abilities and tools for observation. Frayn artistically transforms this scientific idea into his play’s theme by using uncertainty to illustrate that the more each character tries to recount this conversation with details, the less we in the audience (and characters too) know what truly happened. Part of this uncertainty is also related to how time strictures in the play, like tense, constantly alter. Although the play is set in 1941, and the start of act two reflects on how the two physicists met and conversed in 1924, the present tense often collapses. Are the characters speaking in the same present the audience is living? It is unclear. The definitions of the play’s presentness may be tied to death, as Heisenberg states early, “Now we’re all dead and gone” (4). Fittingly, Kirsten Shepherd-Barr calls the play’s setting an “afterlife.”¹⁵ The characters speak with near omniscience about the bomb and its history. Yet, phenomenologically, these characters in no way appear dead—the stage directions do not suggest that they be made to appear otherworldly, they argue passionately, they think aloud with urgency, and they are fully embodied before us in the audience. This is all a part of the

play's intricate design that has offered much for analysis, proven by the amount of articles written about the play from theatre and nontheatre scholars alike.¹⁶

What I think is significant about the play and often overlooked, however, is how the play's deployment of time demonstrates that the atomic bomb ruptured a sense of time for these scientists. The play conveys their thoughts and feelings of guilt and responsibility that time has not dissipated. The first line of the play is Margrethe's question, "But Why?" (3). Asked repeatedly throughout the play is the debated concern: why has Heisenberg visited Bohr and what happened during their conversation? Zehelein describes *Copenhagen* as framed by these poignant questions; the play is "a replay hunting for answers to lingering questions: what happened and why, and for what purpose?"¹⁷ The never-quite-answered answers to her query—and mine—are correlated to the men's work on the bomb, and cannot be solved no matter whether they look at the questions from an afterlife present or from within the past itself. Time has not healed this wound or made the problem easier to unravel.

Heisenberg's visit was questionable in part because Bohr, a prominent physicist who was also half-Jewish, was living in Denmark under German occupation.¹⁸ Heisenberg, working under the Nazis, at times forgets this irreparable division that Bohr, and more often Margrethe, continually remind him about in the play. Their conversation is not only about theoretical possibilities, but also the high stakes of which side might acquire the bomb first (and deal afterwards with the ramifications). The beauty of Frayn's play is how he uses time to allow us in the audience to hear and experience a multitude of possibilities about why Heisenberg visited, demonstrating both the haziness of memories and the inability for history to ever be exacting and unquestionable. Shepherd-Barr states that the "audience watches the characters in *Copenhagen* enact a process of conscious, effortful recall of a transforming moment."¹⁹ These words evoke Husserlian connotations. Yet, the transformation is not only for the characters. The ambiguity of the play's conclusion and of the character's

responsibility regarding the bomb illustrate that we in the audience too were/are transformed by the decisions made by such scientists/characters. Heisenberg declares, “I simply asked you if as a physicist one had the moral right to work on the practical exploitation of atomic energy,” to which Bohr remembers, “I was horrified [...] Because the implication was obvious” (36). The implication was the possibility that Germany would make the atomic bomb; the question transcends simple scientific implications due to the results of what atomic energy and science provides and threatens.

The atomic bomb interested me three years ago when interning at the Mid-America Arts Alliance in Kansas City. Part of its collections of traveling exhibitions included a collection titled *Alert Today, Alive Tomorrow: Living with the Atomic Bomb, 1945–1965*. Images from the exhibition, which depicted the ways Americans lived with the idea of “atomic threat,” seemed like an alien concept to me.²⁰ Bomb shelters and “duck and cover” protocols are things I have only seen in movies. I had a similar reaction reading “Survival Under Atomic Attack,” available at the National Museum of Nuclear Science and History. The document was an official government pamphlet distributed by the Office of Civil Defense. The pamphlet includes six secrets for surviving an atomic bomb, among which are to “drop flat on ground or floor” and “don’t start rumors.”²¹ Created in 1950, the document reads of a bygone era steeped in incomplete warnings, especially given how soon it was written after Hiroshima, including its described risks of radiation. Looking at exhibits and reading pamphlets such as these make atomic bomb fears appear like relics of a past age. By contrast, what a play like *Copenhagen* does is make the historical event seem significant for our present. We empathize with the characters we are watching; and we can see how this conversation and the thoughts debated about the bomb are not just a past moment for these characters but rather a profoundly deliberated issue regarding their work. *Copenhagen* depicts scientists who are anxious about the implications of their work, including their own

contributions to science. Heisenberg points out that Oppenheimer described Bohr as the “team’s father-confessor” of the Manhattan Project, and that “Fermi says it was [he] who worked out how to trigger the Nagasaki bomb” (47). When Margrethe questions Heisenberg’s pointed comments, Bohr states “I was spared the decision,” and Heisenberg retorts, “Yes and I was not [...] When I went to America in 1949 a lot of physicists wouldn’t shake my hand. Hands that had actually built the bomb wouldn’t touch mine” (47).

Frayn, writing his play in 1998, benefited by having temporal distance from the bomb, as well as utilizing historical research in the construction of his play. His choice in source materials has not gone without criticism, since representing the bomb artistically remains complicated due to its ethical and historical significance.²² In many ways it has taken decades to realize the impact of the bomb in order to clearly see its ethical repercussions, which the play with its use of tense dichotomies highlight: hindsight is enlightening. Through *Copenhagen*, audience members may experience the bomb from the perspective of scientists, as two of the three characters are based on real physicists (which is a departure from the other plays I analyze in this chapter). It has taken time for our cultural conversation to move toward questions of responsibility for the bomb in any way, evidenced by Obama’s historic visit to Hiroshima in May 2015: the first for any United States President. It should be of little surprise, then, that *Copenhagen*, one of the most significant and well-written plays about the atomic bomb, could be written only forty years after the bombs dropped.

The play has been analyzed thoroughly since its original production, in large part due to its popularity and critical reception, and also because of its controversial portrayals of Heisenberg and Bohr. David Higgins in “Theatre and Science” describes how the theme of personal responsibility appears in many science plays, but in *Copenhagen* we see Heisenberg’s desire to have his choices “understood,” thus he “endlessly re-enacts his visit to Bohr.”²³ This is also evident when Heisenberg in the play states, “A million things we might

do or might not do every day. A million decisions that make themselves,” illustrating how he is haunted by the choices he will make or made (Frayn 77). The past persists for Heisenberg; he is the ghost of his own memories. However, these are memories vividly performed for the audience, unlike any book, film, or other cultural representation about the bomb. The way time moves in the play adds to this liveness: with it, the audience gets to mentally try to figure out what is happening and who is right. The pieces do not always perfectly align, as one character does something in the present moment, another may comment on it, as if they are objectively outside of the moment. For example, Bohr states, “Heisenberg wants to say goodbye. He’s leaving.” Margrethe replies, “*He* won’t look at me, either,” and Heisenberg, either not in the same tense/present as Margrethe is, does not acknowledge what she has said. He replies, “Thank you. A delightful evening. Almost like old times” (31). A few moments later, Margrethe wonders about the conversation unfolding: “But what exactly had Heisenberg said? That’s what everyone wants to know, then and forever” (34). These questions of uncertainty swirl around the conversation that progresses. The three argue where this infamous exchange occurred in an attempt to clarify the details of the memory. Later, the conversation reflects how the two men’s prominence intersected, along with their work:

MARGRETHE: And that’s what you were trying to get back to in 1941?

HEISENBERG: To something we did in those three years [...] Something we said, something we thought [...] I keep almost seeing it out of the corner of my eyes as we talk! Something about the way we worked. Something about the way we did all those things...

BOHR: Together.

HEISENBERG: Together. Yes, together.

MARGRETHE: No.

Margrethe corrects them: “Not together. You didn’t do any of those things together [...] Every single one of them you were apart” (61). Shepherd-Barr describes such moments, where time and reality merge and clash as an indication of the “postmodern mode” of the play, which “call[s] into question the reliability of memory and the notion of any absolute truth.”²⁴ It mirrors the machinations of memory and experiences that Husserl so profoundly explored in his phenomenological investigations of how we encounter the world. I discussed in Chapter Two that our minds are not perfect memory machines. The characters in Frayn’s play constantly correct one another, and these assertions heighten as the tense of speech continually changes throughout. Heisenberg says in one line: “I can see the drift of autumn leaves...,” Bohr states, “Yes, because you remember it as October!,” and Margrethe corrects, “And it was September” (35). The fluctuation of time and tense is executed so seamlessly that is easy to miss in the play how sophisticated it is—probably even less so when watching than reading.²⁵ With such framing, the conversation of the play hangs in an uncertain, undefined time, as if the questions have always been meant for us in the audience. These characters cannot answer the questions they ask because they cannot agree on the terms of the memories, and they do not fully trust what the others say. *Copenhagen* illustrates how a playwright can collapse the past, present, and future on stage in the theatrical present. Moreover, such a storytelling device allows this contemporary play to depict a temporal anxiety about scientific responsibility toward the bomb that time itself, memory of or relived, has not resolved. It keeps the play and its topic engagingly alive.

I have not seen the production live, and therefore rely on the experiences of reviewers and critics as they recount their observations at past productions. Peter Young reviewed the 1998 premiere at the Royal National Theatre for *Theatre Journal*, writing that the play is not about ethics regarding the atomic bomb, but the “motivations for human actions and the

uncertainty of individuals knowing why they do what they do.”²⁶ Michael Billington, who reviewed the 1999 production (transferred from the National to the West End) described, “Frayn builds a brilliant play—one that replays, from the vantage-point of eternity, the endless possibilities of this collision of human particles.”²⁷ Ben Brantley articulated how the play circles many themes, including loss of a child, quantum mechanics, and the “fate of the world.”²⁸ He suggested it does so “with a logic that keeps moving in variously widening and converging circles,” resulting in a “invigorating and ingenious play of ideas.” Brantley elaborated that the play “humanizes physics,” and does not make an audience member unfamiliar with the science feel frustrated, but rather full of emotion due to “wondering comprehension.”²⁹ Since its inception, the play has continued to find life on the stage—often in reputable productions occurring in professional theatres. In 2011 a production staged at Black Cat Attic in Culver City was criticized for its plodding pace, but reviewer Amy Lyons still praised the script’s “beauty and erudition.”³⁰ Reviewer Chris Bartlett wrote of a 2013 production at the Emlyn Williams Theatre in England that the play is one of the greatest of the twentieth century, and that while the “lack of a conventional plot will frustrate some,” this is not a story with a “traditional beginning, middle, and end, but rather a treatise on ideas, possibilities, and uncertainty.”³¹

Copenhagen continues to entertain and challenge an audience. Its impact on theatre paved the way for other playwrights to integrate science with the stage. Many critics and reviewers discuss how the play is less about the bomb than it is about the characters’ struggles in establishing their memory and accountability. I counter it should not be dismissed that the topic explored in the play is more than a fictional event or about any ordinary dramatic convention. The choice by reviewers to forgo the central subject of the bomb in their writing says less about the play and more about our cultural relationship to the atomic bomb. The depth of the play is due to the ethical complexity that the bomb elicited for

those scientists who contributed to it through their work. What these reviewers and critics are articulating, instead, is something about the artistry of the play. Frayn has made a complicated subject with scientific import a compelling work of art. *Copenhagen* presents scientific ideas while not hinging the play's success on science alone; his mastery of the dialogue and in crafting his characters elevates the work to territory that makes it not only a great science play but also a great play. It should be no surprise that the play, along with Stoppard's *Arcadia*, has heralded the genre due to this ability. Make no mistake, though, that the reason Frayn can illustrate the intricacies of memory and responsibility the way he does is because of the issue at the core of his play and by the means through which he crafts the play. His utilization of time, which converges past as present and present as a search into memory and history, exemplifies time's often inexplicable nature: how we phenomenologically experience time is always in ways beyond our full mental grasp. That Frayn uses this implementation of time to explore a topic as controversial and significant as scientific responsibility is not coincidental.

In the postscript and post-postscript to his play published by Methuen, Frayn details the historical debates occurring around his play, discusses the Bohr letters, and tries to define "how much of [the play] is fiction and how much of it is history."³² Historians of science and physicists weighing in on the play demonstrate that the content of the play bears significance. Robert Marc Friedman writing of the play states, "regardless of the playwright's intentions and even extreme care in creating his characters, audiences may leave the theatre with a wide range of impressions."³³ Friedman is speaking of the fact that Heisenberg may come off as sympathetic and no less morally dubious a person/character as Bohr. Friedman is not wrong to have this concern as *Copenhagen* invited this line of inquiry into the forums of public debate between historians, scientists, and theatre scholars. However, I deem this a successful

side effect that marks the play's cultural significance as an interrogation of science's impact in our culture.

Representations of the Bomb: The Bradbury Science Museum

Renown astrophysicist and former president of the Royal Society, Martin Rees, writes about the bomb: “The second half of the twentieth century was beset by a menace far worse than any that had previously imperiled our species: the threat of all-out nuclear war.”³⁴ He writes this in his book *Our Final Hour*, spending much of his chapter dedicated to potential nuclear devastation by looking at the *Bulletin of Atomic Scientists* and its Doomsday Clock. The *Bulletin* was created in 1945 by a group of Manhattan Project scientists who were quickly learning the consequences of their work on the world stage, and its infamous “doomsday” clock has a minute hand that is updated every year moving closer or further from midnight. Midnight signifies world peril caused by manmade threats to humans’ or Earth’s existence. In January 2016, the clock was updated to “Still 3 Minutes to Midnight,” in part due to persisting nuclear fears. Editor John Mecklin explains that while the 2016’s Iran Deal and Paris climate talks have helped progress against world dangers of atomic weapons and climate change, “At the same time, North Korea’s nuclear test, vastly expensive nuclear modernization programs in the United States and around the globe, the world’s collective inability to effectively deal with nuclear waste, and the drumbeat of continued climate change remain very serious challenges.”³⁵ The bomb, since its inception, has triggered such provocative temporal concerns that are still measured—depicted by the infamous Doomsday Clock.

The Manhattan Project was founded in Los Alamos after Robert Oppenheimer suggested the location, the site previously only housing a remote boys’ school. The destination offered relative privacy, and it guaranteed those working on the project,

“scientific freedom of speech. The price the new community paid [...] was a guarded barbed-wire fence around the town and a second guarded barbed-wire fence around the laboratory itself.”³⁶ Los Alamos is tucked away geographically in New Mexico, established on the scenic Parajirito Plateau (Image 1). Driving to it feels remote. Having done so in May 2015, I drove through bouts of rain and snow, higher and higher up to the town located 7,320 ft. above sea level. Seeing Los Alamos it is apparent why so many years ago brilliant minds of the twentieth century could work on a project that few knew existed. Today, the town still possesses an isolated quietness for its twelve thousand residents. It hosts the Los Alamos National Laboratory, whose public facility is the Bradbury Science Museum. The Museum’s focus is comprised of: “Approximately 40 interactive exhibits which trace the history of the WWII Manhattan Project, highlight the Laboratory’s current and historic research projects related to defense and technology.”³⁷ As a theatre and performance scholar, I look at this museum in ways similar to how Barbara Kirshenblatt-Gimblett discusses museums in *Destination Culture*. She writes, “Exhibitions are fundamentally theatrical, for they are how museums perform the knowledge they create,” and that “Posited meaning derives not from the original contexts of the fragments but from their juxtaposition in a new context.”³⁸ Listening to curators discuss the arrangement of exhibits while at Mid-America Arts Alliance, I have observed them speak about their work—the arrangement of objects, the narrative told by the arrangement, and the purpose strived for—that reminded me of how theatre directors speak about plays they direct. Susan Bennett in *Theatre & Museums* similarly describes that theatre and museums methodologically “share common ground,” and that both partake in “the task of providing entertaining and educational experiences.”³⁹ Interestingly, Bennett describes how “museums traffic mostly in material designated as representing the past, while theatrical performance takes place resolutely in the present.”⁴⁰ In the case of the atomic bomb, museums are seemingly presenting the history as is/was and

plays are instead presenting what could be/have been. In “What, if Anything, is a Museum,” Eugene Dillenburg recounts the ways it is difficult to specify what exactly a museum is. Establishing some common features, including that most are non-profit, permanent, open to the public, offer a public service, and have collections and exhibits, he writes, “Our primary way of serving the public is through education,” and that “exhibits [...] are *the* defining feature of the museum.”⁴¹ Therefore, in examining the museums about atomic science and the bomb I am closely exploring what the exhibits are, how they are arranged, what story they are trying to tell, and what they may be trying to teach.

The two museums I visited were contrasting in their approach and in the layout of the exhibits, which is why I discuss the Bradbury here and wait to discuss the National Museum later in this chapter in correlation with the themes Kopit’s play emphasizes. It does not escape me that the Bradbury Science Museum is located in Los Alamos, where the bomb is a part of local history, versus the National Museum, which is situated in Albuquerque and does not feel connected to the space in the same way. At the Bradbury, there are many ways time performs in the exhibits. For example, in the first room, which holds a statue of J. Robert Oppenheimer, is the exhibit of “History: The Nuclear Age Begins.” This is the predominant display regarding the Manhattan Project. A timeline appears across the top of the room, from Prelude to 1932-1945. This timeline is abbreviated, and in comparison to the National Museum, omitting some historical information about nuclear projects in other countries. Under this timeline are artifacts from this history, like a copy of Einstein’s infamous letter to Roosevelt about the bomb, or Trinitite, the glassy residue fragments from the Trinity bomb testing. There are also videos that one can watch and privately listen to. The Trinity Test Video, about the testing in July 1945, states: “It was time...ready or not” over dramatic music. Next to this timeline, in an adjacent room one can watch a sixteen-minute film on *The Town That Never Was*—telling the history of Los Alamos during the war. I mention these

videos, because by comparison one of the shortest videos under the timeline is the actual bombing of Hiroshima and Nagasaki, lasting only two minutes and thirty seconds. In context of what story this exhibit performs, this is not entirely surprising. American casualties and the prevention of more lost American lives are clear throughout the display as justification for the bomb. Yet, what is strange is how the timeline is framed around Japan and not Germany, with quotes on videos stating that the Japanese “were relentless in their determination,” and discussing World War II predominantly through the theater of operations in the Pacific and with Japan. In skipping over the fears that Germany created the bomb—something many Manhattan Project scientists had direct fears of as European émigrés and as discussed in *Copenhagen*—the timeline and history is reshaped that the public engages with at the museum. Leo Szilard and other scientists even wrote President Truman after Germany’s defeat in July 1945 not to bomb Japan.⁴² This is hard to deduce from the museum’s exhibit.

Timelines are not objective, and like all history have a constructed narrative based on the positionality of a historian. This is harder for a public to recognize when the history presented appears confidently stated on a formal placard, supported by dates, and evidenced by exhibit pieces within a museum. The phenomenological experience of a museum is particular: 1) I can reread placards and take in the objects at my own pace; 2) I get to examine pieces as if I am student absorbing knowledge through my own investigation; 3) the museum is full of hushed sounds as individuals pass each other by in a curatorially-designed flow that provides the space a certain educational reverence (like a library); 4) what is presented is usually not changed by my presence; 5) the experience may be devoid of specific or guided human interaction unless on a tour or listening to a presentation. These smaller experiences give a feeling of weight and seriousness to the larger experience of a museum that theatre often does not and cannot compare. This feels true walking through the Bradbury

Science Museum, in part due to the gravity of what the displays are about. This is also aided by the construction of a specific historical narrative woven through the museum exhibit that is related to time. Speaking on art history, but related to the notion of chronology and timelines presented in museums, Linda Nochlin, the Lila Acheson Wallace Professor of Modern Art at the Institute of Fine Arts in New York, claims, “‘there is a tendency to use chronology as teleology,’ as proof of a march toward a goal.”⁴³ In the Bradbury, the presented timeline, with its omissions (for space, if not also for the historical narrative), demonstrates that the possibilities of atomic science pointed toward the creation of an atomic bomb by America, which was inevitably used (and needed to be used) against Japan.

Historian Reinhart Koselleck has often written about time and history. Analyzing chronology, he writes, “all chronologies are products of certain cultures and are, in this respect, relative.”⁴⁴ He describes further that “Chronology borrowed from natural time is thus indispensable [...] natural time, with its recurrence and its time limits, is a permanent premise both of history and of its interpretation as an academic discipline.”⁴⁵ Differentiating natural time from historical time, he thus sees historical time as dependent on natural time for meaning-making but that the two do not operate in the same way—as is often the case when comparing subjective versus objective concepts of time. In his foreword to Koselleck’s *The Practice of Conceptual History*, Hayden White claims that this differing temporality of historical time “functions not only as a matrix within which historical events happen but also as a causal force in the determination of social reality in its own right.”⁴⁶ In other words, this means that as we structure timelines and write about history within these specific time structures, we are informing how our culture reacts to and is informed by this history making. Many of Koselleck’s thoughts also echo ideas articulated by phenomenologists regarding time. David Carr assesses Koselleck’s *Futures Past* and notes strong correlations to Heidegger and ideas of “self-projection in which past, present, and future are understood in

terms of each other,” particularly Koselleck’s focus on the future and his conception of temporality.⁴⁷ Carr reasons Koselleck goes beyond Heidegger in speaking beyond the individual to include social temporality, suggesting that Koselleck places the concept of time as the “root of all other concepts,” given how our construction of temporality informs what we think we know of the past and potentially of the future. Relatedly, in *Futures Past*, Koselleck discusses the notion of progress, a word often tied to many concepts in the modern age—science being one marker of its cultural value. He writes, “It became a rule that all previous experience might not count against the possible otherness of the future. The future would be different from the past, and better, to boot.”⁴⁸ With the emergence of the modern age and the way it treats time quicker than before, how we view the future and thus the past have become reconstructed. Peter Burke adding to this idea, summarizes Koselleck’s view: “The examples of the past no longer seemed relevant: the future was coming to seem more open, though also subject to control and planning.”⁴⁹ These amalgamations of envisioning the future, belief in progress, and technological and scientific advancement gave way, Koselleck writes, “to an expectation of progress that could not be calculated in advance,” and that the “future [is] not inferable from experience,” reshaping not only what we think of the future, but also of the past.⁵⁰ Koselleck’s views on history and timelines appear in the museum: first, there is a focus on the future where more is possible and happening at the laboratory. Second, that this future is deemed beneficial, and finally, that the past of the bomb does not hinder this future of progress. There is an intimation that we were the victors due to this atomic progress and will continue to be so. While visiting the museum, I found the Nuclear Age exhibit haunting, only more so by the fact that the rest of the museum discusses current projects underway at the national laboratory, including newer defense technology and nanotechnology, but neglects addressing how looking back informs us to be cautious or at least considerate of what may be ahead—instead only the viewing the developments as

positive steps (Image 2). The chronology of the bomb stops in 1945 in this museum's exhibit, with little else specifically dated about atomic science as compared to the National Museum.

The shaping of the exhibitions at the Bradbury Science Museum positions the past and this historical narrative as unavoidable, emphasizing that while the bomb had clear ethical consequences, they do not warrant much attention. The site-specific location certainly plays a role in this omission, as the museum wants its local residents and visitors to think Los Alamos is a place of national importance. By downplaying the actual dropping of the bomb or the ethical and geopolitical consequences after the bomb (there is no mention of the Cold War and limited discussion of the evolution of nuclear science), the apparent message derived from the museum is that the use of the atomic bomb was a significant American moment that helped end a horrific war. This is not a criticism of the museum or its curator, for they are not immune to outside influences: "at the very least their full compliance with the policies and agenda of the state" is in play, and all museums "come under great pressure or at least the threat of withdrawal of public funding."⁵¹ For example, an Enola Gay display at the Smithsonian in Washington D.C. during the 1990s created a firestorm of controversy over its "balanced" representation that drew criticism for not presenting the bombing in the context of the war. Omitted were the potential lives saved in the Pacific campaign, and it was overly focused on "the dropping of the atomic bomb on Japan [beginning] a dark chapter in human history."⁵² The media, Congress, and veterans groups pushed until the exhibit was modified to reduce the focus on the consequences on Japanese lives, changing numbers of prevented American casualties from 31,000 to 260,000 that the bomb evaded by a potential Japanese invasion.

Significantly, near the end of the Bradbury exhibition the controversy about the bomb is on display on two walls in a corner. The smaller exhibits are hosted from different organizations—including a veterans group labeled the Los Alamos Education Group (pro-

bomb), peace project groups (anti-bomb), and a display asking “Did we Bomb Ourselves,” about the fallout from the Trinity testing and future cases of illness, including cancer, by American residents in the surrounding areas. A visitor book lay open in this space where one could write comments and ask questions. Many of the comments demonstrated the myriad of contrasting sentiments the bomb evokes. Bennett describes this as a “collaborative model” in museums that resemble theatre practices, by allowing a visitor to feel like their presence matters.⁵³ Jennifer Barrett in *Museums and The Public Sphere* evaluates these ideas as trying to make a museum public, and for it to be public it should offer people “the opportunity to participate in democratic processes.”⁵⁴ Her book explores when a museum is public how public discourse may occur and how a museum may serve as the “public intellectual.”⁵⁵ To do so, curatorial practices must be based on “ethos of participation [...] a belief in healthy intellectual debate [...] more likely than traditional authoritative practices.”⁵⁶ The limited intellectual debate presented in this museum is near the end of the exhibit, directly after one has seen full-sized displays of Fat Man and Little Boy. Walking through the museum, it is hard not to feel that this is a history Americans would want to believe in, a past we are not obligated to regret or reconsider. It is as if it was only a matter of time before the inevitable bombing of Japan would have occurred. The Bradbury Science Museum must acquiesce to the expectations of its governing body—the Los Alamos National Laboratory, which is a United States Department of Energy national laboratory—and the other many complicated politics involving the atomic bomb. On the other hand, theatrical responses to the bomb have not had to play by the same rules, invoking different experiences and ideas about atomic science.

Atomic Plays: What Will Happen Next?

The Bradbury Science Museum frames the atomic bomb as a historic American event, driven by the efforts occurring at the Manhattan Project and essential to ending World War II. Contrastingly, theatrical responses to the bomb written before *Copenhagen* are varied in quality and few present the bomb with historicity in mind. Before Los Alamos was even a thought in anyone's head, Robert Nichols and Maurice Browne wrote the 1927 prognosticating atomic play, *Wings Over Europe: A Dramatic Extravaganza on a Pressing Theme*. The play is set in England, where the Prime Minister's nephew—the brilliant scientist Francis Lightfoot, described as an “artist-scientist”—has come to announce to the cabinet that he has figured out man's greatest achievement: “I can control—the energy—in the atom.”⁵⁷ It is the cabinet's responsibility, Lightfoot believes, to “act on it for the public good” (18). The play's protagonist, Arthur Evelyn, is one of the cabinet members. He is described as a philosopher king, possessing “aristocratic embodiment,” a Fellow of the Royal Society, and a metaphysician (21). Charles A. Carpenter in *Dramatists and the Bomb: American and British Playwrights Confront the Nuclear Age* surveys *Wings* and other American and British theatrical responses to atomic science and the bomb, suggesting that among the existent plays, many “often deal tentatively or awkwardly” with the subject matter. Carpenter writes that in the years immediately after the war, “None of the dramatic works of the early period is a neglected masterpiece,” nor were there many plays by American writers addressing the topic, despite major playwrights like Arthur Miller stating at one time they might do so.⁵⁸

It is understandable with its style and length why *Wings Over Europe* is not a commonly-staged work today. But the play is also in many ways ahead of its time, with Carpenter calling the play a mix of “realism, fantasy, satire, and prophecy.”⁵⁹ *Wings* depicts control of the atom as the ultimate world-changing power. Focused on the utopian future potential of this power, Lightfoot proclaims, “Yesterday, man was a slave; today he's free” and later, “At this hour the New World begins” (37 and 45). He contends that such prowess

will shift inequalities in society for a better world. Instead, most of the cabinet members share the belief that the average man might end the world with this knowledge and should not even know about this atomic capacity. The first act concludes with Arthur stating, “it would be better for that poor young man and for the world had he never been born” (47).

Browne and Nichol’s grasp of this world-altering atomic science is inexact at best, explained by one cabinet member as the ability to turn a mahogany table into gold if one so wished. The prospect of gold being replicable or that Lightfoot’s science could lead to an explosion that could leave a “crater as big as Saint Paul’s” is terrifying to the powerful elite (50). The cabinet members devise a plan to arrest Lightfoot if he does not abide by their wishes. The cabinet asks for a week to think over Lightfoot’s proposal, but when Lightfoot returns (the start of Act Two), he is told to destroy his research and tell no one else. One of the few cabinet members to want the research is Stapp, the Secretary of the State for War, who recalls his experiences during World War I against the Germans and knows that with such atomic powers and weapons, “we could be the cock o’ the walk” (69).

After much debate, Lightfoot warns, “Understand this: either by *noon* tomorrow you will be prepared to formulate, under *my* supervision, a constructive programme satisfactory to *me*, or at *one o’clock* tomorrow England ends. Where this island was, will be a whirlpool of disintegrating atoms” (75). A countdown begins—one of many specific time references in the play. Throughout the play it is apparent that Lightfoot’s discovery has started a time clock: as political maneuvers and decisions are made over the course of the play, the audience senses how time is expedited with his threats. Returning the next day, the cabinet capitulates to Lightfoot’s demands, but he now believes that earth should be destroyed nevertheless—the characterization of the scientist here falling under the unfavorable mad scientist trope. Lightfoot tells the men that at noon, “fifteen minutes more,” they will “come to terms with your gods” (82). He will return before the fifteen minutes is up to die with these men, which

reads like a necessary plot setup. A “CLOCK TICK” is heard as he exits, reminding the audience that time for these men and the earth is running out (83).

The cabinet of men is left to ponder their imminent demise over the next twelve pages; time waxes and wanes in Lightfoot’s absence. The men reflect on the nature of mankind and the meaning of their own lives: one wants to finish a book he has been putting off, and another confesses to adultery with another’s wife. Lightfoot returns and, as may be expected, dies. One version has him hit by a truck, ambling into the room, and in another version he returns to the room and is shot by the hawkish Stapp—differentiating the 1928 and 1932 versions that premiered in New York and London, respectively. The cabinet men realize his watch is the wireless triggering device for his unspecified world-ending device. It had to be a watch, as time itself is the conduit of change within the play. Upon Lightfoot’s death, it appears the end of the world and time has been prevented. But alas, a note appears from the League of United Scientists of the World with demands that the cabinet listens to them or else face annihilation. There are six planes circling the premises, each with atomic bombs. Evelyn says to Lightfoot’s corpse: “Five minutes past twelve. The clock cannot be set back” (100).⁶⁰

The temporal concerns of this play are evident. It all comes down to the movement of the minute hand in the last act; the realization that the future is already set in motion, and time will never be like the past again, before this science was unleashed. Carpenter states that scholars have seldom analyzed the play, describing it as “first and only drama” prior to 1945 to portray the atomic age, and that it did so by portraying “latent apocalypses.”⁶¹ Carpenter correctly assesses that the play is a “dramatic harbinger” despite its often “absurd extremes” regarding atomic capabilities, and that Lightfoot is portrayed as an “addict of such extremes.”⁶² I did not find much evidence of its staging history other than running in New York for ninety performances at the Martin Beck Theatre in 1928-1929 and in England for

twenty-one performances at London's Globe Theatre in 1932.⁶³ A letter to *The Spectator's* editor by a patron of the play at the Globe on May 13, 1932, reads, "But there certainly is a public, perhaps not often frequenting the theatre, which would be interested in a play dealing with so live a subject," further suggesting that the play deals with a topic that is significantly important to the "contemporary world."⁶⁴ For the *New York Times*, J. Brooks Atkinson described the play as "so preposterous that it is probably true," and likely more exhilarating in print than it was on stage. Contrasted to *Copenhagen's* more favorable reviews, Atkinson wrote that the playwrights had "chosen a theme difficult to grasp in the theatre [and] have scarcely lightened the playgoer's burden with their setting." He conjectured that likely other more "experienced and alert authors" could do the theme greater justice by achieving the goal Nichols and Browne likely strived for but did not succeed in accomplishing: "to upset the complacency of their audiences."⁶⁵

It is worth considering how much of this criticism would have altered had the play been produced after 1945. The play is at times overwritten, fittingly titled a "dramatic extravaganza," and heavy-handed in its depiction of the scientist. Nevertheless, the play's larger thematic exploration of a scientist with noble ambitions for his research, and encountering a government authority that either wants no part or only deems it worthwhile if the research can guarantee more power, is not as overly fictitious compared to the real events that would later unfold. Moreover, the play's use of time illustrates how atomic science would alter time as civilization knew it by breaking the past from the future, even if at the time audiences and critics could not foresee the play's prescience. Ralph Willingham in *Science Fiction and Theatre* writes that the setting of the play, which is placed in the "seats of world power," gives the audience a feeling that the "future of the world is being decided."⁶⁶ Seventeen years after its premiere, the history of atomic science would soon

mirror such decision-making behind closed doors, and thus create a future where nuclear weapons were ready at a moment's notice if needed.

The presentation of time in these representations can be about what happens in the minutiae of minutes and seconds, symbolizing the bomb itself. When “Little Boy” was dropped on August 6, 1945 it “incinerated Hiroshima in seconds, killing more than a hundred thousand people.”⁶⁷ By 1986 the Soviet Union, United Kingdom, and the United States had so many nuclear weapons targeted at each other, that “Had these full arsenals ever been unleashed, the apocalyptic conclusion of human civilization would have been fast and horrifically efficient.”⁶⁸ A matter of seconds is significant when it comes to nuclear weapons, which *Wings Over Europe* portrayed. Despite its overall length, the central moment of conflict in Arch Oboler’s *Night of the Auk: A Free Prose Play* (1956) also occurs within a matter of seconds. Written a year before the Soviets launched Sputnik, the play portrays a group of five astronauts returning from man’s first successful trip to the moon. The play prognosticates a future of space travel with the direst of predictions: on the verge of mankind’s greatest achievements, humanity destroys itself. The play, like *Wings Over Europe*, involves some plot twists that unnecessarily complicate the narrative—including speculation that men had once lived on the moon but likely blasted each other to pieces, hence the “cindered craters.”⁶⁹ Carpenter describes that the play has “Enough relevance to the nuclear situation in 1956 [...] to work as a parable with an antinuclear point.”⁷⁰

Night of the Auk reads like a lengthy exposition until the crew communicates back to the President about their mission’s success, “conceal[ing] the truth of the moon’s irreparable state.”⁷¹ Instead, they claim with bravado they have landed on “a great new territory” and are “Masters of the Moon” (95-95). Suddenly, the transmission is lost. At the end of Act Two the big theatrical moment occurs as the crew hears over headphones the unmistakable word: “War! He said war!” (133). The third act, which is by far the most dramatically compelling,

begins with the men watching from space as bombs appear on Earth like flashing lights. Dr. Bruner, the Nobel Prize winning atomic scientist on board, reflects, “Some of the architects of fission Built a clock [...] That ticking is a time bomb of extinction” (139). The bomb and a clock are inseparably linked. Bruner becomes consumed with this notion as the crew can only helplessly watch humanity’s demise from space. America’s enemies, never directly stated as the Soviets, heard the boastful transmission about America’s new magnificent feats in space and have responded with an all out nuclear war.

Dr. Bruner continues to consider the ramifications of the bomb that started the current war, remarking that as Americans, “cheered a reddened flag of sudden victory,” in Japan, “on their streets, and in their houses [...] In the dentist office, in the playground, The flame of our treachery to humanity Seared the flesh, the blood, the very genes,” and we instead “turned our heads” (170-171). These words are an unforgiving criticism of the bomb’s use and our American cultural reaction to it. Bruner knows that in the history of mankind, humanity has often faced such bleak endings as apparent in his assessment: “At Waterloo...at Calvary... And Dachau, Ended, ended, A million times in agony man had ended!,” contrasting such demises to the universe’s “Four billion years that Earth moved in its orbit, and Billions more it will be there” (174). The play’s scientist thus grasps that humanity’s timeline is and will be much shorter than that of the universe, and likely for reasons of its own making. The play lacks a well-structured narrative, but these moments of dialogue read powerfully as the men realize that their life and everyone else’s on Earth is likely doomed. *Auk* concludes with two men left—Dr. Bruner and Lt. Mac Hartman—in the rocket ship that hurtles back to earth or what remains of it.

Atkinson critiqued the production that Sidney Lumet directed on December 4, 1956 at the Playhouse in New York. He wrote that Oboler’s play demonstrates his skills as a “rhetorical writer, stirring up scientific jargon,” and that the “tone is appropriately mournful.”

He credited the set designer for fashioning the set like a rocket ship and Christopher Plummer's role as a "psychotic civilian" crew member.⁷² In his analysis, Willingham includes sketches of the set design and critics' praise of it; making it evident it was the standout element of the performance.⁷³ In 1960 the play was aired on television as a "Play of the week," featuring William Shatner. Richard Shepard described that while the performance felt long and the dialogue was full of "numberless random philosophies and observations," that the emerging theme is "humanity will somehow survive anything."⁷⁴ The play was generally not a commercial or critical success. It apparently ran for only eight performances in New York. Interestingly, in the foreword for the printed text, Oboler takes the blame for its failure. He describes how he had been warned of the critics' power over Broadway, that his play had a looser style than the realism of the set-designer and director's approach, concluding that "I had made the playwright's fatal error—I was permitting my play to be presented fundamentally out of key with its writing form and concept."⁷⁵ Whether or not that would have made the difference in the play's reception, time cannot tell.

Time in atomic plays is always a steady undercurrent. Often these plays underline the demarcations of tense: that the past as we knew it is gone, and we are heading toward a potential future that looks drastically different. Carpenter adds that these plays also depict "The dichotomy between hopes and terrors [as] a focal point."⁷⁶ Lorraine Hansberry's *What Use Are Flowers?* ends with an arguably hopeful outcome. The *A Raisin in the Sun* playwright's posthumously produced play deals with what Carpenter describes as "not such specifics of the nuclear situation," but instead a "plea to avoid letting a nuclear confrontation occur."⁷⁷ Originally conceived for television in 1961, Robert Neimoff says the play was Hansberry's response to *Waiting for Godot*, and that "*Godot* was only one of the more striking expressions of the prevailing attitudes of a generation that had come to maturity under the shadow of the Bomb, to which the young black playwright brought a quite different

point of view.”⁷⁸ Neimoff continues, explaining that Hansberry believed that black writers should “devote themselves to *all* aspects of the freedom struggle,” including the possibilities of destruction and war.⁷⁹ This is the only play I analyze that has no scientist in the cast of characters, but its future setting and its noteworthy playwright felt remiss to not include. Never produced professionally until the play premiered at the National Black Arts Festival in 1994, recent productions have been staged at universities and colleges.⁸⁰

The play is set in an apocalyptic future in an unspecified location or year. There an elderly Hermit comes out of hiding to see a group of wild children alone, raising themselves. The Hermit talks to the children, though they cannot understand language. He tells them he left society because he could no “longer stand the dominion of time in the lives of men and the things that they did with it,” and thus threw away his watch, philosophizing that humans “may give time its dimensions and meanings [...] But ultimately I am afraid it has a value of its own.”⁸¹ His words hint at a civilization geared toward the belief in progress but altered by the bomb. Man’s created civilization was not as formidable as once thought. Realizing the children do not understand fire, eat raw meat, and are “unfamiliar with the simplest implement of civilization,” the Hermit curses the universe, “WHAT HAVE YOU DONE!” (338-339). In scene two, set weeks later, the old hermit, a former Professor of English, surmising that his own life is coming to an end takes on the task of teaching the unruly children about beauty, art, music, and how civilization may continue peacefully with them. The play’s title comes from a moment when one child holds up a flower, asking the Hermit “USE?,” to which the Hermit tells the children about their smell, their touch, and poetry written about them (347-348). Yet, when the Hermit sees two children viciously fighting, he questions whether man could ever rebuild again after the post-nuclear holocaust, shouting, “*Destroy yourselves!* You do not deserve to survive! (357). In the play’s last moments, a curious child called Charlie seeks the Hermit to give him some flowers, who then tells the

child that he will soon die. Preparing the child, he cautions Charlie: “It is in the nature of men to take life for granted; only the *absence* of life will seem to you the miracle, the greatest miracle—and by the time you understand that it should be the other way around—well, it will be too late, it won’t matter then” (361). The hermit is out of time—that is, “being” in the phenomenological sense is reaching its end. As the old man dies, imparting his last words of wisdom to Charlie, we see two cycles bound to repeat: that mankind’s greatest weaknesses will continue, including violence, jealousy, and anger, but that mankind also possesses an appreciation of beauty, curiosity, and ingenuity. This is evident when another small child constructs a rudimentary water mill wheel in the background. Hansberry once wrote of the play, “we are left at the end, hopefully, with some appreciation of the fact of the cumulative processes which created modern man and his greatness and how we ought not go around blowing it up.”⁸²

By setting the play in the future tense, Hansberry better critiques her society’s ills. Looking at Carpenter’s survey of plays about the atomic bomb, this is not uncommon as the question “what might be?” haunted Americans and British playwrights and pervaded their works. This work has features common to those in dystopian fiction. Keith M. Booker writes that defamiliarization is an essential ingredient to the dystopian genre.⁸³ He explains defamiliarization: “by focusing their critiques of society on spatially or temporally distant settings, dystopian fictions provide fresh perspectives on problematic social and political practices that might otherwise be taken for granted or considered natural and inevitable.”⁸⁴ Hansberry’s temporally distant future, a future of destruction and time-consuming rebuilding, allows the Hermit character to be a stronger opponent against violence and the bomb. Through presenting the play in the future, Hansberry can critique her present society’s actions by depicting what could happen if humanity does not figure out how to change its course. The play highlights the concern that in the shadow of nuclear war perhaps we are not

masters of time/our time we have believed we are. By setting these plays in the future, like Booker describes, the playgoers can observe their fears and such critiques in a three-dimensional portrayal. The immediacy of the theatre allows a phenomenological experience of envisioning our future that a book or film cannot achieve in the same way. Moreover, by watching these events on stage and viewing “the characters’ experiences with scientific advancements, we experience the risks of such progress through our personal and empathetic connection to the individuals on stage.”⁸⁵ In Hansberry’s play we know very little of what happened and could argue that what the playwright has characterized is unlikely: we have not yet and will likely never face such nuclear doomsday realities; but, there are still notable lessons in the play.

The Hermit states in his last moments “only man could have dreamed of triumph over this reckless universe” (367). It is a provocative sentiment to express, and something that reemerges in plays about climate change. The Hermit’s words reverberate, but the play ends with a hopeful stage picture of the children creating inventions and possibilities for future life. Those in the audience at the play’s end will return to their civilized lives, perhaps with a reflection to not take it all for granted. Hansberry hoped as much. Admittedly, the play reads at times underdeveloped, likely due to Hansberry’s death soon after working on an early draft of the script. Critic Dan Hubert wrote of the 1994 stage production that the play felt incomplete and suffered from performance shortcomings. However, he described that the play demonstrates “the stirrings of Hansberry as an abstract, philosophical dramatist. The Cold War and its threat of nuclear doomsday may be over, but today the terrifying image of violent, parentless children is more common than Hansberry could have imagined.”⁸⁶ Hubert’s words typify common comments about atomic plays: this is a gone past, but the play still has meaning. For Hansberry, that meaning was meant to demonstrate a hope for a future we would never encounter.

It is likely not happenstance that these three plays all struggled to find their credit and due on stage, though not even Carpenter digs deeply into possible explanations. None are masterpieces—Carpenter is right—but each has its redeeming qualities. Other playwrights, Beckett being the most commonly written about, appeared to hint at some of the existential crises that stemmed from life in the Nuclear Age. Carpenter even examines *Endgame* as portraying a “private fallout shelter dilemma.”⁸⁷ Yet, most of the plays deliberately dealing with atomic science, atomic bombs, and the resulting consequences have been less revered. Why? Some of this is directly related to the quality of the scripts, which the criticisms I have cited reference. Or perhaps the playwrights were too temporally close to the events that they struggled in taking an event so momentous and downsizing it for the stage. Maybe the setting of their plays in a future of potentialities did not allow enough temporal distance for the audience or critics to appreciate what the playwrights were trying to do. As I mentioned, when Frayn wrote *Copenhagen* he had many more resources and public information to draw on about atomic science and the bomb than did these earlier playwrights. Maybe there was little interest in seeing such science or its potential consequences on stage, something hinted at in Atkinson’s review of *Wings*, when off stage real ramifications of the bomb had to be dealt with. Sociologist Robert Wuthnow describes in relation to thinking of events like an atomic bomb that, “The uncertainty, the scale of the impending catastrophes, and the inability to comprehend them are surely a source of profound anxiety.”⁸⁸ It may be that audiences were simply not interested in attending the theatre to experience such anxiety. Yet, that too does not feel sufficient to explain why other playwrights who were strong vocal opponents of the bomb did not address the topic in their work. One cannot entirely ignore the influence of McCarthyism in the theatre. If Oppenheimer was not safe from accusations of communist ties after his work on the Manhattan Project, what guarantee was there that a playwright writing a searing, intelligent critique about the bomb would not fare worse?⁸⁹ Or maybe, just like many

American and British citizens, playwrights did not likely think the bomb was something that needed to be addressed.

From 1945 on the fears of nuclear destruction have conjured moments of cultural urgency *and* cultural complacency. Wuthnow details surges of concern that arose during the Cuban Missile Crisis, Bikini Atoll, Three-Mile Island, and with fears spiking in recent international incidents like Fukushima and North Korea's threats that have continued over the last decade. Yet, Wuthnow describes that recurring in these fears and anxieties was also a reaction from many that "were unconcerned or had complicated opinions," and there was a "more common sense [...] that government officials and scientists were making the important decisions."⁹⁰ Most people trusted the experts because "Humans were rational after all."⁹¹ Arthur Kopit's play and my experiences at the National Museum illustrate that while that response by the public is not surprising, it also illuminates that trusting the experts is easier when the public is left largely in the dark.

A History that Continues: Past Persistence

In Kopit's satirical 1984 play *The End of the World*, playwright Michael Trent is hired by the mysterious Philip Stone to write a play about nuclear proliferation. Stone believes "time is precious" and that "the earth is doomed."⁹² The business of theatre interrupts Stone's production as Trent, his agent, and others question how a play about nuclear weapons could ever sell tickets. At one point Trent's agent is in talks with Paramount, but "Paramount will only consider projects about nuclear war if there's an upbeat ending" (20). When Trent asks Stone why he wants to produce a play, Stone replies: "Because the theater, sir, alone among the arts, engages, in equal measure, the emotion and the intellect. And both must be touched here, if we are to survive" (32). With Stone's money in hand, Trent attempts to learn more about the bomb to write a play about a subject he does

not quite understand. *End of the World* is comprised of Trent's wild goose chase of a research hunt, talking to top government officials about why we need more nuclear weapons—with most answers concluding, “not to win wars but to *prevent* them” (47). The character General Wilmer tells Trent that fear is “the great deterrent [...] Don't want to do too much to reduce the fear” (48). Trent is amused by such logic but also horrified when piecing together the consequences of such thinking by those in power. Trent becomes increasingly haunted by his research and conversations. He comes to believe humanity is doomed because it is in the “hands of assholes!” (56). He claims that even his son avoids him because he weeps when he sees him, unable to avoid contemplating nuclear war in the face of innocence. Trent exclaims at one point, “I DON'T WANT TO HAVE TO THINK ABOUT THIS STUFF EVERY DAY!” (42). These pointed words from Kopit's meta-theatrical play within a play highlight an honest response to atomic weapons and nuclear fears. Maybe we avoid thinking about the nuclear weapons not out of ignorance but rather out of avoidance.

Trent realizes that most people who work on nuclear warheads know that the system “simply doesn't work,” but their plans of deterrence and war are like an M.C. Escher painting—only making sense when you see the logic is circular by nature (83). At the play's end Stone tells Trent of watching atomic testing at Christmas Island, which was carried out between 1956-1958. Stone felt a certain inexplicable and curious excitement as he watched the vapor rising, the surface of the water heated by the intense flash thinking, “*This is what it will be like at the end of time...And we all felt...the thrill of that idea*” (85). He explains this as a seductive thrill, similar to an experience one has near a high window with the realization that if one were to jump, it would be death, and he concludes, “If doom comes [...] it will come in *that way*” (86). To be on the threshold of such a possibility there is a thrilling sense of power, analogous to thinking about bombing the world.

The play's ending is elusive. The audience is uncertain whether Trent finishes the play or if anything is resolved. Kopit does not explicitly investigate time in this play like the other playwrights I have mentioned. However, the feeling of humanity running out of time shadows Trent as he realizes at any minute the course of deterrence and logic guiding the officials making decisions could change. And as Stone so vividly explains, these officials could be pushed by the seductive thrill of it all, of having the power to control the world. In Kopit's play, Stone's words juxtapose Wuthnow's claims that humans are rational after all. Trent learns that the irrational way of thinking about atomic weapons has only increased the stockpiles, leaving humanity at the brink of blind faith. Currently, the continued nuclear proliferation illustrates that there is a certain powerful thrill associated with the bomb, and that the events of 1945 set off a chain reaction, which Kopit so humorously and sharply presented.⁹³

Dragan Klaić calls the play an exploration of the “moral and logical reasoning of the large industrial military political establishment.”⁹⁴ While Kopit links “nuclear weapons and madness,” he critiques confidence in policy makers and leaders who are apparently “so sane [...] that they are entrusted with key policy- and decision-making positions” about something as complicated as nuclear weapons.⁹⁵ Kopit does not write explicitly about the future, but instead illustrates that “the future endangered by nuclear weaponry appears as a cognitive problem.”⁹⁶ This is a future teetering due to our past. *End of the World* opened on May 6, 1984 at the Music Box Theatre, New York, closing thirty-three performances later on June 2, 1984. Benedict Nightingale writing about the play production described that though the work was not well received by other critics, it was “shrewd and lively” and displayed “educated anguishings about the Bomb.”⁹⁷ Nightingale echoes sentiments I have expressed throughout the chapter; that while the play is perhaps not similar to popular Broadway fare, it

exemplified that “most of our minds are too firmly fixed in their own ruts to begin to comprehend devastation so total as the scientists promise us.”⁹⁸

The humor and astute criticisms Kopit enfold into his play make the work an insightful commentary, not only about the deadly potential of the bomb, but also the public’s willingness to accept that the decisions about nuclear weapons are left to the leaders we elect and the experts we seldom know of but are supposed to trust. Yet, politicians are not scientists and scientists are not politicians; and the atomic bomb demonstrated what can happen when science becomes highly politicized. Many physicists involved with the Manhattan Project after the war wanted to de-escalate the quickly evolving arms race, but many also continued working on development of thermonuclear weapons.⁹⁹ Science in the twentieth and twenty-first century is complicated due to the complex ethical questions it demands, as John Forge writes in *The Responsible Scientist*. Forge debates whether a scientist could be held responsible for his work when it is the decision of officials and government how to use such research. Forge concludes, “not only is the scientist responsible for what he intends to do, and for what he foresees that he does, but he may also be responsible for actions and outcomes that he does not foresee.”¹⁰⁰ In contrast, Richard Rhodes in his Pulitzer-Prize winning book, *The Making of the Bomb*, states that while science “is sometimes blamed for the nuclear dilemma. Such blame confuses the messenger with the message.” He further claims that the escalation of warheads was not inevitable, but “it resulted from a series of deliberate choices the superpowers made in pursuit of national interests.”¹⁰¹ Kopit’s play exemplifies Rhodes’s point well, whereas Frayn’s play may better explain that even if “science” cannot be blamed, these difficult decisions by scientists enabled the superpowers’ continued nuclear games.

The fear and temporal anxiety included in these dramatic representations “pre-*Copenhagen*” may be exaggerated, with many theatricalized liberties taken. The anxieties

articulated may be just that—figments of our mental apparatuses, manifested through our trauma and guilt. But what the audience observes in these plays is the mixture of a certain hubris by the characters that gives way to humility. The humility, in turn, often stems from a realization that time is not always on our side, whether due to the finiteness of our own temporal lives (as Hansberry's *Hermit* expresses) or in our species possible extinction. Wuthnow writes about our cultural response to terror, devastation, and nuclear bombs, making a significant point. It is not just that Hiroshima and Nagasaki's death toll was so tragic or terrifying compared to other potential threats, but that the tragedy happened by a man-made device in a matter of seconds.

The astonishing and complex series of such man-made devices is on display at the National Museum of Nuclear Science and History. The museum's many displays exhibit a detailed history that includes nuclear projects underway in other countries pre-Hiroshima, as well as a comprehensive description of events transpiring in Los Alamos and elsewhere across the nation. Additionally, the permanent exhibit about the bomb gives appropriate attention to Hiroshima and Nagasaki, while describing in-depth the cultural responses to the bomb, including popular culture intersections seen in comics, television shows, films, and advertising. The most striking experience I had at the museum was observing how quickly the weaponry progressed after World War II. As one leaves exhibits about the Manhattan Project and the bombing of Japan, one can walk up a hallway, through a plastic curtain with the Soviet Union's emblematic Hammer and Sickle. This leads into a room fit with a sensorial replication of a bomb dropping. Once seated on a bench, one could watch video footage of a bright mushroom cloud explosion, hear a loud siren wailing, feel the floor rumbling, while a fan strongly blew air directly on viewers. The siren could be heard in other parts of the museum. Is this meant to scare or amuse the museum patron? I am still not sure given the framing of this exhibit. It felt like a peculiar inclusion that only those who have not

experienced a bombing would dare present. The American ideology surrounding the bomb is clear as one moves toward the back of the museum. Walking into the Cold War exhibition room, I felt I had left a science museum and entered into a military museum. On display were an extensive collection of military devices from the Cold War, displays about Mutually Assured Destruction (a logic numbing theory of deterrence that harkens back to Kopit's play), and a multitude of triggering devices that looked like movie props. Beyond this room, one can walk around Heritage Park – a nine-acre outdoor exhibit replete with planes, rockets, missiles, cannons, and nuclear submarine sails (Image 3). I saw so many of these militarized devices and weapons that after awhile, they appeared benign. I am not convinced that this should be the experience one associates with anything involving the atomic bomb or nuclear weapons.

Of note, this museum is next door to and is affiliated with the Sandia National Laboratory, a contractor for the U.S. Department of Energy and an owned subsidiary of Lockheed Martin Corporation—the world's largest defense contractor, with over 80% of its contracts coming from the U.S. Government, 60% of which come from the Defense Department, and 36 billion in arms sales in 2013.¹⁰² While much of this defense-related weaponry does not have to do with nuclear arms or weapons similar to Fat Boy and Little Man, Sandia claims on its website that it is committed to nuclear deterrence. By comparison, the Los Alamos Laboratory claims that it focuses on violations of nuclear test treaties. The nuclear age is not past for either laboratory. Their adjacent museums demonstrate that the bomb was a game changer. We have not rid our governments of all nuclear weapons, and while there is admirable work occurring at both laboratories that inevitably has helped human life in health and ecology or protected our military with more advanced weaponry, the shadow of the bomb still remains. In the United States we often forget how this past paved the way for the prolonged Cold War arms race, contentious nuclear treaties, and our

exorbitant defense budget. This, of course, says little about our ongoing concerns about the intricate difficulties in transporting and long-term storage of nuclear waste that requires planning that lasts thousands of years; once again demonstrating how when it comes to nuclear science, concerns of time are inescapable. Nor does it account for our aging nuclear power plants, or the Chernobyl and Fukushima catastrophes, which scientists are still studying to see long-term effects in the surrounding environment and animal life.

A shift in time is evident walking through the National Museum. It is a shift that scientists years ago could not foresee, a shift that made the public sometimes fearful and often forgetful that our world had changed, and a shift that forever altered the relationship of science, government, and industry. This is a past that is still actively present, evident in Kopit's metatheatrical exploration of deterrence and the power we have given to our political organizations. Evident in this museum and by Kopit's sharp, dramatic work, nuclear science continues to evolve and requires our attention as it remains vital to the negotiation of power and politics.

Conclusion

We are no longer under the immediate threat of the bomb, wondering what it would be like were we attacked, as Nichols and Browne's *Wings Over Europe* depicted. We no longer participate in an escalating arms race with another superpower, fearing that our lives could be reshaped entirely, as dramatized in Hansberry's *What Use Are Flowers*, Oboler's *Night of the Auk*, and in the interactive exhibits at both museums, which detail what were once matters of protected national secrecy now translated into public display. We instead fall under a strange umbrella of time regarding the atomic science and the bomb. As a culture we do not necessarily question the perpetuation of the bomb, as Michael Trent does in *The End of the World*. We seem to be beyond that historical moment, perhaps taking a false security in

believing we have surpassed the need to question the governance of nuclear weapons. There has been a reemergence in thinking about the use of nuclear weapons with the presidency of Donald Trump, who has also threatened to dissolve the Iran Nuclear deal—which the consequences of, only time will tell. Perhaps we are just uncertain, like the characters of Bohr and Heisenberg in Frayn’s *Copenhagen*. It is clear that the bomb can still intrigue us, evident by the critical and commercial success of Tom Morton-Smith’s *Oppenheimer* that played in 2015 at the Shakespeare Company in London. The play depicts the career and love life of Oppenheimer, and neither “eulogises nor condemns” the physicist.¹⁰³ Maybe now, apparent by the plays *Copenhagen* and *Oppenheimer*, we are less interested by the ramifications of the bomb and are more interested in the men behind it and how it came to be.

Bill Lott, co-editor of the *Journal of Popular Science & Culture*, recently discussed at a conference panel how scientists are often treated as either our potential saviors or our destroyers.¹⁰⁴ Neither characterization is fair, but these myths can persist, evident in political and cultural rhetoric that often too easily describes scientists and science in one way or another. While the plays in the early half of the twentieth century characterized scientists as our possible destroyers who created a time bomb, these were responses playwrights believed appropriate given the fears of the day. The bomb was shrouded in such secrecy that the dramatizations featured here can be viewed as a struggle to warn a public to wake up. As more nuanced characterizations have evolved in the last half of the century and even in the past year, we see that playwrights have begun to understand how scientists and their science collaborated with those in power, often leaving scientists with conflicted feelings about their work. The history revisited in such plays show an atomic past that honors the intelligence of scientists and complexities of science. Yet, the plays and the museums that perform this history still leave a haunting feeling that Oppenheimer describes so aptly in the last moments of Morton-Smith’s play, “I feel like I’ve left a loaded gun in a playground.”¹⁰⁵

We have beaten the clock thus far. But I am reminded of Martin Rees's chapter title for his evaluation of atomic science: "The Doomsday Clock: Have We Been Lucky to Survive This Long?" I suggest we pause in light of the plays that underline the fear and ethical questions we have had about the bomb, and the museums that show the bomb as just a beginning. We pause to reflect on that the effects and consequences of atomic science are not simply a matter of our past: they are and continue to be one of the most formidable demands of our time. For as I wrote previously and have elaborated on in this chapter, to say this event is part of our past does not mean all that much. Even if we never have to confront the atomic bomb in ways that playwrights have depicted, the bomb nevertheless marked a monumental scientific moment that we as a culture struggle to make sense of, heightening our awareness that time may not be under our control. The bomb changed us. It changed our relationship to science, and changed science's relationship with power and culture. While we may have transcended an age of nuclear threats, this is a past from which we may still glean some lessons. For we may not be so lucky when it comes to climate change.

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1. Frank 177.
 2. According to Gallup polls, 85% Americans in 1945 approved of the use of atomic weapons on Japanese cities—but these statistics have continued to change with approval dropping. According to a 2015 Pew Research Study, the share of Americans who believe the use of nuclear weapons was justified is now 56%, with 34% saying it was not. In Japan, only 14% say the bombing was justified, versus 79% who say it was not. See "Majority Supports Use of Atomic Bomb on Japan in WWII," *Gallup*, 5 Apr. 2005, <<http://www.gallup.com/poll/17677/majority-supports-use-atomic-bomb-japan-wwii.aspx>> (accessed 5 Mar. 2016); "Americans, Japanese: Mutual Respect 70 Years After the End of WWII," *Pew Research Center*, 7 Apr. 2015, <<http://www.pewglobal.org/2015/04/07/americans-japanese-mutual-respect-70-years-after-the-end-of-wwii/>> (accessed 5 Mar. 2016).
 3. Spencer Weart, *Nuclear Fear: A History of Images* (Cambridge: Harvard UP, 1988) 186.
 4. Weart 188.
 5. Dragan Klaić, *The Plot of the Future: Utopia and Dystopia in Modern Drama* (Ann Arbor: University of Michigan Press, 1991) 92.

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6. While I focus considerable attention on American culture, British interests and cultural responses to the atomic age were not that dissimilar in some regards. Jonathan Hogg in *British Nuclear Culture* writes that the existential reality after Hiroshima meant “everyone was involved in the atomic age” (2). The British government also conducted nuclear and thermonuclear tests in the 1950s, and like the majority of Americans, few British knew the scale of the testing due to its secrecy. See, Jonathan Hogg, *British Nuclear Culture: Official and Unofficial Narratives in the Long 20th Century* (London: Bloomsbury, 2015).
 7. “Nuclear Weapons,” *Sandia National Laboratories*, <http://www.sandia.gov/missions/nuclear_weapons/index.html> (accessed 15 Mar. 2016).
 8. Michael Frayn, “‘Copenhagen’ Revisited,” *The New York Review of Books*, 28 Mar. 2002, <<http://www.nybooks.com/articles/2002/03/28/copenhagen-revisited/>> (accessed 5 May 2016).
 9. Margaret Araneo, “Theatre Studies and Science,” *PAJ: A Journal of Performance and Art* 29.1 (Jan. 2007): 49.
 10. Michael Frayn, *Copenhagen* (London: Methuen Drama, 1998) 40-41. Future citations of this text will be parenthetical unless necessary.
 11. Shepherd-Barr, *Stage* 91.
 12. Jesse Gordon, “What is the scientific principle stating that the measurement of any object affects that object--that is, that it is impossible to get a perfect measurement? Who came up with this idea, and can it be tested?,” *Scientific American*, 21 Oct. 1999, <<http://www.scientificamerican.com/article/what-is-the-scientific-pr/>> (accessed 27 May 2016).
 13. Alok Jha, “What is Heisenberg’s Uncertainty Principle,” *The Guardian*, 10 Nov. 2013, <<https://www.theguardian.com/science/2013/nov/10/what-is-heisenbergs-uncertainty-principle>> (accessed 12 Dec. 2016).
 14. Michael Frayn, “Postscript,” in *Copenhagen*, ed. Robert Butler (London: Methuen Drama, 1998) 99.
 15. Frayn, *Copenhagen* 4; Shepherd-Barr, *Stage* 91.
 16. See Karen C. Blansfield, “Atom and Eve: The Mating of Science and Humanism,” *South Atlantic Review* 68, no. 4 (Fall 2003): 1-16; Nancy Spillane, “What’s *Copenhagen* got to do with chemistry class? Using a play to teach history and practice of science,” *Journal of Chemical Education* 90.2 (Feb. 2013): 219-223; and Reed Way Dasenbrock, “*Copenhagen*: The Drama of History,” *Contemporary Literature* 45.2 (Summer 2004): 218-238, to get some of the examples of scholars across disciplines engaging with the play as a source of study.
 17. Zehelein 251.
 18. The play won the Drama Desk, Evening Standard, and Tony awards for best play.
 19. Shepherd-Barr, *Stage* 92.
 20. “Alert Today, Alive Tomorrow: Living With the Atomic Bomb, 1945-1965,” *Exhibits USA: Traveling Exhibitions*, <<http://www.eusa.org/exhibit/AlertToday>> (accessed 12 Apr. 2016). This exhibit was part of the Mid-America Arts Alliance in Kansas City, offered to museums, libraries, and galleries as a traveling exhibit. I learned about it during my internship with M-AAA in the summer of 2013.
 21. *Survival Under Atomic Attack*, Booklet, Office of Civil Defense, Oct. 1950: 16-17.
 22. The sources Frayn used have come under some criticism. Frayn’s use of Thomas Powers’s *Heisenberg’s War: The Secret History of the German Bomb* has been criticized for being “sympathetic” toward Heisenberg (Butler, introduction to *Copenhagen*, xxxiv). One of Powers’s claims is that Heisenberg sabotaged the German atomic science program out of some moral compunction, which other historians dispute. David Higgins writes that “Frayn’s willingness to at least consider this possibility [...] have led to criticism, most notably from

Paul Lawrence Rose, author of *Heisenberg and the Nazi Atomic Bomb Project*” (Higgins 229). In 2002 letters were released from the Bohr archive that show Bohr believed “that Heisenberg's reasons for making the trip were far from benign, and certainly did not involve moral qualms over his (ultimately failed) program to build the bomb for Hitler” (Glanz). Frayn has commented on these letters, which he says still does not resolve the historical fact that Heisenberg ultimately never worked on a successful atomic bomb project and Bohr did (Glanz). Rose and Powers continued to write articles about the play and the characterization of Heisenberg, to which Zehelein argues, “Frayn has not aimed for a historical drama [...] Instead, he wished to explore human motivations and characters” (263). For more on this topic, see James Glanz, “Frayn Takes Stock Of Bohr Revelations,” *New York Times*, 9 Feb. 2002, <<http://www.nytimes.com/2002/02/09/theater/frayn-takes-stock-of-bohr-revelations.html>> (accessed 16 Dec. 2016); David Higgins, “Theatre and Science,” *A Concise Companion to Contemporary British and Irish Drama*, ed. Nadien Holdsworth and Mary Luckhurst (Ames, IA: Blackwell Publishing Ltd, 2007) 225-244; Robert Marc Friedman, “Dangers of Dramatizing Science,” *Physics World* (November 2002): 16-17; Paul Lawrence Rose, *Heisenberg and the Nazi Atomic Bomb Project: A Study in German Culture* (Berkeley: University of California Press, 1998); and Thomas Powers, *Heisenberg's War: The Secret History of the German Bomb* (New York: Da Capo Press, 1993).

23. Higgins 240-241.
24. Shepherd-Barr, *Stage* 92.
25. I have watched the television adaptation starring Daniel Craig, Stephen Rea, and Francesca Annis. Performed well, the film gives the play a certain coldness and stiffness I would contend a good live production would likely not share. *Copenhagen*, dir. Howard Davies, Perf. Daniel Craig, Stephen Rea, and Francesca Annis, PBS, Sept. 2002.
26. Peter B. Young, “Review: *Copenhagen* by Michael Frayn,” *Theatre Journal* 51.2 (May 1999): 218.
27. Michael Billington, “Copenhagen,” *The Guardian*, 10 Feb. 1999, <<http://www.theguardian.com/stage/1999/feb/10/theatre.artsfeatures>> (accessed 3 Apr. 2016).
28. Ben Brantley, “Theater Review: A Fiery Power in the Behavior of Particles and Humans,” *New York Times*, 12 Apr. 2000, <<http://www.nytimes.com/2000/04/12/theater/theater-review-a-fiery-power-in-the-behavior-of-particles-and-humans.html>> (accessed 15 Jan. 2017).
29. Brantley.
30. Amy Lyons, “Reviews: Theater Reviews: LA: COPENHAGEN,” *Back Stage—National Edition* 52.13 (31 Mar. 2011-6 Apr. 2011): 41.
31. Chris Bartlett, “Reviews: Copenhagen,” *The Stage*, 14 Nov. 2013, pg. 17.
32. Frayn, “Postscript,” 95.
33. Friedman 17.
34. Martin Rees, *Our Final Hour: A Scientist's Warning* (New York: Basic Books, 2003) 26.
35. John Mecklin, editor, “It is still 3 minutes to midnight,” *Bulletin of the Atomic Scientists*, 22 Jan. 2016, <<http://thebulletin.org/it-still-three-minutes-midnight9107>> (accessed 3 Mar. 2016).
36. Richard Rhodes, *The Making of the Atomic Bomb* (New York: Simon & Schuster, 1986) 454-455.
37. “About the Museum,” <<http://www.lanl.gov/museum/visit/about-museum.php>> (accessed 10 May 2016). While I do not discuss it in this chapter, I also took the “Historic Walking Tour” of Los Alamos, which included an interesting stop at the Los Alamos Historical Museum. In the museum there were many mementos from the residents during the Manhattan Project, including several letters from residents stating that they were not certain what work

was happening and that their “mail was censored.” One letter even detailed the impeccable thrill of knowing something great was happening in this quickly made community, hearing the names of great physicists coming over the PA system he had read about, like Fermi and Bohr.

38. Barbara Kirshenblatt-Gimblett, *Destination Culture: Tourism, Museums, and Heritage* (Oakland: U California Press, 1998) 3.

39. Susan Bennett, *Theatre and Museums* (New York: Palgrave Macmillan, 2013) 3.

40. Bennett 5.

41. Eugene Dillenburg, “What, if Anything, is a Museum?” *Exhibitionist* (Spring 2011): 10-11.

42. “A Petition from Leo Szilard and Other Scientists to President Harry S. Truman,” *U.S. National Archives*, <<http://research.archives.gov/description/6250638>> (accessed 4 Feb. 2016). It is evident in this petition that some of the scientists felt justified in using the bomb against Germany but not Japan.

43. Sarah Boxer, “Snubbing Chronology As a Guiding Force in Art,” *New York Times*, 2 Sept. 2000, <<http://www.nytimes.com/2000/09/02/arts/snubbing-chronology-as-a-guiding-force-in-art.html?pagewanted=all>> (accessed 14 Apr. 2016).

44. Reinhart Koselleck, “Time and History,” *The Practice of Conceptual History: Timing History, Spacing Concepts*, trans. Kerstin Behnke (Stanford: Stanford UP, 2002) 106.

45. Koselleck, *Conceptual* 107-109.

46. Hayden White, Foreword, *The Practice of Conceptual History: Timing History, Spacing Concepts* by Reinhart Koselleck (Stanford: Stanford UP, 2002) xii.

47. David Carr, “Reviewed Work: *Futures Past: On the Semantic of Historical Time*,” *History and Theory* 26.2 (May 1987): 198.

48. Reinhart Koselleck, *Futures Past: On the Semantics Of Historical Time*, trans. Keith Tribe (New York: U of Columbia P, 2004) 280.

49. Peter Burke, “Book Reviews: *Futures Past*,” *History of European Ideas* 8.6 (1987): 744.

50. Koselleck, *Futures* 282.

51. Patrick J. Boylan, “Museums: Targets or Instruments of Cultural Policies?,” *Museum International* 58.4 (2006): 11.

52. Neil A. Lewis, “Smithsonian Substantially Alters Enola Gay Exhibit After Criticism,” *New York Times*, 1 Oct. 1994 <<http://www.nytimes.com/1994/10/01/us/smithsonian-substantially-alters-enola-gay-exhibit-after-criticism.html>> (accessed 13 Apr. 2016). See also, Thomas F. Gieryn, “Balancing Acts: Science, *Enola Gay* and History Wars at the Smithsonian,” in *The Politics of Display: Museums, Science, Culture*, ed. Sharon Macdonald (New York: Routledge, 1998). Gieryn writes, “A balanced exhibition invites visitors to participate in scholarly and political debates over the bomb [...] Questions are posed; answers always hedged” (202). By removing that element from the exhibition, it watered down the invitation for debate about the bomb—in ways I think the plays can give due to the lack of authority or history they are expected to follow.

53. Bennett elaborates that a more “vivified concept of education has produced a synergic turn to theatricality,” and that to attract more admissions, museums have “increasingly sought out ways to incorporate visitors in active roles in the creation and experience of the exhibition” (22). Certainly by allowing community organizations to post small exhibits and this entry book allow this sort of engagement, but there is something to be said that the museum distances itself from this interactive component.

54. Jennifer Barrett, *Museums and the Public Sphere* (Malden, MA: Blackwell Pub., 2011) 9.

55. Barrett 162.

56. Barrett 162.

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57. Robert Nichols and Maurice Browne, *Wings Over Europe* (New York: Samuel French, 1927) 12 and 36. All future citations will be parenthetical.
58. Charles A. Carpenter, *Dramatists and the Bomb: American and British Playwrights Confront the Nuclear Age, 1945-1964* (Westport: Greenwood Press, 1999) 2, 1, and 30.
59. Charles A. Carpenter, "A 'Dramatic Extravaganza' of the Projected Atomic Age: *Wings Over Europe* (1928)," *Modern Drama* 35.4 (Win. 1992): 553.
60. The play actually ends with Arthur, who "brandishes the remote-control watch before his colleagues [...] like an anarchist with a bomb [...] he does tell the men that he alone is going to Geneva." Carpenter assesses, "In Geneva, we presume, he will oppose the Guild's limited nuclear blackmail with his own homicidal brand" (Carpenter, *Dramatists* 24). This ending is left, as most atomic plays are, somewhat uncertain.
61. Carpenter, "Wings" 553.
62. Carpenter, *Dramatists* 26; Carpenter, "Wings" 558.
63. Amnon Kabatchnik, *Blood on the Stage: 1925-1950* (Lanham: Scarecrow Press, 2010) 233.
64. "Wings Over Europe," *The Spectator Archive*, 13 May 1932, <<http://archive.spectator.co.uk/article/14th-may-1932/16/wings-over-europe>> (accessed 5 May 2016).
65. The last few quotations are found in J. Brooks Atkinson, "The Play: Intimations of Immortality," *New York Times*, 11 Dec. 1928: 40.
66. Ralph Willingham, *Science Fiction and the Theatre* (Westport: Greenwood Press, 1994) 20.
67. Frank 185.
68. Frank 190.
69. Arch Oboler, *Night of the Auk*, (New York: Horizon Press, 1958) 60. All future citations will be parenthetical.
70. Carpenter, *Dramatists* 79.
71. Carpenter, *Dramatists* 80.
72. Brooks Atkinson, "Theatre: Science Fiction," *New York Times*, 4 Dec. 1956: 48.
73. Willingham 52-53.
74. Richard F. Shepard, "'Night of the Auk' on 'Play of the Week,'" *New York Times*, 3 May 1960: 79.
75. Arch Oboler, Foreword, *Night of the Auk*, (New York: Horizon Press, 1958).
76. Carpenter, *Dramatists*, 20.
77. Carpenter 89.
78. Robert Neimoff, "A Critical Background," in *Les Blancs: The Collected Last Plays of Lorraine Hansberry*, ed. Robert Neimoff (New York: Random House, 1972) 318. Certainly there are other plays about the bomb without explicitly stating so.
79. Neimoff 318.
80. Richard M. Leeson, *Lorraine Hansberry: A Research and Production Sourcebook* (Westport: Greenwood Press, 1997) 77-78.
81. Lorraine Hansberry, *What Use are Flowers?*, in *Les Blancs: The Collected Last Plays of Lorraine Hansberry*, ed. Robert Neimoff (New York: Random House, 1972) 331-332. All future citations will be parenthetical.
82. Neimoff 317.
83. Thomas Moylan describes dystopian narratives as a "product of the terrors of the twentieth century," including themes of war, genocide, exploitation, and debt. He writes that dystopia's truth "lies in its ability to reflect upon the causes of social and ecological evil as systemic." The bomb, in this way, is not seen as simply a singular event but as part of a larger society ills or problems—which is evident in the Hermit's sentiments and Hansberry's

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- critiques of society in her play. See, Moylan, *Scraps of the Untainted Sky: Science Fiction, Utopia, and Dystopia* (Boulder: Westview Press, 2000) xi and xii.
84. M. Keith Booker, *The Dystopian Impulse in Modern Literature: Fiction as Social Criticism* (Westport: Greenwood Press, 1994) 19.
85. Jeanne Tiehen, "Dystopian Drama: Imagining Science Without Limitations," in *The Age of Dystopia: One Genre, Our Fears and Our Future*, ed. Louisa MacKay Demerjian (Newcastle upon Tyne: Cambridge Scholars Publishing, 2016) 61.
86. Dan Hubert, "Review: *What Use Are Flowers?*," *Atlanta Journal Constitution*, 31 July 1994.
87. Carpenter, *Dramatists* 136.
88. Wuthnow 8.
89. Albert Wertheim recalls Barry Witham's argument that "American drama during the 1950s averted its face from politics," instead producing wistful melodramas. Yet, Wertheim states that many American playwrights did deal indirectly and directly with the issues of the times—it just does not seem like the bomb fit in. See Albert Wertheim, "The McCarthy Era and the American Theatre," *Theatre Journal* 34.2 (May 1982): 212-213.
90. Wuthnow 38.
91. Wuthnow 46.
92. Arthur Kopit, *End of the World* (New York: Hill and Wang, 1984) 5, 13. All future citations of this text will be parenthetical.
93. This was also evident in the recent presidential debates regarding the rhetoric involving control over the nuclear bomb and pushing the button.
94. Dragan Klaić, *The Plot of the Future: Utopia and Dystopia in Modern Drama* (Ann Arbor: University of Michigan Press, 1991) 90.
95. Ibid.
96. Ibid. 92.
97. Benedict Nightingale, "Stage View; Kopit's 'End of the World' is Serious, Urgent Drama," *New York Times*, 20 May 1984, <<http://www.nytimes.com/1984/05/20/arts/stage-view-kopit-s-end-of-the-world-is-serious-urgent-drama.html?pagewanted=all>> (accessed 26 May 2016).
98. Nightingale.
99. Richard Rhodes's epilogue to *The Making of the Atomic Bomb* gives an excellent historical description of the events proceeding the bomb. This includes Leo Szilard's vehement wishes to stop nuclear weapon development, the work underway at Los Alamos for an H-bomb, and considerations of whether nuclear bombs were a pathway to less horrific wars: if the bomb had been "big enough to end world war, big enough to challenge mankind to find its way beyond man-made death" (778). Niels Bohr, Rhodes writes, asked Oppenheimer those last sentiments. See Richard Rhodes, "Epilogue," (New York: Simon & Schuster, 1998).
100. John Forge, *The Responsible Scientist: A Philosophical Inquiry* (Pittsburgh: U of Pittsburgh P, 2008) 223.
101. Rhodes, 784.
102. "Contribution Programs," *Sandia National Laboratories*, <http://www.sandia.gov/about/community/contribution_programs.html> (accessed 26 May 2016) ; "Lockheed Martin Earnings Preview: Defense Business Likely Propelled Growth Last Quarter," *Forbes*, 25 Jan. 2016, <<http://www.forbes.com/sites/greatspeculations/2016/01/25/lockheed-martin-earnings-preview-defense-business-likely-propelled-growth-last-quarter/#3359de734388>> (accessed 26 May 2016); Samuel Wiegley, "10 companies profiting the most from war," *USA Today*,

10 Mar. 2013, < <http://www.usatoday.com/story/money/business/2013/03/10/10-companies-profitting-most-from-war/1970997/>> (accessed 26 May 2016).

103. Michael Billington, “Oppenheimer five-star review – father of atomic bomb becomes tragic hero at RSC,” *The Guardian*, 23 Jan. 2015, <<https://www.theguardian.com/stage/2015/jan/23/oppenheimer-review-rsc-atomic-bomb-drama-tom-morton-smith>> (accessed 27 May 2016).

104. Bill Lott, “Science is no longer the new god, and necessity is the neglected grandmother of invention,” Presentation, Science and Society, National Popular Culture Association and American Culture Association Conference, Seattle, WA, 23 Mar. 2016.

105. Tom Morton-Smith, *Oppenheimer* (London: Oberon Books, 2015).

Chapter 4.1: Presentism and Climate Change: A Theory of Time Convenience

Looking at climate change through the lens of time, two important ideas emerge. The first is that climate change is a story interconnected with time, particularly tense. Thinking about climate change raises the questions of how the past has led us to this moment in time, what we are doing in the present to halt global warming's consequences, and what our future may look like. The second is that climate change encounters our culture and society at a moment when time feels scarce. These two narrative threads interweave and appear in this first section of this chapter and in the plays I analyze in the next. Time, as I have written about in this dissertation, is something philosophical, scientific, phenomenological, theatrical, and cultural. In this chapter, I will show how time will also prove to be, if it has not already, economic, political, and personal. Climate change science demands that we ask ourselves in the time we have left to make a difference regarding what are we doing as a culture and as individuals to protect our environment and the species on this planet—humans included—in order to prevent an unrecognizable future from approaching.

At the moment I began writing this chapter I was moving out of a house and into a smaller apartment. The ecologically minded conservationist was glad to transition into a space that inevitably uses less energy. However, this move presented its challenges in my desire to not be wasteful or environmentally unsound. This required a considerable amount of time. I recycled the broken desktop computer at an electronics store, old prescription medications were recycled at a local law center to prevent potential negative effects on soil or water from runoff at landfills, yard sprays and household cleaners were delivered by appointment to the hazardous household waste site, other electronics and books went to an expansive recycling location thirty-five miles away, the spare tire had to be picked up by appointment, and many other odds and ends had been delivered to Goodwill. I could not find

a suitable location to recycle the broken microwave and read on my local waste resource website I could throw it away, which I begrudgingly did. I try to make conscientious efforts toward recycling, minimizing carbon footprints, reducing waste, limiting unused food, and disposing of trash in ways that diminish the impact for humans, animals, and the environment. Yet, even I, who has read considerable amounts of articles and books about the devastating potential consequences to our planet by not making such efforts, also know that my minor individual actions do little to remedy a problem that registers on the global scale. Moreover, I too am frustrated that doing these environmental steps required so much time and energy when it seems so many other pressing life needs require my attention. Why?

In some measure, this is because time in this modern day seems to operate differently than it used to, even compared to ten to fifteen years ago. The article “Why is everyone so busy?” in *The Economist* describes in American culture that “When people see their time in terms of money, they often grow stingy with the former to maximise the latter.” Adding to this anxious time compression is the fact that now that we have more options for entertainment and leisure: “The ability to satisfy desires instantly also breeds impatience, fuelled by a nagging sense that one could be doing so much else.”¹ Recently talking with a theatre colleague, I heard a story about a regional director urging that plays not run more than an hour and a half because modern audiences do not have the patience to sit through anything much longer than that. Mark Lawson in *The Guardian* similarly describes how play length matters to prospective audiences: “But it’s also of concern to audiences, not only because of transport connections and baby-sitting arrangements but because live drama is an art form that demands intense concentration in a dark warm space at the end of what is for many people a working day.”² Discussing the long length of an epic theatre marathon, Lawson evaluates the play experience of both participant and spectator as an activity of stamina. It is

amusing to consider that dedicating our time to watching a live production is now “testing the physical limits of the transmission and reception of drama.”³

Yet, even outside the theatre, time appears to be a commodity we have desperately little of and thus want to preserve. As Judy Wajcman writes, “Time-space compression is a constant theme in mainstream sociological accounts of post-modern society,” adding that even though automation has increased within industry and our homes, we still have a “time poverty and the paucity of leisure.”⁴ Speaking further on this current time compression, Adam Frank explains that our use of cellphones and technology has crafted a digital revolution that “directly reshape[s] the human experience of time.”⁵ It is obvious from these articles, and the many others like them that derive from different disciplines, that time is not what it used to be, and that we are fighting against its fleeting quality. We seem to not know where to direct our time: we question if we are spending our time well, and use the word “busy” to such an extent it seems inseparable from our temporal realities.

This acceleration of our lives has paralleled another acceleration with potential catastrophic consequences: climate change. In response to our hurried lives, the question playwrights and scholars ask is “Do we have the time to care?” I contend we do not, *or* more importantly, think and act like we do not because of how presentism dominates the way we think about time and climate change science. Introduced in this section and explored as an underlying theme in the plays in the next is the time-oriented theory of presentism. In this chapter, I look at three plays about climate change, extrapolating how they demonstrate presentist cultural behaviors toward climate change. In contrast, I compare these three plays to a sampling of nonfiction books that address climate change to question how theatrical representations of this subject differ phenomenologically from such non-dramatic literature. One significant variance is that plays can display people like us within the present who are very concerned with the future of climate change, while frustrated by those who are

unwilling or unable to change the course of conversation, politics, or behaviors toward climate change. I contend this is similar to how many people react toward climate change science in real life. This also has a lot to do with time, because time is a controlling force in how we also think about and understand science. Quite simply, climate change will be one of the most pressing issues of our time, as most scientists agree. However, perhaps it is largely because of presentism and our focus on the present tense that we cannot fully mentally entertain climate change as a real entity or foresee its significant role as a shaping dynamic for our future. The plays that I analyze in this chapter demonstrate why this approach to our present, and more importantly our potential future, needs to change.

Presentism is a weighted term that can convey multiple meanings. To state that I think we as a culture are presentists can be contested given the word's many meanings and how philosophers and physicists have articulated presentism. From a philosophical perspective, David Zimmerman defines presentism as an "extreme form of the A-theory" of time.⁶ A-theories are those articulated by J. M. E. McTaggart, author of "The Unreality of Time," who describes them as positing an "objective distinction between what is present and what is past and what is future."⁷ Philosophers like D. H. Mellor favor the B-series of time, which assume that events can be earlier or later, rather than tensed as A-theorists suggest. Zimmerman critiques McTaggart's theory division and calls the A-theory a belief held in the minority, even though most agree that the present differs from the past and future (as I suggested earlier, phenomenology and our orientation of experiencing life, being, and the world in the present is one argument for tense distinctions as each does not feel experientially the same to us—or specifically, the events within them). Presentism defined, according to Zimmerman, is the belief "that all reality is confined to the present—that past and future things simply do not exist, and that all quantified statements that seem to carry commitment to past or future things are either false or susceptible of paraphrase."⁸ As I wrote about in Chapter 1.2,

phenomenologically speaking our minds and bodies can only perceive in the present, and we have anticipations and memories of the future and past that may not come to be or never truly were as we remember them. Therefore, the past and future as our mind conceives them are arguably false and susceptible of the paraphrase Zimmerman describes. We can see, thus, how the theory of presentism has threads that are not impossible to agree with. Bardon elaborates that presentism hits a snag when considering any true statement about the past, such as the fact that the Berlin Wall fell in 1989. It seems obvious this is true; this history was recent enough and documented thoroughly no one is rationally arguing that the Berlin Wall did not fall in 1989. Yet, Bardon clarifies the problem with presentist logic: a “presentist can’t consistently agree to that, though, because presentism doesn’t allow for the reality of events that aren’t happening now.” Moreover, he/she likely would argue that people having memories of the Berlin events *now* does not prove that the events in 1989 actually happened.⁹ This is a form of presentism taken to the extreme.

Perhaps unsurprisingly given the suggestion of these ideas, philosophers continue to debate the merits of presentism. Opposed to presentism is eternalism—which posits that all times are equally real. This concept is often currently correlated with the theory of relativity and spacetime and the co-existence of all tenses. These two binary positions need not be viewed as polar opposites, however. Mark Hinchcliff in “A Defense of Presentism in a Relativistic Setting” counters that the theory of presentism offers “attractive solutions to philosophical problems not only in several areas of metaphysics but also in the philosophy of language and the philosophy of the mind.”¹⁰ Hinchcliff further clarifies that unlike many arguments directed toward presentism, which pits it against eternalism, both positions actually suggest that “dinosaurs *existed* and do not presently exist; they will disagree over whether they *exist*.”¹¹ He continues, explaining that eternalists treat time like space and presentists treat time like a modality. Looking at this theory of time, other scholars have

chosen alternate paths of philosophical argumentation regarding the merits of presentism, including the idea of whether it can hold up to “cross-time” relations that illustrate the causality of yesterday’s events toward today’s circumstances, whether presentists could believe in time travel, and how presentism re-invites inquiries into the idea of tensed time.¹²

A recurring theme that appears in some offshoots of presentism and the physical theory of the Growing Block Universe Theory of Time is that the past and present are real, but the future does not exist. Amongst many physicists, this still does little to assuage a dismissal of presentism. Philosopher of Physics Steven Saunders, for example, describes presentism as a “realist thesis,” noting that it is a “claim about temporal reality which is supposed to hold independent of our state of knowledge and beliefs.”¹³ He counters that relativity contradicts presentism in that its focus is about “intersubjective reality [...] a reality which contains us only as an incidental part.”¹⁴ Saunders concludes that the demands presentism places on the theory of special relativity are problematic, because as a theory of time it is not concerned with what, as physics suggest, is real. It goes without saying that “real” is also highly contested as an idea, as the most fundamental question, “what is real?” can conjure up many arguments. However, if presentists want the *present* and the *real* to be all that matters, the more intricate theories of physics that often span beyond such parameters cannot be weighed against such a scale without failing. This in turn debunks presentism. Carroll, building on this line of thinking, argues: “Concerning the debate between eternalism and presentism, a typical physicist would say: ‘Who cares?’ [...] physicists are not overly concerned with adjudicating which particular concepts are ‘real’ or not. They care very much about how the real world works.”¹⁵ His point is hasty, as both philosophers and theoretical physicists have concerned themselves with concepts of tense and there are still many aspects in physics and “the real world” that are questioned. Carroll highlights, however, that the questions presentists ask do not usually make physicists apprehensive.

The idea of presentism has warranted much more speculation from philosophers and physicists than I have outlined here. In sum, in regards to philosophy and physics and presentism, two points are worth thinking about for the next section. First, although we can believe that most people do not subscribe to the idea that the present is “all that exists,” I think we still may contemplate whether most people in our current day treat the present like the only reality *that matters*. If presentism explains how we may see the world—that the present is all that is real and matters—this is in many ways a phenomenological orientation. We experience life in the present, so it is no real surprise we favor the present. Moreover, in our time poverty, which I wrote of earlier, we are not always attentive to the past and future because we feel we cannot afford to be. A person may infer that all that matters is all that I know and do now for the “near now,” which our present culture and its treatment and use of time appears to reward and expect. In writing this dissertation, for example, I am pressed for time in ways I have never experienced, leaving me little time for retrospection about yesterday and little forethought into my future beyond what is manageable tomorrow and this week. I will explore such experiences and sentiments with the application of Douglas Rushkoff’s *Present Shock: When Everything Happens Now* in my next section. Rushkoff’s book explains in detail why we as a culture have become oriented to the present in this way, largely evidenced by how technology has shifted our sense of “now.” Second, the ideas of real and reality emerge in correlation to presentism in both the work of philosophers and physicists. Much like other time theories I have introduced, the finer points of presentism will continue to be examined within these two disciplines, likely more so by philosophers who are interested in the questions “what is real?” and added to that, “how do we know it to be so?”—which presentism engages. But the question of what is real also comes up and is challenged by ideas associated with phenomenology and theatre. The real in theatre is a shifting entity (as I have argued throughout this dissertation), just as it is in

phenomenological thinking, i.e. is what I think about in this moment as real any less so than what I see or touch simultaneously? Theatre encounters climate change and presentism with its unique twist that overlaps these boundaries of the real, given its own phenomenological treatment of time and its ability to make abstract scientific possibilities transform into “real” experiences for fictional characters on stage.

Climate change plays challenge presentist perceptions and behavior that treat the present day and its status quo as the way things will always be; that the present and our present problems are our only “real” problems and will continue to be so. With their phenomenological demands for our present-attention, of putting our personal technological gadgets aside, and of staging the past or future in a live production with breathing people who embody characters with whom we come to empathize, these plays boldly address climate change with urgency and a style no other medium can replicate. These plays present a science that is complicated by dire consequences, done so by playing with tense and by underlining the importance of time. The playwrights craft works that leave an intellectual and emotional impact on audience members and critics, and the plays reiterate how we should listen to climate change scientists who advise us how our times will drastically change unless we wake up from our present haze.

Stepping back from the ways in which philosophers and physicists evaluate presentism, there is still something about the presentist belief underpinning this theory of time that speaks to our current era. Many of us may not be dogmatic enough to think that the present is all that exists intellectually. I think many people would not think the past or future are unreal or entirely insignificant. Yet, as I highlighted in my previous chapter, we can be easily forgetful or relaxed about our past involving the atomic bomb, as well as the future of nuclear weaponry and aging nuclear infrastructure and waste. In regard to climate change, we can confront recurrent headlines that describe near-future catastrophe, but seem unbothered

by it in our day-to-day activities and choices. In 2013 Daniel Stone for *National Geographic* described “6 Ways Climate Change Will Affect You,” including more energy demand at higher prices, transportation infrastructure pushed to the limit due to extreme weather, more droughts, and more allergy and asthma problems.¹⁶ These warnings are tame compared to some of predictions by many climate change scientists. I bring these ideas up, because even though these concerns resurface with every new hurricane, drought, wildfire, or some story about an almost-extinct animal species, our culture has not drastically overhauled current practices that exacerbate these anxieties. The same is true for other national and global crises, where people question why are we not doing anything or taking action; presentist habits of a culture appear to explain much of this inaction. In America, we still debate the merits of climate change and the words of the scientists warning us—all the while the planet continues to illustrate to us that it will not wait for us to believe. With the ideas of presentism at hand, the next section will illustrate the power of theatre in the fight against climate change and in light of the limitations of time. Counteracting our presentist mindset, theatre demands our utmost attention before its own ephemerality makes it recede into the past; it offers a temporal experience we hope our own planet and species do not replicate.

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1. “Why is Everyone so Busy?,” *The Economist*, 20 Dec. 2014, <www.economist.com/news/Christmas-specials/21636612-time-poverty-problem-partly-perception-and-partly-distribution-why> (accessed 26 Sept. 2016).
 2. Mark Lawson, “Endurance performances: Why length matters in the theatre,” *The Guardian*, 19 June 2012 <<https://www.theguardian.com/stage/2012/jun/19/endurance-performance-theatre-length-matters>>, (accessed 16 July 2016).
 3. Lawson.

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4. Judy Wacjman, "Life in the fast lane? Towards a sociology of technology and time," *The British Journal of Sociology* 59.1 (2008): 59-60. Wacjman compares different sociologists—some who argue that time today is speeding up due to technology, and others who suggest that this "speeding up" has reoccurred throughout history. Wacjman argues regardless, "time pressure and time poverty are major preoccupations of contemporary sociology" (61).
 5. Frank 211.
 6. David Zimmerman, "The A-Theory of Time, The B-Theory of Time, and 'Taking Tense Seriously'" *Dialectica* 59.4 (2005): 402.
 7. Zimmerman 402.
 8. Zimmerman 402.
 9. Bardon 86.
 10. Mark Hinchcliff, "A Defense of Presentism in a Relativistic Setting," *Philosophy of Science* 67 (Sept 2000): S575.
 11. Hinchcliff.
 12. See Thomas M. Crisp, "Presentism and 'Cross-Time' Relations," *American Philosophical Quarterly* 42.1 (Jan. 2005): 5-17; Bradley Monton, "Presentists can believe in closed timelike curves," *Analysis* 63.3 (July 2003): 199-202; and Craig Bourne, *A Future for Presentism* (Oxford: Oxford University Press, 2006) Introduction. Bourne details in his introduction the variances of presentist theories, illustrating that criticism against presentism is sometimes a sweeping dismissal that can ignore such nuances (which still might not matter much to many who disagree with its general premise).
 13. Simon Saunders, "How Relativism Contractions Presentism," *Time, Reality & Experience*, ed. Craig Callender (Cambridge: Cambridge UP, 2002): 279.
 14. Saunders 280.
 15. Carroll 25.
 16. Daniel Stone, "6 Ways Climate Change Will Affect You," *National Geographic* 15 Jan. 2013 <<http://news.nationalgeographic.com/news/2013/01/pictures/130115-climate-change-superstorm-atmosphere-science/>> (accessed 14 July 2016).

Chapter 4.2: Climate Change on Stage: A Future of Present Concern

On February 17, 2016 I joined other members of the Sierra Club of Kansas to watch the documentary *This Changes Everything*. The Sierra Club, founded in 1892, claims it is the “nation's largest and most influential grassroots environmental organization.”¹ The Kansas Sierra Club chapter works toward the same issues that the national organization does, such as fighting for clean air, clean water, and endangered species acts, but it emphasizes that its “major challenges include the impact of industrial agriculture and meat production.”² *This Changes Everything* is based on Naomi Klein’s bestselling nonfiction book of the same name; Klein is one of the better-known climate change authors and social activists. Her book, which I discuss more within this section, positions climate change against the ethos of late market capitalism and neoliberal philosophy. Rob Nixon for the *New York Times* states that it is a book of “such ambition and consequence that it is almost unreviewable.”³ The film considerably abbreviates Klein’s book, portraying different areas throughout the world affected directly by climate change and its negative consequences. Watching a small group of villagers in Andhra Pradesh, India effectively protest the construction of yet another coal-fired power plant is powerful, particularly in its interwoven narrative of others living in Greece and the Tar Sands of Canada, who are fighting against the decisions by powerful corporations and governments to destroy their homelands for the sake of profit and resources. As I anticipated the movie starting, I wondered whether this film could make any impact or increase awareness about a problem so big that many claim we are running out of time to solve it?⁴ This question is not just relevant to this documentary, but also significant to the plays produced and the books about climate change that I analyze at the core of this section. As the movie began, I thought about the audience around me—older, environmentally conscientious, most members of the Sierra Club—pondering where were the people from my

generation. If people my age and younger are likely the ones going to be most affected by climate change, why is that so many people I know in my age group and younger seemingly care so little about it?⁵ Writer Amitav Ghosh asks a similar question in his book *The Great Derangement: Climate Change and the Unthinkable*, contemplating that “if the urgency of a subject were indeed a criterion of its seriousness [...] it should surely follow that this would be the principal preoccupation of writers the world over—and this, I think is very far from being the case.”⁶ Likewise, only a small number of plays exist that dramatize climate change. It reminds me of the general question I find myself asking about climate change: where is everyone?

Admittedly, that question may be overly dramatic—there are many people who care about climate change.⁷ Yet, once one becomes more informed about climate change and its many adverse effects, being dramatic seems a tempered response to the catastrophic possibilities many intelligent and well-versed scientists and scholars in the field suggest. How then do playwrights capture the drama of climate change, a topic complexly multifaceted, for the stage? To answer this question, I examine three theatrical productions about climate change: Moira Buffini, Matt Charman, Penelope Skinner, and Jack Thorne’s *Greenland* (2011), Mike Bartlett’s *Earthquakes in London* (2010), and Stephen Emmott’s 2012 hybrid science presentation/theatrical event staged at the Royal Court Theatre, *Ten Billion*. The first two are large-scale plays that have several overlapping storylines, including many involving scientists and politicians who work on climate change policy. Both plays demonstrate the effects of climate change on a personal and global scale. Emmott’s play, which has since been adapted to a book and movie, sharply prognosticates the dangers of our growing population in light of restricted resources due to climate change. The three plays exemplify the clash of scientific knowledge against inaction, which is perpetuated by presentist interests and preserving the status quo, usually due to economic, political, or

cultural interests. When it comes to time, the plays focus—albeit through different storytelling means—on the salient argument that we may essentially be running out of time to reverse the effects of climate change, which in turn highlights the problem of why we continue to ignore the warnings by scientists regarding climate change. The three plays, like the articles and books written on climate change, suggest the future of our planet and our existence as a species depends critically on what we do now, in the present.

As I mentioned previously, the time component in thinking about climate change is largely interrelated with the idea of presentism. Time is discussed in all three titles as playwrights emphasize tense, a characteristic we have repeatedly seen in science plays. In each of the three plays, characters (often scientists) warn others of what is coming in the future, with those in the present heeding the warnings or complacently shrugging them off. Structurally, the contrasting or merging of scenes set in different tenses appears in *Greenland* and *Earthquakes in London*, as if the present is so busy we cannot even hold a moment for just one thing to occur. To contrast the theoretical explorations of presentism I introduced in the previous section, I draw upon David Rushkoff's book *Present Shock: When Everything Happens Now*. Rushkoff's book allows me to better explore time concerns in these plays, because he explicates why the "twenty-first [century] can be defined by presentism," clarifying that this presentism can often lead to an increased ease of distraction and the distortion of scientific and knowledgeable truths, such as those surrounding climate change.⁸ Rushkoff also illustrates many current cultural examples of why this is true, often relating this construction of time to our present culture's use of the internet and technology. Thus, Rushkoff's claims allow me to elucidate how theatre enables a space and time that counters the presentist demand of a distracted "nowness."⁹ It is presentism that best explains our cultural behavior toward climate change science; presentism defies scientific warnings for a more palatable belief about the future that permits us to remain unworried in the present.

Scientists, instead, often prognosticate what to expect with the residual and future consequences of climate change, for example, when considering what cities might look like by the year 2050. Climate change is a future crisis bearing down on our present day, and the plays I analyze illustrate the creative and powerful ways that several playwrights have attempted to address the monumental event for the confines of the stage.

To this end, I also contrast the plays with nonfiction books, such as Naomi Klein's, Elizabeth Kolbert's *The Sixth Extinction*, and Seamus McGraw's *Betting the Farm on a Drought*. What I find most powerful about these books is their integration of science and their readability. I also compare the vital phenomenological differences and the potential impact that differentiates a book from a performed play. In looking at the printed word versus theatre, the differences can be obvious. The printed word does not perform, and a book can contain hundreds of pages of information that no performance medium could rival. At the same time, I consider what theatre offers to the climate change conversation—a conversation that should be addressed and challenged on all fronts if an effort is made to change our cultural response to this science. This includes the glaring fact that in examining climate change plays, I am looking at three British plays that had premieres at notable theatres and attention from national media. When it comes to staging climate change, the playwriting efforts and mainstream response in the United States has not been as strong as it has been in England. Therefore, in discussing the science plays dedicated to climate change, I also introduce how other scholars have explained the dearth of discussion on climate change in the theatre and in general.

Throughout this analysis, time continues to be a familiar refrain that returns in each play, essay, or book I consider. Time itself is an inescapable concept in talks of climate change: be it of tense in the recurring predictions of the future or the ways our meteorological past is used as evidence for or against climate change's existence. Moreover, time-related

concerns are significant in the ways scientists and cultural theorists suggest how our current practices are rooted in revolutions that made life easier and businesses more profitable but that impacted our environment negatively. Time is also evident in the inaction of our present government, society, and even ourselves, indicating that we may not be fully ready for what the scientists and researchers warn us might lie ahead. Climate change is a highly challenging occurrence given that its processes cannot be negotiated with, nor will its effects be pinpointed to any specific geographic location or temporally defined by a date in time (like the bomb). Added to this picture are the many causes of global warming linked to climate change that are so wide-spread and deeply entrenched into many of our societal behaviors and “needs” that it is hard not to see the spider web of problems we have created in the United States, England, and in other parts of the world.¹⁰ Our rampant use of fossil fuels, the amount of carbon dioxide generated from transportation, how we farm and how much meat we consume, deforestation, pollution, and how much trash we throw away that creates methane gases are only some of the causes. Even as we make global, national, and personal changes to these current behaviors, many scientists and climate change experts argue it may not be enough and it may still be too late. In our lifetime we may see mass extinction, increased migration, war, and disease prompted by climate change in ways that are currently not apparent. Robert J. Bruelle and Riley E. Dunlap write in the introduction to *Climate Change and Society: Sociological Perspectives* that the most “immediate and severe effects of rapid climate change [...] are likely to fall upon the most socially vulnerable communities in both the United States and globally—those that are already experiencing economic, political, and cultural marginalization.”¹¹ These ideas are also woven within each play I analyze. Scientists have pleaded with us to listen to their predictions, and we as a culture have been slow to respond.

Complicating climate change are the segments of our population that have obvious denial or doubt geared toward this science, and the fact that climate change science remains politicized.¹² While the statistics vary depending on the source and poll, the Pew Research Center reported in July 2015 that 87% of members of the American Association for the Advancement of Science believe the earth is getting warmer due to human activity, and only 50% of the polled public does. That is a 37 percent difference, illustrating a gap of scientific influence on public opinion and a considerable amount of the population who do not know, trust, or believe what the scientists are saying.¹³ As I explore the plays and books in this chapter that focus on climate change, the potential efficacy of arts and humanities in this debate could be the dissemination of knowledge and provoking representations that may help close the gap.

In thinking about the difference between scientists and the public, I first turn to Stephen Emmott's *Ten Billion*. The play introduces the nonfiction book comparisons in this chapter, as the "play" then became a book, and recently, as of 2015, a documentary film, appearing at film festivals across the world.¹⁴ Obvious from the play's title, the work focuses on the potential of our global population reaching ten billion while resources and food are becoming increasingly limited due to the effects of climate change. The play is a one-man show and essentially is a straightforward lecture about climate change, "performed" by Emmott, who is an actual scientist. The play is perhaps the most unique in this dissertation from a phenomenological perspective. As Garner writes, "theater can never be spoken of in terms of uncomplicated presentness, actuality continually pressures representation/fiction/illusion with the phenomenal claims of an experiential moment."¹⁵ In Emmott's play actuality and representation are one and the same, further complicating the presentness of the production.

Converging Illusion/Reality and Science/Theatre in the Age of Presentism

To see *Ten Billion* at the Royal Court Theatre in 2012 was to see a performance unlike most other science plays. Michael Billington for *The Guardian* described his response in the first sentence of his review: “This is one of the most disturbing evenings I have ever spent in the theatre.”¹⁶ He defined Emmott’s performance as using “an array of statistics to reinforce his argument” regarding the dire effects of our surging global population. Having described Emmott at his strongest when he “castigates politicians and world leaders,”—not that this stopped him from also chiding our minor actions of hybrid cars and urinating in the shower versus wasting water flushing a toilet—Billington wrote, “Some will argue this is a lecture, not theatre. But the distinction seems nonsensical.”¹⁷ Emmott himself posited, “It’s not really a play. I don’t know how to describe it. I have been calling it *The Thing* so far,” continuing that the set looked like his actual office with journals, books, and a whiteboard.¹⁸ The idea of this performance being theatre and *not* a scientific lecture is interesting, and as a science play scholar, the phenomenon of having a legitimate scientist crossing the boundary on to the stage is one I hope will happen more often.

The play focuses on the potential of our global population reaching ten billion. The play ran a limited run at the Royal Court Theatre, directed by Katie Mitchell. Emmott is Head of Computational Science at Microsoft and Professor of Computational Science at Oxford. To describe the play one must refer to the book that became a byproduct of the theatrical performance—which is also an exceptional consequence of a theatre production; there is no play script version in print. The website for the Royal Court cites other names in correlation with the production, including their theatrical titles, such as lighting designer, composer, and director, but Emmott’s name is listed without a designation. He is not noted as “actor,” “performer,” or “scientist.” Emmott describes the process of the performance:

It is like nothing else I have ever done before and has involved a great deal of revision. My first scripts were too formal. It was as if I was writing for a journal. I have had to find a more naturalistic voice. I am not learning lines, however, just a set of points that I want to make as the show progresses. Katie will then introduce the kind of tempo that the show needs. I want to change people's ideas about the impact we are having on the planet.¹⁹

The process alone is worth more inquiry into what makes a play a play, and what variances happen night to night when Emmott is “not learning lines.” Prior to the work between Mitchell and Emmott—who met at a function and began thinking of collaborating—the National Theatre had selected several theatre artists and experts to figure out a way to address climate change for the stage. For those involved, it was a struggle deciding how to broach the topic. As Matt Trueman for *The Stage* writes, “Theatre (and art more generally) has long struggled to encapsulate climate change. Until a decade ago, it was almost completely ignored, deemed at odds with the sort of human story that drama holds best.”²⁰ Trueman details Mitchell's attempt to use surrealism, agit-prop, symbolism, and other theatrical approaches, but ultimately having no success. Instead, for Mitchell the solution “for staging climate change was simple: just put the science onstage as is.”²¹

The struggle to put climate change on stage is seemingly common, evident by the lack of play titles that exist about the topic. Julie Hudson in “‘If You Want to Be Green Hold Your Breath’: Climate Change in Theatre” describes the scarcity of climate change plays. Assessing that the climate change debate is “made for the stage,” because it has a ripe combination of ethical dilemma, narrative tension, and special effects, she observes that it is “conspicuous by its absence on the stage” until recently.²² She notes that while Shepherd-Barr includes eighty-two plays in her survey of science plays from 1992-2004, none are

climate change plays. The same is true for Zehelein's science play survey. This says something about the status of climate change plays. In context of this dissertation, I draw a parallel between the slow theatrical response to climate change and that of the theatrical response to the atomic bomb—which I discussed was small compared to the magnitude of the event at the time. Both topics offer substantial questions and a consideration of ethics, responsibility, and response, but the most significant theatrical question might be how to dramatize such a topic. Catherine Diamond, who writes about climate change plays in her article, "Staging Global Warming, the Genre-Bending Hyperobject," offers Timothy Morton's idea of the "hyperobject" to the conversation. Diamond explains, citing Morton, that the hyperobject involves "profoundly different temporalities than the human-scale ones we are used to," and that while these hyperobjects therefore "exceed" most of the confined expectations of drama, she adds they "can also create an illusion of locality because we can only experience them in parts and never in entirety."²³ This reiterates ideas I express: not only is climate change expansive in terms of its effects or its causes, but it also hard to conceive in terms of temporality, time spans and tense, and the space it affects. In contrast to the temporal scale of climate change, consider the bombs that dropped on August 6 and 9, 1945. Those dates are finite points in time—the bomb is sealed by their instantaneity (not to ignore the long-term effects of radiation or nuclear arms development). Yet, climate change in comparison has no clear start date or end date. The predictions scientists make, for example, of when sea levels may rise or when species may go extinct seem hazy and beyond our temporal experience. When reading the literature and articles about the future of climate change it is difficult to look ahead and conceive that the world will change in the ways that have been prognosticated. Plays may help this cognitive dissonance through representing potential future scenarios, but even playwrights must pinpoint such a vast-time topic to

specific spaces and time in settings (not to speak of the time and space of the actual theatre/stage itself). This has been hard to do and hard to do well.

Despite the enormity of climate change in scope of space and time, Emmott shows little concern about overwhelming his audience.²⁴ In the book/play, Emmott suggests that the situation at hand is an “unprecedented planetary emergency.”²⁵ He does not let the reader/audience member off easily, and writes, “Our cleverness, our inventiveness, and our activities have modified almost every part of our planet,” contributing these three features as the “drivers of every global problem we face” (8). Emmott positions himself as a scientist immediately, affirming that science “is ultimately about *understanding*,” while claiming that scientists then use this understanding to “predict how these vital planetary systems will respond to change” (10 and 11). The book quickly progresses into a litany of facts and data. Emmott states that in 1800, the world’s population had reached 1 billion—possible due to developments in agriculture (18). He continues, describing the rapid increase of our earth’s population, asserting that by 1930 we had hit two billion and by 1960, three billion. The proliferation of using pesticides and improved public health enabled these population growths. The book continues with this upward count of the world’s population, explaining the increases of billions that happened in less and less time. Intermixed in the book are various graphs and photographs, demonstrating the changing landscape of our world in visual simplicity. On page forty-two, he writes that “In the past twelve years, we’ve grown by yet another billion,” which is a startling statistic. Emmott adds that as the population number swells, our need for water, food, land, transportation, and energy match these rising numbers, and in turn, “we are now accelerating the rate at which we’re changing our climate” (44). Having presented the picture of where we as a people, our environment, and world have progressed in the past two centuries, he then assesses where we are. It is a shift from the past into the present.

Emmott's arguments cover every possible angle; our meat consumption, the amount of water we use to make chocolate, our use of oil and gas—where he explicates he is “not worried about running out [...] I'm worried that we're going to continue to use them”—the amount of cars we continue to make and scrap, how much we will fly this year, and how much we are transporting various manufactured goods across the globe (86). He lays out these facts, then turns to the climate, evaluating how quickly climate change is accelerating because of these behaviors. As he explains it, “every leaf on every tree on Earth is experiencing a level of CO₂ that the planet has not experienced for millions of years” (122). He then boldly states, “But this favor may be about to end”—meaning that our carbon emissions cycle may exceed what our plants and oceans can absorb. Jumping to the year 2050, he estimates how many people will live in cities (70%), and that our food production may encounter unmanageable conditions with the soil degradation and desertification of agricultural lands. Further, he warns of the potential for pathogens that devastate crops in an ever-changing climate to which we have not adapted, and increased water shortages that will make it hard to water said crops (135). He also mentions our staggering rates of transportation production and shipping, and how that will create more risks for the transportation of deadly viruses. In questioning whether we will transition wholly to green energy, he doubts “governments and the world's major oil, coal, and gas companies—some of the most influential corporations on Earth—[are] really going to decide to leave this money in the ground as demand for energy increases relentlessly” (155).

Emmott the scientist offers caveats and outs, such as nuclear power, desalination, geoengineering, and a second green revolution (169). Yet, even those are problematic. For many of them to have been effective, we would have had to implement them at least in the last decade or two. For the more adventurous solutions, like geoengineering, Emmott states not only are they not proven methods, they are also vastly expensive, summing up that

“technologizing our way out of this does not look likely” (177 and 184). Hitting a critical point, he discusses how these practices are embedded into our behavior and attitudes, admitting that the “changes required of us are so fundamental no one wants to make them [...] We need to consume less. A lot less. Less food, less, energy, and less stuff” (203). The worst thing we can do, Emmott writes, is to “have children at the current rate” (205). Addressing reproduction rates in many countries, particularly increases in African nations, he describes that if we were to keep up the current rates the world would hit 28 billion people by the end of the century rather than 10 (209).²⁶ After informing his audience of what got us to here, why we are here, and what we have tried to do to rectify where we are Emmott concludes, “We urgently need to do—and I mean *actually* do—something radical to avert a global catastrophe. But I don’t think we will. I think we’re fucked” (216). Those are his last words.

Reviews of Emmott’s play are varied, as are the responses to his book. Dominic Cavendish for *The Telegraph* wrote of the play that Mitchell would have “been wiser to acknowledge the flagrant lecture format. There’s not time allotted for a Q&A afterwards, no room for challenges from the audience.” Cavendish concluded his three out of five-star review, “I realise time is of the essence but couldn’t the Royal Court have lent his doomy expertise to a few playwrights before they vanish along with the rest of their species? It’s going to take much more than this to make waves.”²⁷ Cavendish appears to have wanted the message to be more palatable than Emmott’s lecture. Referring to time, Paul Taylor in the *Independent* wrote, “And if you are allergic to false consolation, then he is just what the doctor ordered too, with his unsettling reports on how the military has started to attend climate conferences and how it may well be too late.”²⁸ Time in light of climate change often reads ambiguously as such—too late—as though we missed our chance at a moment in time that is still not always defined. Georgina Brown’s review for the *Mail on Sunday*, echoing

Billington's response, described the play as "certainly the most scary show in London," while Dominic Maxwell for *The Times* mentioned the short-run time of the play (like many other critics), and stated, "This is an hour of Matrix moments, of reminders of what underlies our daily lives. It's freeing to face the facts as well as alarming."²⁹ In sixty-five to seventy minutes, Emmott presented a considerable amount of information to a live audience. The performance's liveness matters; in watching the trailer for *Ten Billion* the movie, which aptly shows Emmott's style of speaking and delivery mentioned in many of the reviews, the phenomenological difference between viewing theatre and film is noticeable. His piercing critique does not translate or unsettle on screen quite like it does if one shares the same space/time with Emmott, something also written about by those critics watching Emmott's performance.

The phenomenological collapse of the real and unreal, of Garner's described "is" and "as if," also occurs in Emmott's performance. "Jointly claimed by actor and character, the body on stage is also implicated in the real and the imaginary that underlie the twinning of dramatic fiction" writes Garner, describing how the actor's body can be "eclipsed" by the character's fiction.³⁰ In contrast, the performance space in this production becomes imbued by a resistance of fiction by having Emmott immediately state he is not an actor but rather a scientist. It makes the words and data that Emmott shares that much more haunting. We do not get to dismiss him as only a character. In this space that is so often filled with the make-believe and imaginary fictions of created worlds, there are now facts and information of our reality. We may wish it were a fiction because it seems so scary that it feels like it might be a dystopian vision. It disturbs us when Emmott tells his audience his grim truth, especially because he tells us that we are out of time to change it.

Not everyone has been a fan of Emmott's work, even aside from his theatrical endeavors. Chris Goodall, an author and businessman, whose work centers on climate

change, heavily criticized Emmott's book. It should be noted, Goodall's efforts often focus considerable attention on green energy and technologies that might save our planet, writing about what businesses could do to be greener. His is clearly a different approach from Emmott's. Goodall counters the book, concluding: "Emmott's book is error-strewn, full of careless exaggeration and weak on basic science. Its reliance on random facts pulled from the internet is truly shocking and it will harm the cause of environmental protection."³¹ Similarly, Michael Shermer for the *Wall Street Journal* describes, "Mr. Emmott provides few references to support his claims, and his extrapolations are mired in 19th-century Malthusian thinking [...] as if science and technology were incapable of solving problems as they did in the past and as if time will stop in 2050."³² Science for Shermer may still be our savior, a claim that is not unheard of amid climate change predictions; a claim that if it is true, will also likely need far more financial support to do so. The second edition of Emmott's book did correct some of the data and information from the earlier edition. Yet, similar disapproval of Emmott and his play is evident in Diamond's words that critique how the play takes the data "out of contact" for a "visceral response," which in turn obstructs the actual science from being fairly presented.³³ Her article also cites Shepherd-Barr, Hudson, and Djerassi in her argument that Emmott delivered a "nightmare," and that the play is a "doomsday litany of collective moral failure, by conflating the dyad of character and performer."³⁴ This may be fair criticism, but I am phenomenologically interested in the conflation of character/performer and person/scientist. Furthermore, I contend the bigger takeaway from Emmott's play is something worthwhile.

Surely, there is something to be said for factual accuracy, and for not providing those who deny climate change with more ammunition by giving them faulty information—which Goodall, and Diamond citing Goodall, reference. However, this performance happened in the frame of the stage where fact is never the ruler of efficacy; and the play's general message

and the urgency and anxiety Emmott describes and evokes are still inherently true.

Achenbach's article "The Age of Disbelief," shows a study by Dan Kahan at Yale University that tested 1,540 Americans' beliefs in the "threat of climate change." As it turned out, scientific literacy did not point to consensus, but rather "promoted polarization on climate change [...] people tend to use scientific knowledge to reinforce beliefs they have already."³⁵ The study concluded that our "beliefs are motivated largely by emotion," so even though science may appear to appeal to our rational brain, our beliefs will not necessarily follow suit.³⁶ The article also describes that those trying to teach scientists how to reach out to the public—like the organization Compass, which helps scientists engage more effectively in public discourse—have learned: "throwing more facts at [people] doesn't help [...] people need to hear from believers they can trust."³⁷ Facts about climate change, therefore, do not lead to converting those who deny climate change or sway those "on the fence," as powerful as they might be. In light of these findings, the import of *Ten Billion* then might be—instead of the facts shared—Emmott's style of delivery, his positionality as a scientist before the audience, the simplicity of the production's set design to resemble an office, and the atmosphere of intensity that affected critics, which all provided the overarching message some impact. Andrew J. Hoffman in his book *How Culture Shapes the Climate Change Debate* corroborates this potential impact and the article by Achenbach. He discusses why people disbelieve or believe in climate change, grasping the nuances and politics behind this cultural schism. Yet, he too acknowledges, "Before asking people to consider changing their worldview, you must begin by gaining their trust."³⁸

Bringing Climate Science to the Stage

This is one way where theatre can assist science. Scientists have not always been the best communicators, nor have they known how to convey their research to a public without

that research coming from a place of reasoning, fact, and rationalization. An increasing practice to help scientists is utilizing techniques from theatre. The Alfred P. Sloan Foundation, for example, in collaboration with the Manhattan Theatre Club and the Ensemble Studio Theatre, has tried “to encourage leading theater artists to explore scientific or technological themes, to write works featuring scientists.”³⁹ This significant project is tied to the Foundation’s initiative to build bridges between the sciences and humanities, and to help the public better understand science. In this way, the foundation promotes literature, film, theatre, and television that present scientific stories —*Constellations* and David Auburn’s *Proof* being two dramatic byproducts. As I argue in this dissertation, the Sloan Foundation believes that through each science play, we can see the scientist as a human being. In this study, I already have displayed a series of scientists who express a range of human emotions, experience a gamut of wins and losses, and sometimes do so in ways that are ordinary and at other times through extraordinary means. Scientists are more than merely bearers of facts and knowledge, but also people who are like us as they move, breathe, and talk in front of us. When we see scientists as relatable people, we can build trust in them. We can hear what they are saying with different ears; and we can feel emotion toward them and what affects them. It is this humanness, embodied phenomenologically before us, that is potentially more effective in changing beliefs about climate change than only by the presentation of scientific fact. The argument alone is not going to do the trick, as hard as that may be to conceive. Perhaps this is where Emmott’s play—despite its phenomenological distinctiveness—shows its weakness most as a theatrical piece. He has not earned our trust as a character, but rather frightens us in his real-life role as a scientist. Due to the play’s debatable approach and sometimes-questionable deductions, he may not have earned our full trust as a scientist either.

Despite this, perhaps it is useful for us to feel afraid when it comes to climate change. Not without its controversies, Emmott’s play in ways offers a particular experience as he—a

scientist—performed this one-man performance every night during its July 12 through August 11 limited run at the Royal Court Theatre in 2012.⁴⁰ His play is not an attempt to acquaint us with climate change or feel an empathetic response toward him as scientist (or others, as there are no other “characters” or individuals discussed in the play). He is not working toward earning our trust, but instead working toward us to fully realize the problem. His thesis is that we are losing the fight against climate change, and he had no desire—and ultimately Mitchell did not either—to sugarcoat this reality. Is that the most effective climate change message the theatre can tell? That is debatable, as evidenced. Keeping in mind Gillian Beer’s words about transformation and translation that occurs when science intersects with other disciplines, especially with the arts, Emmott’s play, in spite of its potential weaknesses, has a different mission. Rather than weighing the play for its veracity, I consider instead the effect of the play on an audience and its ability to reach us in our cultural moment where inaction is common and indifference is frequent; Emmott instead wants to command our attention. I defer to Billington’s apt words: “Theatre is whatever we want it to be and gains immeasurably from engaging with momentous political, social or scientific issues.”⁴¹ *Ten Billion* left a mark on reviewers and audiences, and started conversations through its direct messaging and phenomenological uniqueness of having the scientist as the performer. As a theatre scholar and as a person concerned about climate change, I consider these outcomes praiseworthy.

Greenland and the Present, Now

Emmott’s play, if nothing else, depicts a vision that we have not done enough to prevent, nor will we be able to halt, the cataclysmic effects of climate change. Viewing his play production from a framework of time, the style and directness of the performance is jarring; it clearly disrupts any presentist malaise, as demonstrated by the reviews. Emmott’s

statements are deliberate and sharp, illustrating how the past's industrial and agricultural revolutions have transformed our environment through practices that are now intertwined with consumerism and capitalism. As a result, our future is all but hopeless. Why, he posits, is because we are inactive in our present, ignoring the reasonable and rational claims of scientists and climate researchers who deduce that we should be concerned and doing more about our planet. John Cook supports this in his article, "Yes, there really is scientific consensus on climate change," writing that while 97 percent of climate scientists agree humans contribute to climate change, a 2015 survey found only 12% of Americans were "aware that the scientific consensus was over 90 percent."⁴² Investigating this further, Cook claims that some major strategists and politicians in the early 2000s realized that for scientific knowledge to be ineffective toward public knowledge, anti-climate policies would need to "cast doubt on scientific consensus."⁴³ This is an ongoing practice in our politics. Climate change is undeniably entwined with politics, as Buffini, Charman, Skinner, and Thorne's play *Greenland* strongly highlights. Yet, politics alone do not explain all of our cultural behaviors; instead, I contend it is presentism that helps explain why we are drawn to dismissing climate change and doing so little within our present time.

Although I considered presentism from a philosophical and physical theoretical perspective in the previous section, presentism has also become a way to explain our cultural behavior. Media theorist Douglas Rushkoff writes in his preface to *Present Shock*, "Our society has reoriented itself to the present moment. Everything is live, real time, and always-on."⁴⁴ The live he describes in his book is how everything is happening *while* we watch and assess it happening, such as following the 2016 political conventions or debates in America, which one could watch on a Twitter live feed while simultaneously watching live tweets about the event at the same time. This is different from the liveness of theatre, which often seems to correlate liveness with copresence. Rushkoff's assessments are astute: he thinks we

live in a “distracted present” – one in which meaningless, pop culture events can hold our attention while those forces “immediately before us are ignored.”⁴⁵ Climate change is a fitting example of one of those things immediately before us we ignore. Rushkoff explains that while we were “correct about the way all this presentism would affect investments and finance, even technology and media, we were utterly wrong about how living in the ‘now’ would end up impacting us as people.”⁴⁶ This is a temporal/cultural problem, and he is not the only one to make such arguments.⁴⁷

It is difficult not to agree with Rushkoff’s arguments about how we as a culture and individuals are focused on the now all the time.⁴⁸ His book hints at the same core ideas that David Wiles discusses in *Theatre and Time*. Citing Professor of Geography and Anthropology, David Harvey, Wiles writes that the “ever increasing speed of trains, jet aircraft and digital telecommunications [...] means that capitalism puts a premium on ephemerality, and if the present is volatile and subject to instant change, there can be no point in engaging with the past or in long-term planning for the future.”⁴⁹ These thoughts reiterate much of what I discussed in the atomic bomb chapter about our relationship to the past, while the latter consequence is embedded throughout this chapter. This sentiment also appears near the end of *Greenland* when the character Sarah states:

It’s not like I don’t ever watch the news. I see the fires. The floods. But two minutes later It’s all about the recession. Or some election [...] They say we’re all going to die. Then there’s an ad break full of happy songs and adverts for airlines.⁵⁰

What are we supposed to believe or focus on when everything happens so fast and we are inundated with so much information about so many occurrences—terrorism, economic

downturns, political divineness, gun violence, etc.—that may need our immediate (in)attention? In contingency with exploring such ideas, Wiles asks, “Does theatre matter in the world of today?”⁵¹ I will continue to answer this question within this chapter, if it is not been an obvious undercurrent throughout this dissertation. It is worth considering, however, if ephemerality is strongly valued in our presentist-oriented present, how theatre’s ephemerality translates to modern audiences.

Greenland embodies many of the ideas that Rushkoff assesses within his book. The play begins with a monologue by Adeel, who recounts to the audience the idea of seeing smoke filling up in a room as everyone around you denies it. The analogy is clear, and *Greenland* is not often subtle in its message or critiques. The play, written by Moira Buffini, Matt Charman, Penelope Skinner, and Jack Thorne, is a kaleidoscope of scenes set in the present, with several characters struggling with some aspect of climate change in ways that are relatable and real. The panoply of scenes and characters is extensive—with some characters consistently reappearing and others only once, and with most of the scenes in different locations that are only minimally suggested through set and design. The overlay of scenes creates a scaffolding picture of how the scope of climate change and its effects are far-reaching and diverse. Scene two begins with the stage directions: “*The company try and respond to a series of climate-based quiz questions. They don’t know the answers. Music and a large amount of plastic falls from above. The company scatter it about the space*” (4). It is a Brechtian-inspired moment, reminding us in the audience not to be lulled by the theatricality of the play or separate ourselves from the reality of climate change. It is also a moment that appears to capture the audience’s attention.

There is much that climate change science has to compete against today to hold our attention, and that *Greenland* and other plays about climate change confront in terms of what an audience thinks they already know. This includes understanding that the constant barrage

of information and news we receive via technology means that we often only can be moved by what shocks us, and even then, only momentarily. When we watch events like Hurricane Katrina unfold, as Ruskhoff notes, we feel them as “both unnerving and desensitizing at the same time.”⁵² When climate change is not portrayed as catastrophic, but rather with scientists prognosticating about what *could* happen with a rise of an inch or two of sea levels, it is hard for that information to rival our fading attention and interest in an immediate spectacle. Theatre has to contend with this affect, and many of the surreal, surprising moments in *Greenland*—such as the stage filling with copious amounts of plastic, and later snow—jolts us to take notice. Theatricality and the shocking do capture our attention, but only for so long, as recent presidential campaigns may attest.⁵³ Coupled with this, Ruskhoff describes that with the constant influx of information the internet provides, there is a blending of news stories written and researched by legitimate journalists with click-bait articles written from non-journalists, creating “a population who believes its uniformed opinions are as valid as those of experts who have actually studied a particular problem”—as can be seen in the prevailing problem with Climate Change deniers, as seldom are they actual experts or scientists.⁵⁴ Doing a Google search of “climate change is not real,” one can find fifty-two million results and many arguing for its nonexistence written by, well, anyone.

In *Greenland* such doubt and denial is often pointed toward the character of Lisa. Lisa is a young woman, who becomes a passionate new crusader in the environmental fight by joining radical protestors. In her first scene, Lisa is with her mother Paula at the grocery store. Having read books such as *Climate Wars*, she informs Paula that she is not finishing her postgraduate certificate in education because “Ipswich might drown” (5). She has come to the grocery store to protest: citing the plastic packaging, the global transportation of food, and the waste of produce and meats that should not even be offered off season as it is environmentally unsound. Paula retorts, “Yes but we recycle” (6). While her mother does not

outright deny Lisa's claims, she also tries to passively assuage them. Lisa's enthusiasm for trying to save the world through activism continues as the play returns to her journey across multiple scenes. Her father, Al, is less obliging, asking her, "Are you really going to leave your course because [...] these science fascists who are very well paid – And these bunny-hugging eco monsters Terrorists Are telling you the world is going to end?" (15). He tells her that the books she reads are creating "a campaign of fear," and that global warming has happened time and again through "geological time" (16). Such arguments echo popular ones by climate change deniers and can be heard even on certain mainstream media programming. Her father reassures her that "The world is not about to end," to which Lisa replies, "No, the world will go on. It's us. If we do nothing, we will end" (17).

Lisa falls in and out of love with a fellow protestor, Dav, assisting him and others to protest an environmental organization that only advocates killing ecosystems in less harmful ways. She finally shares with her parents the news of a protest underway at an oilrig drilling in the Arctic (45). She tells them that she and others held the drilling off for two days, realizing it is "just a blip but...that's what it is, a pause, a breath, where we can look at it" (87-88). A pause—much like Rushkoff suggests at the end of his preface, writing, "I suggest we intervene on our own behalf [...] Press pause. We have time for this."⁵⁵ Lisa realizes that slowing down is a necessity to analyze the actions we choose, many of which intensify environmental problems; we need the time to consider what we are doing. Her parents, who appear aloof and confused about their daughter's passionate fight throughout the play, finally tell her, "You've been a gift to us. Exceptional" (88).

Not everyone who believes in climate change science or in the urgency for attention toward climate change can make such life upheavals like Lisa. Most of us would not want to, or are too busy. Busy dominates the present. It makes time merely a commodity to dictate our needs. Rushkoff accurately assesses how technology has dominated our natural rhythms and

pace, where instead of traveling less, we do more for business, and instead of working less, we are expected to be on call for emails at all hours. This is also evident with the character Phoebe, who works for the Department of Energy and adamantly believes that living her life with a complete lack of personal time is necessary to defend climate change. In the real world, paralleling this busy-ness is the growth of consumption, whereas Rushkoff reminds us, “we just can’t go faster. Even when we consume and dispose of resources at a pace that threatens the ability of our environment to sustain human life, we can’t consume rapidly enough to meet the demands of the market for growth.”⁵⁶ We are also expected to do more work in less time, which means we simply do not have the time to be as thoughtful in our actions or choices; where could the environment fit in this puzzle but as a footnote. Barbara Adam similarly evaluates this phenomenon, describing how “Time has been compressed to its limit [...] Information and money move at the speed of light. No-where and now-here have become interchangeable.” As time and intervals have compressed to the point of collapse in our culture, she makes clear that “there is no before and after, no cause and effect.”⁵⁷ The present is all that exists, and we seldom can think of how we got here or where we go next. The overall tone of *Greenland* captures this feeling with its intersecting storylines, reappearing characters, its moments of directly addressing the audience, and its blend of minimalism and high theatricality that gives the play a feeling of no-where and now-here. It is hard to anticipate what is next within the play, perhaps replicating our world outside the theatre doors.

The fragmented feel of the play continues throughout the two-hour running time, as in addition to Sarah, Lisa, and Phoebe, a myriad of characters enter and exit in a flow of scenes. Time in this sense is hard to parse out—it is hard to gather *when* any of this is exactly happening, or if these events are happening simultaneously to all of the characters. There are, however, some “time-stamped” moments, such as the climate conference that several

characters attend. Yet, the play absorbs a sort of no-where/now-here phenomenological feel, evident by reviewer comments I detail ahead.

Other characters include Sarah's partner Freya, who often fights with her over what each is willing to compromise for the lifestyle and beliefs of the other. They fight about flushing the toilet and the purchase of expensive lattes that Sarah tries to give up for Freya's strong environmental beliefs. Freya scolds Sarah when she says she believes in climate change, "Like it's fairies [...] Like we might wake up tomorrow and it's all been a dream" (35). There is also Harry/Harold. Harold is a young student at Cambridge, who wants to study geography, and Harry is a researcher, who studies guillemot birds in the northern reaches of Alaska. Harry is Harold grown up. The two converse, almost as if Harry in his solitude and isolation of research longs to converse with his younger self. This is the only example in the play of the past fusing with the present, as the other scenes are set only in the present. Harold tells Harry that he has "thirty years of data" on guillemots, because they have been "breeding [...] responsive to slow-melt," and they are showing real evidence that "the Arctic summer is arriving earlier" (64). While Harold talks to his younger, more idealistic self and teaches him about his research, one cannot help but think that he is trying to make him aware that this is all meaningful *or* fruitless—it is hard to say which.

Alamir and Seydou, members of the Mali ministry of the environment, directly address the audience in yet another rupture of the fourth wall that the playwrights utilize. Such moments disrupt not only the space of the stage reality but also its temporal boundaries—are we to believe that they are in Copenhagen during 2009 as they say they are, or do we understand they are speaking as actors/characters in a play within the temporal space of no-where, or is it both and neither? Alamir and Seydou attend the Copenhagen Climate Change Conference (which in real life occurred in December 2009). At one point Seydou asks the audience if they know the capital of Mali, and Alamir replies, "that lady

almost had her hand up” (49). Bert States writing about the representational mode of performance, describes, “In one case, the performer comes forth and astonishes us with the possibilities of virtuosity; in the other, theater says to the spectator, ‘Why should we pretend this is an illusion. We are in this together.’”⁵⁸ This is such a moment that calls attention to itself through such virtuosity, and reality and illusion colliding; this break from illusion also reminds the audience we need to be in this (climate change concern) together. Seydou tells Alamir that the audience will know nothing about their country’s plight with climate change, despite them being members of the educated middle class. Preparing for this conference for two years, they tell the audience that their desert back home is growing by “half a kilometer a year,” and that “Livestock is dying. People are starving” (50). Seydou and Alamir, like their country’s dire needs, are ignored at the conference. They do not have the privileges of being from a more developed country, something the playwrights emphasize, because even their hotel is not near the conference center, making it harder for them to keep up with the rigorous negotiations that occur at all hours of the day at the summit.

Perhaps the two most central characters of the play are Ray and Phoebe. Dr. Ray Boynkin, the scientist in the play, studies climate change. He explains that in 1998 the first quantitative reconstruction model showed a “sharp rise in temperatures during the second half of the twentieth century,” convincing him to study the climate (8). He states how his newer climate models are “full dynamic process based” and should be even more accurate than previous models. He further explains, “Climate science has been completely dominated for the past fifty years by physicists. That’s why there’s little or no biology in the models” (9). Harold’s study of birds and his insights offered throughout the play illustrate why we need the input of biologists too. When Ray meets Phoebe, they connect on a flirtatious level, but also share their common interest in climate science. Phoebe has come on behalf of her job to investigate the model that Ray has created, which includes “A global model country by

country up to 2100” (20). Ever the presentist, Phoebe has little patience when running these future calculations, which take “two and half more minutes.” When Ray wants to wait until his work is peer-reviewed before it is shared with political advisors and the public, Phoebe retorts, “That could take years,” to which Ray parries, “given time, science can do anything” (23-24). The two of them continue this love tango of time and science throughout the play, arguing about whether what they are discussing is scientific or political, and for both, also deeply personal. Even when Ray concedes that he expects “the sixth mass extinction of life on the planet [...] Half the species gone by the end of the century,” he also admits, “I want a future. I want a family. A family one day...” (51). He has dedicated so much of his life to his work, that while aware of his work’s devastating implications, he cannot turn off that inherent need.

Even when visiting Phoebe at the Copenhagen Conference, Ray is again adamant that she not get too carried away; his model is only a “projection [...] a prototype. We don’t even know if the carbon is going to remain in the atmosphere or not” (68). His decisions are rational and measured, but Phoebe is here to generate action. She knows important policies may be written at the conference, and she cannot hedge by equivocating about the data’s limitations: things have to change through this political process. She is not wrong— but neither is Ray in seeing the potential futility of the conference and the many handshakes behind closed doors that may, in the end, do nothing. Additional characters appear to discuss what happened in Copenhagen, including how President Obama and Secretary Clinton attended, that China did more than the U.S., and that leaders of India, Brazil, and South Africa would only agree to a deal on their terms. The characters in the play accurately state, “People think that climate change negotiations are finding the best solution [...] They’re not [...] Seventy per cent of it is procedural wrangling” (73). Obama flew back to D.C. and publicly announced the deal was done before the deal had been formally agreed on. And all

of these events transpired in reality, as *The Guardian* reports that Obama's speech "offered no indication America was ready to embrace bold measures [...] offered no further commitments," and "in the absence of any evidence of that commitment the words rang hollow."⁵⁹

In the play, a year later, Phoebe and Ray dine together. Ray questions Phoebe on her five-year plans, hoping that she will agree to marry him. Phoebe asks him, "When could there possibly be anyone for me? At 12:45 at night for ten minutes, while I get undressed, take my make up off" (86). Ray pushes, offering to raise their kids so that she could work. She agrees. Yet it does not feel like a happily ever after as both, "*look at each other. Her iPhone beeps. They both stare at it. Darkness*" (87). This is to live in the present and be dedicated to climate change science.

Living in this current moment, one cannot be completely oblivious to climate change, no matter their life's work or their belief in the science. This has happened to me in an everyday type moment: at a coffee shop recently, a waitress said to me, "Could you believe those thunderstorms this Christmas? I do not remember ever seeing that before." The weather patterns and seasons will continue to change as climate change evolves. It is thus fitting *Greenland* concludes in a scene surrounded by snow—with weather setting the stage—between Harry and Harold. Harry says, "This is the time I like best [...] The time when the sun hasn't set or risen but snow petrels still sing the dawn chorus" (90). It is the time when we can do something for our planet before the sun sets. In an unusual flashback, where the present merges with the past, we also see Harold telling his old school advisor about wanting to study geography because he likes the idea of examining habitats: "It's about seeing the world as it is, not how you want the world to be [...] And I'm excited by watching that change" (94). We know that Harold, as an adult, is not excited by what changes tragically have come to light through his research. The play ends with the entire cast on stage, a voice

shouting in the wind “Harry? Harry. Where are you...?” and the stage directions, “*The snow consumes everyone*” (95). What are we to make of this ending, other than its symbolic imagery of all of us one day consumed by nature?

The reception of *Greenland* was not highly favorable. Michael Billington for *The Guardian* gave it three out of five stars. He noted the “intersecting narratives,” and stated that the play “while well staged, lacks focus,” and that it “stabs the conscience without offering a perceptible point of view.”⁶⁰ He clarified, “You could argue that the play accurately reflects society's fractured uncertainty over how to tackle climate change,” but suggests that the playwrights might have taken the more “traditional route of beginning with characters and a situation and working outwards,” rather than the “confusing, multi-perspective mosaic” that transpired.⁶¹ Paul Taylor for the *Independent* called the play one of “conceptual compositeness,” and “an intellectual extravaganza” that was “brilliantly directed [...] stunningly well designed.” While Taylor complimented the play for being “undeniably stimulating,” he nonetheless concluded, “I couldn’t give a damn about any of the multiply-authored characters,” because the play lacked ““felt life.”⁶² Matt Wolf for the *New York Times* appeared to agree with these sentiments; he wrote that the play “itself feels largely recycled, at least in structure,” adding that as “a faultily stitched patchwork quilt, the play bears evidence of having been authored by four writers, all tugging in different directions.”⁶³ He too praised the set, which appeared like a “gaping bleak, black hole in which anything is possible, given the impossible mess we are making of life on Earth.”⁶⁴ Perhaps this is not coincidental when thinking about the play in terms of time. *Greenland* confronts this anxiety that we, spatially and temporally, will cease to be—dissolving into the darkness. What better than a black hole of a set to represent this idea?⁶⁵

Rushkoff makes a point about our presentist age that appears pertinent to the general remarks that critics have made about *Greenland*. He describes narrative collapse as one

consequence in the present age, where we are unable to hold our attention long enough to follow a linear narrative. Dedicating an entire chapter to this phenomenon, he describes that prior to the last two decades, storytelling helped “us construct a narrative experience of our lives, our nation, our culture, and our faith.”⁶⁶ Added to this, in our current era with remote controls and internet viewing that welcomes binge-watching and channel-changing, we do not want to follow any narrative that is not immediately entertaining. Even if we are engaged, we often digest as much as we can, as quickly as we can. Diagnosing our television/internet habits, Rushkoff writes, “The bigger challenge is creating content compelling enough to watch, and to do so without any setup at all.”⁶⁷ Theatre, I assert, does not adhere to the same rules. Instead, playwrights may “play” with the narrative structure, while upholding the tradition and maybe more significantly, the belief, that an audience can sit and watch a performance with our attention focused on the narrative that unfolds before us.⁶⁸ In fact, I posit that theatre performs a common and necessary public good for exercising our patience and this “cultural muscle” of sustaining interest in narratives we might now always want to see or find instantaneously gratifying. The conventions of theatre force us to put aside the constant distractions of life we have become so accustomed to, allowing the story and performance to remain center stage. Rushkoff advises us to find such moments of balance and lack of urgency: “It means we can stop the onslaught of demands on our attention, we can create a safe space for uninterrupted contemplation.”⁶⁹ Is theatre not such a safe, sacred place? In those moments of sitting in an audience, with my phone away and off, I remember how rare such moments of focus are, leading to a sense of temporal relief.

The question remains whether *Greenland* created such an experience for its audiences. It appears that the play, with its narrative structure that seemingly tried to replicate on stage the world of internet/remote control watching. It did not resonate with critics who wanted a more centralized narrative rather than the disjunction dictated by the script and

playwrights. Unlike some other plays I have discussed, the multiple narratives in *Greenland* appeared to be too many, which compromised how spectators related to the characters. Perhaps the play tried to do so much that it resulted in it not doing enough at all. In wanting to demonstrate the immediate needs of climate change to a presentist-oriented audience, the playwrights may have forgotten that theatre should not compromise its narrative to do so—whether linear or not.

Nonfiction Narratives and The Phenomenology of Reading versus Watching

Simply put, more stories need to be told about climate change to combat the dismissal, lack of knowledge, and inaction toward climate change scientists' proposals and concerned politicians push for policy changes. This has been increasingly true as many newspapers dismantled "their science and environmental reporting staffs" from 1989 to 2013, shifting from ninety-five newspapers that had science sections to only nineteen.⁷⁰ This has greatly reduced climate change reporting, making it increasingly more difficult for information—well researched, accurate, and true—to be disseminated. While theatre is slowly but surely responding to climate change, there are a burgeoning number of nonfiction narratives that are tackling the topic from various angles in the dwindling of news media reporting.⁷¹ These works address many of the same ideas and topics that the plays do in this section, but they also do so phenomenologically in a different manner, which is what I analyze here.

Such nonfiction literature includes Seamus McGraw's book, *Betting the Farm on a Drought: Stories From the Front Lines of Climate Change*. McGraw summarizes the present situation: "After all, insulated as we are, it's not a surprise that most harried Americans find little time to ponder the complex network that links their consumption of everything to the rising sea levels [. . .] Americans, who are by the millions treading water just trying to keep

pace with their mortgages and their rising grocery bills, would rather not think about the issue at all.”⁷² This is an intelligent explanation regarding some of our presentist procrastination, as many people in the United States and elsewhere have their attention diverted to more pressing matters that have consequences in the now.⁷³ His book describes how farmers are already affected in the United States by drought weather patterns, discussing how science “is not magic” and cannot give us all answers to climate change at once, but simultaneously acknowledges that science is “also the only tool we have to read the clock.”⁷⁴ Yet again, another clock/time reference appears in conversation with climate change. In the three plays I analyze there is only passing mention of rural communities or farming specifics. Naomi Klein’s book *This Changes Everything*, the basis for the documentary I mentioned at the beginning of this section, presents exhaustively thorough and startling research. Writing about the Copenhagen conference that *Greenland* depicted, Klein describes understanding that the United States government would likely not do anything significant for the climate, calling it a coming of age: “It was the moment when the realization truly sank in that no one was coming to save us.”⁷⁵ E. Ann Kaplan states that Klein’s book, nonetheless, offers a positive outlook regarding climate change, seeing it as a challenge that “might force societies to abandon greed and profit mongering.”⁷⁶ This hopeful tone was apparent in the documentary as well, and it is obvious from both the book and film that the target of Klein’s ire is capitalism and not humanity itself. In all three plays, capitalistic, short-term cultural habits are on display and critiqued, evident in Emmott’s assessment of our rapid consumption, Lisa’s harsh words about the grocery store waste in *Greenland*, and in *Earthquakes in London* regarding the commercial aviation industry.

Taking a more scientific bent, Elizaeth Kolbert’s *The Sixth Extinction* looks carefully at how the environment—flora and fauna and ocean acidification—is being affected by climate change. She cites that “one third of all reef-building corals, a third of all freshwater

mollusks, a third of sharks and rays, a quarter of all mammals, a fifth of all reptiles, and a sixth of all birds are headed toward oblivion.”⁷⁷ Her book looks at species before that have already gone extinct, touching on the great auk—harkening Oboler’s play *Night of the Auk* (with his interpretation that mankind would itself go extinct due to war and nuclear weapons). Kolbert describes how these findings point to us now being in the “Anthropocene” era, which was first referred to by atmospheric chemist Paul Crutzen, who described that “Human activity has transformed between a third and a half of the land surface,” and that “people have altered the composition of the atmosphere.”⁷⁸ Kolbert assesses in her last pages, “Right now, in the amazing moment that to us counts as the present, we are deciding, without quite meaning to, which evolutionary pathways will remain open and which will forever be closed.”⁷⁹ As a species we may be too expended in the present to ever truly understand what it is we are doing to the environment and Earth. Such is the world of presentism we live within and seemingly cannot escape; such is the world of living under the threat of climate change, where we might not see the long-term consequences in all of our short-term decisions.

All of these nonfiction titles, and many more in existence, illustrate that climate change science is not simply a question of scientific probabilities but also of our cultural practices, our economics and values, and of course, our ability to be concerned about how we treat time, whether it be the threat of it running out or our present temporal focus. These nonfiction works address many of the same themes the plays do: cultural practices *and* time are of the utmost importance in climate change science. Yet the phenomenologies between these two mediums are offering something quite distinct. Certainly, nonfiction books provide substantial research and information, which even Emmott on his best night of performance could not rival. This information is vital in an age when mainstream media is often not doing the reporting that it should, and information itself is hard to parse out as factual or not. Yet, I

contend nonfiction does not make the same impression on our presentist culture in ways that a theatre performance can, largely due to the way the phenomenological experiences differ between the two.

Georges Poulet in writing about the phenomenology of reading describes the “openness of the book”—in ways defining both what you do with the book and the consciousness that occurs when you read, where “the falling away of the barriers between you and it” happens as imagination takes hold.⁸⁰ He continues clarifying the many images, words, and objects introduced when reading, and the way in which he feels a personal attachment to the reading or a “take-over of my innermost subjective being.”⁸¹ His words feel experientially true, and writers like McGraw, Klein, and Kolbert have skillfully crafted their books to include personal stories of themselves and others, so one can develop a subjective relation—something likely easier in fiction—to this otherwise dense material. Reading is a personal act and one that is much more about an intimacy of consciousness between the story and mind, unlike the communal experience that is had in the theatre that is both personal and public. If I see a play on a night with a rowdy audience it will impact my experience by affecting what stimuli I perceive and the ways I interpret the performance in my consciousness, contrasted to how I get to be more selective in my experience as a reader. In a recent article, Jennifer Roswell evaluates how technology and digital reading affects the phenomenal experience of reading, including the embodied actions of reading, such as scrolling through pages versus flipping them.⁸² She describes how unlike the linearity of traditional books, reading now through apps and e-readers is usually more “hybrid,” and due to increased reading of news and stories online, overall “there is a greater fusion of reading and writing.”⁸³ One can read the news and write about a news story on the same social media site, like Facebook or Twitter, which is increasingly how many Americans receive their news.⁸⁴ Yet, more reading and writing that occurs through technology via social media is also

problematic. What if what one is reading and thus writing about constructs limited cycles of information, especially as it contains only topics that one finds interesting?⁸⁵ I suggest all this only to demonstrate that reading in this presentist moment is also affected by technology, distracted attention spans, and the present practice to read and write with less and less time for reflection to do so. While books are not prone to these same problems, per se, they too are affected by these trends given they are reading materials that are much longer than an online article; Bijan Stephens cites a study from the U.S. Bureau of Labor Statistics in *Time* that the average American only spends nineteen minutes reading a day.⁸⁶ Moreover, less and less of that time is spent reading books.⁸⁷

Bert States writes about reading versus watching, explaining the vital difference: “reading affords the leisure to go back and ponder,” but it offers “almost no phenomenal distraction.” The key word here being distraction—although we think of the word as negative, it can be a useful experience as well. States elaborates, “In reading, the eye is an anesthetized organ [...] In the theater, however, the eye awakens and confiscates the image. What the text loses in significant power in the theater it gains in corporeal presence.”⁸⁸ Reading about climate change matters, but it is the theatre that can move us, distract us—awaken the eye, as States discusses—through the corporeal presence of people in a shared time and space. We cannot jump to the final pages of a performed play like we can with a book, and we cannot ever truly extract ourselves from the theatrical demand that we share this experience with at least one other person. Due to this, I contend theatre and science plays offer our culture the reminder that climate change is about and affecting humans, collectively. While nonfiction literature imparts important knowledge for the public, as a method of engagement, it is a leap for those who are not already invested in climate change science—such as Lisa’s father Al demonstrates in his dismissive words in *Greenland* about nonfiction literature. Plays, instead, put a person on stage, and suddenly it is not about, or

only about, the science. It is now also about a human connection—between audience and actor—and a story is performed we are expected to listen to and watch. Of course, getting the public to the theatre is still the battle.

It is a wholly different phenomenological experience to observe humans affected by climate change on a theatre stage than to view a film, museum, or read a book. In watching scientists struggle to make us understand, like Stephen Emmott and Ray Boynkin, we see the human face of this sometimes-controversial science. Seeing non-scientist characters such as Lisa, Phoebe, Harry, Seydou and Alamir affected by climate change and try to alter the conversation surrounding it, professionally and personally, demonstrates that it is also *not only* the scientists who care. Theatre shatters our presentist busyness when we in the audience watch actors perform stories about climate change science. With little else distracting us, we may be able to be ever more present in the present within the theatre and absorb what we are watching through uninterrupted perspectives. And, perhaps, more significantly, we also gain a chance to experience empathy. David Krasner aptly describes such a situation:

Although my feelings exist in a different temporal and spatial consciousness than that of the actor, empathy nonetheless inspires my imagination, intuition, and observation in an act of comprehending another world. A spectator might watch a play about people whose lifestyles are different, but through a process of empathetic imagination the spectator is brought into contact with what for her is a vastly different living circumstance. This is empathy's potential: it allows us to cross the boundaries between us...⁸⁹

A nonfiction book cannot create this exact bond, nor can a museum or film to the same degree given the boundaries of space and time. As I have already demonstrated, citing the

studies by Dan Kahan and the research of Andrew Hoffman, empathy is vital for arguments about climate change to be persuasive. Unlike reading a nonfiction narrative, or even a fictive narrative about climate change, theatre forges this empathetic bond not only between the individual spectator and the performer, but rather the collective spectator as a community and the performer/s through the boundary crossing Krasner describes. It is an experience both individually and socially constructed, both an event that phenomenologically I experience through my subjective consciousness *and* do so while surrounded by others, affected by their responses. Climate change necessitates not only an individual empathetic response, but the ability for us as individuals to realize that we as a culture and society will be negatively impacted by climate change. Theatre lets us experience this together, as we are/will experience climate change together. In Mike Bartlett's *Earthquakes in London* this power of theatre is on full display as the play is able to capture our attention *and* evoke our empathy.

The Effectiveness of *Earthquakes in London*

Earthquakes in London spans five acts and tells the story of a father and his three daughters. Like *Ten Billion*, the father in this play is a pessimistic scientist who does not have much hope for the future. This time he is a fictional character. Much like *Greenland*, the play follows multiple narratives. Yet, rather than using the perspective of many disparate characters, *Earthquakes* presents a family affected by climate change. Bartlett explains the play should use as much set and costume as possible: "*It is too much. The play is about excess, and we should feel that.*" He adds, "*Scenes crash into each other impolitely. They overflow, overlap. The production should always seem at risk of descending into chaos but never actually does so.*"⁹⁰ My synopsis of the play cannot fully capture the way in which the plot progresses quickly for each character within each act, often with no clear delineation of scene markers. There is a seeming lack of linearity of the play as it is a collective web of

constant action; each character faces their independent circumstances, yet their stories are also interwoven at multiple points in the play. Furthermore, Bartlett's description lays out phenomenologically what an audience might experience and indicates the pacing and tempo of the show. Time should be fluid and urgent, imposing like the theatrical design he describes. We as an audience should be overwhelmed by how the play looks and feels.

The play begins in 1968 with Robert Crannock and Grace, who are a young couple on a date. Robert tells Grace that he is completing his doctorate degree studying atmospheric conditions on other planets. The two flirt, and we can sense an optimism and hope Robert possesses that we watch disintegrate over the many following acts. Grace and Robert become the parents of three daughters—Freya, Jasmine, and Sarah—whom we meet in the next scene, set in 2010. Scenes contain multiple settings, so the audience is introduced to a very pregnant Freya and her husband Steve, in another location Jasmine, who is nineteen, is conversing with a relative stranger, Tom, and finally the oldest daughter Sarah, a government official, is talking to her assistant. After Steve tells Freya he is leaving on a short trip, Freya responds, “The building might collapse while you’re away [...] They said there’s going to be an earthquake” (16). Steve tries to calm her down, but as Freya confides in him, “I’m a bit lost at the moment, Steve, really. Don’t go,” he replies, “Just three days. That’s all” (18). In terms of time, three days means everything to Freya in her anxious state. We learn why over the course of the play.

Intermixed with this conversation between Freya and Steve is a plotline in which Jasmine tells Tom about her “*very* political” performance art she will be doing that night (20). Jasmine is a free spirit, who lives her life with an energetic and impulsive honesty—which seems a result of her nature and partly how she was raised. In the play, she boldly performs environmental burlesque, gets involved with Tom, and kisses Sarah’s husband, Colin. After her fling with Tom, Jasmine informs her sister Sarah that Tom is blackmailing

her with pictures of her wildly drinking and having sex. His family in Africa is severely affected by climate change and out of desperation, he used Jasmine to get to Sarah's political influence, as currently she and the rest of the government are not "doing anything," including supporting airport expansion. He argues his family will die as a result (51). When Sarah talks to Tom, she tells him that she is aware of the plights in his country, but that as an elected government official, "we have to consider everything. Transport means investment. Investment means greater employment. Greater employment means less poverty" (53). Environmental decisions are weighed against political and economic choices, with most decisions leaning toward what is good-for-now instead of what is good in the long term.⁹¹

Peter, a young teenage boy, knocks on Freya's door after Steve's departure. Peter and Freya spend the rest of the day together, but her day is marred by surreal moments that are manifested by her nihilistic mindset about being a mom; we realize late in the play that Peter is not even real. She smokes and drinks, and at one point goes to the hospital under severe pain, telling the young doctor examining her, "You should get rid of it. The baby" (76). The play is dotted with many dream-like conversations Freya has as she seeks confirmation either of her earthquakes fears or of her impending motherhood. In the meantime, Sarah meets Carter, an airline business executive, admitting that while the public voted down the Heathrow third runway, she is actually proposing to stop expansion everywhere.⁹² The scene cuts to Steve in flight—we still do not know where he is headed precisely—and Jasmine comes on stage, "*dressed in branches and leaves. She holds a sign, which says 'The willful destruction of the rainforest'*" (28). She continues her "green performance" while the action jumps to Freya, who asks Peter if there is going to be an earthquake, "why aren't people scared?" (29). Her pervading sense of doom about the earthquake is analogous to climate change.

The scenes move in quickly shifting ways, as Bartlett has suggested. They fly by when reading the script, and as comments by critics will illustrate— they were even swifter when watching the play live. As Tom and Jasmine talk after her performance, Colin— Sarah’s husband—pops by to see Jasmine. Their misplaced flirtatious energy over the course of the play demonstrates how emotionally needy both characters feel. It also underlines the contentious status of Colin and Sarah’s marriage, as it is apparent they no longer see each other as the idealists they once were. The scenes move both seamlessly, and yet in juxtaposition because of the different lines of action. As the momentum grows, a new act begins, transitioning us back to the past to a different point in time in Robert’s life. This storytelling device is reminiscent of *Constellations*, only instead of peering into the future to learn more about these characters, we go to the past to have Robert’s history revealed, including why his familial relationships are so acrimonious.

Act Two begins in 1973. Robert speaks with two businessmen who represent the main airline for the UK. One of them reports that questions are floating around about “what the effect will be of all this air travel? With the emissions into the atmosphere” (40). Robert replies he needs to build a scale like no one has done before, and deduces, “obviously you’re hoping for a negative answer here aren’t you?” (40). They reply that they do not, but promise him future work in the “motor industry, oil companies [...] They would all be very interested in promising results” (41). The implication is clear and the high fee paid to Robert entices him. This moment repeats itself with Sarah and Carter in 2010. Carter shows Sarah scientific reports written by her father that indicated even though Robert knew emissions would be disastrous for the environment, he stated they would have “little or *no effect*,” repeating this finding for over twenty years (74). Like her dealings with Tom, she is not threatened and reveals to Carter that she would happily disown her father. Carter counters, offering her the chance to make more money outside of politics and government in the private sector working

for him: history is repeating itself. He proposes doing so would give her more time for her personal life and a way to make a real difference. Time is the one commodity Sarah desperately wants to save her marriage. This pitting of ethics versus economics thus shadows the entire play. The start of Act Three returns to Robert's accumulating work for the airlines. When Robert again meets the airline executives, telling them how his science proves the dire effects air travel can have, they buy him off yet again.

In the present, Steve knocks on Robert's door. Robert appears and is a man of seventy, who shares astute assessments of Steve that are nothing short of rude. Steve says "I know what you did to them," to which Robert replies "I told them the truth" (80). It is still unclear what this means or the implications, yet it is evident that Robert's tenuous relationship with his daughters is not something he apparently has much guilt about. In front of Steve, as if he is not even there, Robert recounts to the housekeeper that Freya visited him recently; Steve admits since that moment in time Freya never leaves the apartment and cries all the time. Robert lectures Steve about global warming and that the environmental system is somewhat stable, "then something happens [...] it collapses and changes, in hundreds not thousands of years. You understand?" (88). In the end, the system and world "want to get rid of us," The pressure of this scene swells, and simultaneously we see Colin and Jasmine getting high and dancing, Sarah saying goodbye to Carter, and the doctor leaving Freya's side. Robert continues:

Best way to reduce the carbon footprint? [...] Hold your breath [...] Freya came to ask my advice about children [...] I told her that her child will regret she was ever born. Hate her mother for forcing her into a terrible world. I told her to do whatever it takes. I told her to kill it. (96)

His words were akin to a prophecy in a Greek tragedy for Freya. Robert adds with no sympathy, “It’s Weimar time, it’s Cabaret [...] We know there’s nothing to be done [...] Freya’s not the first to suffer, and she won’t be the last” (97). Similar to Stephen Emmott, Robert thinks we are fucked. Steve counter argues with Robert that his daughter will be clever and practical, and the “world’ll be better with her in it [...] this isn’t the future, she’s already there, thinking, learning” (110). Steve cannot align his thinking with Robert’s as his daughter’s future is already a reality unfolding in this present; she is not an abstract being but is instead his daughter he already cares deeply for. As Steve leaves he takes Robert’s book out of his bag and recalls a section in it about angry old men, standing on “street corners with signs [...] They want the world to end when they do” (111). Steve rejects Robert the prophet.

Sarah does too. She will not repeat her father’s legacy, and she tells Carter, the airline executive, that she called the Prime Minister and received a guarantee to a total halt to airport expansion (118). She wants to become the hopeful idealist she once was, that her husband once loved. Freya wanders the city, and in her delusional state, imagines Peter turning into her soon-to-be-born daughter Emily, who warns her of a future of shantytowns and bleak circumstances. It is Robert’s apparent vision of the future projected into what Freya fears for her daughter. In a last ditch effort, she climbs over the side of a bridge, ready to jump. She had told her family to meet her there, and Jasmine, Sarah, and Colin arrive, and Steve, still traveling back home, calls her. However, while on the bridge “*The ground shakes. An earthquake. The bridge is moving,*” and she slips (136). There is a blackout.

In 2525 or a hospital, as the stage directions describe, Freya is visited by her mother, Grace. Grace tells Freya she is in the future—it appears that she is in some sort of afterlife or comatose hallucination. Grace tells Freya that the date on the bridge, the place where she fell, was the “moment. The tide turned” because of the speech that was given (143). Freya is confused as Grace keeps mentioning a woman named “Solomon” that “walked to London,

stood at the centre of the earth and changed everything” (144). The family in present time grapples with Freya’s medical crisis. Robert appears at the hospital, but Jasmine does not recognize him. He has come to say goodbye and to give Freya a dress of their mother’s, to which Jasmine states, “Bit fucking late now” (152). Sarah enters and drinks with Robert and Jasmine, as the three surrender to the gravity of the moment. In Freya’s surreal future Grace tells her, “this is the future and I am your mother. But this is also the past and the present, and I am your father, your sisters, your friends, your husband, your friends, your husband [...] we are everyone that is, was, and everything that will be. I’m nature all in one. So are you” (153). In this moment, time, space, and being have collapsed for Freya. The family takes leave of Freya as she passes away. Yet, Emily, her baby, has lived. At the end of the play we see Emily enter, “sixteen [...] Bright, optimistic, intelligent” (156). She wears the floral dress Grace wore in the first scene—the same dress Robert brought to Freya in the hospital. We learn that it is Emily who goes barefoot to London and stands on the bridge her mother fell from years earlier. Emily Sullivan has become “Solomon”—a visionary leader—that her father Steve told Robert she might be, and she will change the world in the way that Grace spoke of to Freya. It was Freya’s daughter that changes the world, which changes the legacy this family has left on the planet. It is a final message of hope.

Charles Spencer for *The Telegraph* called the play the “equivalent of a thrilling roller coaster ride,” and that the “sheer energy and the ambition of the piece are irresistible.”⁹³ Michael Billington touched upon the time leaps in the play, writing, “Bartlett’s play spans the period from 1968 to the distant future and, in essence, deals with our disregard for our planet. Wisely, it tackles a vast theme by pursuing the fortunes of a single family.”⁹⁴ He concluded by describing the work as a “big play that has the courage of its convictions.”⁹⁵ Aleks Sierz for *The Arts Desk*, also described the play in similar terms to Spencer and Billington:

The complex family conflicts between father and three daughters, and between the siblings themselves, and then between the sisters and their spouses, are confidently and convincingly sketched out, and Bartlett weaves all of these strands together in an epic tapestry of metropolitan life. It's hard to convey the thrilling fragmentation and ambitious sweep of this amazing play, so you just have to close your eyes and imagine that the whole of the action takes place in a crowded bar.⁹⁶

The pacing of the play, its shape, and overlapping pieces of story appear to have electrified the critics. In a play that spans decades, the temporality of the play is an essential ingredient of the work; the play compresses time in the ways these multiple strands of plot overlap and are returned to, threaded together to make a stimulating collage. This nature of the play feeds our presentist need for the fast and frenzied stimuli we receive from technology and entertainment. However, the play also extenuates time, offering an astute critique of our behaviors and cultural patterns, by covering a span of years where we see the effects of climate change on this family and on society at large. By demonstrating the past, present, and future of climate change through this family's actions, which had personal and public consequences, Bartlett composed an intelligent dramatic portrayal of climate change on stage. It is evident from the reviews that the play is good art, making it an effective play about climate change that did not sacrifice its own content for the sake of its form. Its 2010 production successfully, as Julie Hudson described, "combines textual richness with visual excess."⁹⁷ Almost all of the reviews also mention the quality of the performances, which added to the play's quality and effectiveness. The story resonates because of its structure and the characters, who are interconnected in ways that mirror many successful theatrical works: it is about family, which is relatable to audiences. At the same time, the play broaches the

topic of climate change, displaying its scientific, political, and cultural reach, without losing its human touch or ability to generate empathy in the audience.

In his book, Ghosh describes the “mysterious absence of climate disaster from contemporary arts and fiction [as] the central issue,” asking if one day arts and literature will “be remembered not for their daring, nor their championing of freedom, but rather because of their complicity in the Great Derangement?”⁹⁸ That complicity is often one of silence and absence in the theatre. Plays like *Ten Billion*, *Greenland*, and *Earthquakes in London* and books like *The Sixth Extinction*, *Betting the Farm on a Drought*, and *This Changes Everything* exemplify that there are those daring and hopeful enough about our future to question short-term economic and political practices that reinforce cultural habits that are not ecologically mindful. Do we have enough time for these theatrical and other representations to make any difference? Ultimately, time will tell.

What do we do now?

The three plays I discussed in this chapter were all British works, staged at prestigious theatres in London. In the United States plays about climate change have been far less mainstream than abroad. It is not surprising when one considers that in the United States, green initiatives sometimes stall, recycling programs can teeter, and the discussion of the climate is present, but not always center stage—and not without strong dissidents. Wuthnow writes that the consensus at the beginning of the twenty-first century in America was that “the planet probably had been warming and would continue to do so, but largely endorsed the notion that there was too much uncertainty about scientific predictions to warrant significant regulations.”⁹⁹ Similarly, Andrew Hoffman adds that climate change will not force people to be “increasingly open to the reality of climate change” until catastrophes continue to affect the economic market “and costs begin to rise for both business and the consumer.”¹⁰⁰

In Chapter Two I wrote in my discussion of phenomenology how our brains tie together little moments of time into a composite, and the composite uses our experiences and knowledge to formulate what it is that we perceive. I stated that our brains are not blank slates for incoming stimuli, using past “data” to anticipate what we will experience. What makes climate change so difficult for our brains to perceive is that we as a species cannot recall an experience like it, nor can we seem to absorb the scientific knowledge that is developing, demanding that we pay better attention. We have forgotten that as a progressing species with an increasing ability to travel and communicate like never before, just how time-centered our Earth and environment remains. The environment does not care if we can do more in less time or how much money we can earn. Earth continues to follow the rhythms of time to which it responds, even if we are the ones who are speeding the clock on the climate. We have hastened ecological change as a result of our human activity. And because we are so consumed with other human problems and events, we cannot see past our present horizon into the future, where the world we come to know is unlike any world humans have ever seen. This may include our own demise, which as I discussed in my chapter about Phenomenology and Heidegger’s thoughts on death, is something that we not only struggle to comprehend on an individual scale, but also on a larger species scale. How can we in our consciousness fathom something like that?¹⁰¹

In the meantime, scientists lecture, writers write, and theatre artists continue to create theatre, hoping that maybe with more information and insight, we as a species will collectively take action. Already theatre scholar/practitioners like Theresa May and Wendy Arons have expressed a desire to “provoke an increasingly diverse and complex discourse, one that has the purpose of inspiring *artists* as well as scholars,” as they write in their introduction to *Readings in Performance and Ecology*.¹⁰² Una Chaudhuri too continues to analyze climate change, recently writing about approaching it with dramaturgy. She makes

clear her views, reminding us that, “It’s no surprise that reaching across the fourth wall is one of the ways contemporary theatre is engaging with the ecological crisis.”¹⁰³ Kirsten Shepherd-Barr in her latest book, *Theatre and Evolution from Ibsen to Beckett*, includes a brief summary about climate change dramas, writing that some “see theatre as playing an almost-salvationist role, getting us ‘back to nature in an authentic way,’” because it is a “live experience.”¹⁰⁴ I am one of those people. There are groups like Climate Change Theatre Action, which started a “series of worldwide readings and performances presented in support of the United Nations Climate Change Conference.” Now, the organization has reportedly “grown into a global movement. Theatre artists reached across geographical and cultural borders, and united in our common concern for the planet,” and there have been related readings, productions, and unique performances staged in many countries across the planet.¹⁰⁵ There are also demonstrations and marches happening that may be assessed from a performance studies lens, like the People’s Climate March, for example, that took place in New York during September 2014, which “demand[ed] action from leaders” due to the lack of progress made by the U.S. and China on climate change.¹⁰⁶ There are more demonstrations being planned due to the policies possible under the Trump administration. People are still making theatre and writing science plays to convey the message about climate change, hoping that somewhere and somehow, audiences will watch and listen.

The April 2016 edition of the *Chronicle For Higher Education* featured an article titled, “Why Theater Majors Are Vital in the Digital Age” by Tracey Moore. She discusses how theatre classes have different requirements from typical college classes and how acting reflects and studies human behavior. Whereas technology and cell phones are “altering modes of attention” and many students “are unfamiliar with the experience of being alone,” students in theatre classes have to instead “connect with one another and themselves.”¹⁰⁷ Her words tap into an undercurrent I have articulated in this chapter; theatre’s role for younger

generations may matter even more due to presentist practices and culture, and the ways theatre counteracts them. Moore assesses that many theatre artists possess foresight, or “the talent to envision many possible outcomes or possibilities,” and this is “impossible without empathy,” which theatre fosters for students in classes around the country.¹⁰⁸ For all of the books, articles, and news media, perhaps it is in the theatre where climate change may be understood differently. It is in the theatre, after all, where playwrights have envisioned the world impacted by climate change and where the actor and audience member can experience that rare connection that is undisturbed by an altering mode of attention. It is in the theatre where audiences can empathize with the scientist, or the young protestor, or the government politician—all of whom may struggle to do what is most effective to help reverse the effects of climate change in whatever way they can. In climate change plays, where the present direly matters, a living connection of copresence between the spectator and the character onstage is perhaps one of the last vestiges that can break the time-numbing hum of presentism. Our presentist age makes it hard to see ahead or care beyond our current scope of worries that affects us personally, and it distracts us with all of the information and stimuli technology has accustomed us to. We can hope theatre can instead make a difference. Like Alamir who told Seydou in *Greenland*, “We don’t have time” to worry, only time to act.¹⁰⁹ Through getting audiences to empathize with onstage characters and care about the science of climate change and its consequences, we may be able to reverse or at least halt the clock that ticks ever forward.

1. “Who We Are,” *Sierra Club*, <<http://www.sierraclub.org/about>> (accessed 5 Aug. 2016). *This Changes Everything – The Film*, dir. Avi Lewis, (Canada: Klein Lewis Productions, 2015).

2. “The Sierra Club-Kansas Chapter,” *Sierra Club*, <<http://kansas.sierraclub.org/about/>> (accessed 4 Aug. 2016).

3. Rob Nixon, “Sunday Book Review: Naomi Klein’s ‘This Changes Everything,’” *The New York Times*, 6 Nov. 2014 <http://www.nytimes.com/2014/11/09/books/review/naomi-klein-this-changes-everything-review.html?_r=0> (accessed 20 July 2016).

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4. For this particular viewing, the Sierra Club attended the film because the organizing members had asked the theatre to play it. Demographically, it appeared roughly ninety percent of those attending the film that night were Sierra Club members, most over the age of fifty.
 5. I do not exclude myself in this criticism, as I too know more and do not often do as much as I can.
 6. Amitav Ghosh, *The Great Derangement: Climate Change and the Unthinkable* (Chicago: U of Chicago P, 2016) 8.
 7. Richard Wike reports that when asked if global climate change is a very serious problem, 20% of American Republicans responded yes, 41% of Independents did, and 68% of Democrats did. He also adds, “Majorities in all 40 nations polled say climate change is a serious problem,” but the areas where people are most concerned live in Latin America and sub-Saharan Africa. See Wike, “What the world thinks about climate change in 7 charts,” *Pew Research Center*, 18 Apr. 2016, <<http://www.pewresearch.org/fact-tank/2016/04/18/what-the-world-thinks-about-climate-change-in-7-charts/>> (accessed 10 July 2016).
 8. Douglas Rushkoff, *Present Shock: When Everything Happens Now* (New York: Penguin Group, 2013) 3.
 9. As I stated in my Introduction, theatre still asks us to sit in the dark, to put away our technology, and to watch the performance without distracting ourselves or controlling the way the performance is watched (as opposed to internet viewing habits). This, as I argue in my dissertation, counters the presentist culture most of us experience, which is habituated by technological inundation of new stimuli.
 10. NASA differentiates global warming from climate change. Erik Conway explains, “Global warming refers to surface temperature increases, while climate change includes global warming and everything else that increasing greenhouse gas amounts will affect.” Elaborating further, NASA uses the term global climate change to encompass all the changes that will happen to Earth and life on earth that go beyond just the effects of changing climate (including precipitation patterns and the sea level). Agreeing this term is more inclusive of the full scope of the picture, I use climate change as it has more popularity and currency, but still on occasion use the term global warming as it is still something people culturally refer to. See Erik Conway, “What’s in a Name? Global Warming vs. Climate Change,” *NASA*, <http://www.nasa.gov/topics/earth/features/climate_by_any_other_name.html> (accessed 11 July 2016).
 11. Riley E. Dunlap and Robert J. Bruelle, *Climate Change and Society: Sociological Perspectives* (New York: Oxford University Press, 2015) 1.
 12. Writing this prior to President Trump’s inauguration, since his election there has been considerable media attention regarding Trump and his appointed cabinet’s views on climate change science. Justin Worland on December 19, 2016 wrote in “Climate Scientists Fear Trump May Fatally Undermine Their Work,” that “Trump’s transition team has suggested that the incoming administration will not simply challenge the Obama administration’s policies but will also launch an attempt to undermine the years of science underpinning them. Such an effort could have major implications for the credibility of U.S. government data—and the ability of the world to fight global warming.” See Worland, *Time*, <<http://time.com/4602461/climate-change-scientists-donald-trump/>> (accessed 28 Dec. 2016). To this end, I should also explain I use Naomi Klein’s use of the word “deniers” to refer to those who do not believe or consider climate change science a serious issue. Andrew Hoffman discusses segments of the population that are defined as Alarmed, Concerned, Cautious, Disengaged, Doubtful, Dismissive. Certainly, his words are slightly more generous

if not specific, but I defer to Klein as I think the gravity of the word denier gives context to the polarization at hand, particularly in this current political climate. Alexander Verbeek, a Strategic Policy Advisor on Global Issues of the Netherlands and Yale World Fellow, also uses the word extensively on Twitter, especially now as the suggestion of living in a Post-Truth world is gaining more traction.

13. “Major Gaps Between the Public, Scientists on Key Issues,” *Pew Research Center*, 1 July 2015, <<http://www.pewinternet.org/interactives/public-scientists-opinion-gap/>> (accessed 11 July 2016).

14. See *Ten Billion*, directed by Peter Webber, 2015, <<http://www.tenbillionmovie.com/>> (accessed 4 Dec 2016). Looking at the trailer for the movie, one can get a feel for Emmott’s style of delivery and tone.

15. Garner, *Bodied Spaces* 41.

16. Michael Billington, “Ten Billion – review,” *The Guardian*, 19 July 2012, <<https://www.theguardian.com/stage/2012/jul/19/ten-billion-review-royal-court>> (accessed 15 July 2016).

17. Billington, “Ten Billion.”

18. Robin McKie, “Stephen Emmott, co-creator of Ten Billion: Interview,” *Population Matters*, 22 July 2012, <<http://www.populationmatters.org/stephen-emmott-cocreator-ten-billion-interview>> (accessed 22 July 2016).

19. McKie, “Interview.”

20. Matt Trueman, “Katie Mitchell and Duncan Macmillan on 2071,” *Matt Trueman*, 23 Nov. 2014, <<http://matttrueman.co.uk/2014/11/katie-mitchell-and-duncan-macmillan-on-2071.html>> (accessed 15 Aug 2016).

21. Trueman.

22. Julie Hudson, “‘If You Want to Be Green Hold Your Breath’: Climate Change in British Theatre,” *New Theatre Quarterly* 28.3 (Aug. 2012): 260.

23. Catherine Diamond, “Staging Global Warming, the Genre-Bending Hyperobject,” *Journal of Dramatic Theory and Criticism*, 30.2 (Spring 2016): 102-103. See also Timothy Morton, *Hyperobjects: Philosophy and Ecology after the End of the World* (Minneapolis: U of Minnesota P, 2013).

24. The book also has conjured time-oriented comments, with Harry de Quetteville writing for *The Telegraph*: “And with the book in his reader’s hands, Emmott clearly wants to offer no excuse for the time-starved or attention-deficit disordered to put it down again. The whole thing is set out in large, often bold type, with bullet points taking up less than half of each page, sometimes as little as a line. It can be wolfed down in barely more than an hour.”

See, de Quetteville, “10 Billion, by Stephen Emmott, review,” *The Telegraph*, 31 July 2013, <<http://www.telegraph.co.uk/culture/books/10208831/10-Billion-by-Stephen-Emmott-review.html>> (accessed 7 July 2016).

25. Stephen Emmott, *Ten Billion* (New York: Random House, 2013) 9. All future citations will be parenthetical.

26. Robert Engelman writes in “Six Billion in Africa” that women in Africa give birth on average to 4.7 children, “and the population is rising nearly three times faster than in the rest of civilization” (58). The U.N. even predicts that by the end of 2100, Africa’s population could be anywhere from 3 to 6.1 billion. Engleman describes that addressing what could be a potentially devastating population boom means first and foremost “making sure women have access to effective contraceptives and knowledge to use them,” and that “educating girls and women and equalizing their social and legal status to those of men” will help reduce such staggering rises in population (58-59). Wolfgang Lutz similarly reports this in his article “Global Demography: Population Inflation.” He writes that evidence from the Demographic

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- and Health Survey demonstrates that “more educated women want fewer children and tend to provide them with better opportunities in terms of health and education. More educated women tend to have better access to information and to reproductive health services that enable them manage their fertility” (25). See Lutz, “Global Demography: Population Inflation,” *The World Today* 67.5 (May 2011): 24-26; Engelman, “Six Billion in Africa,” *Scientific American* (Feb 2016): 58-63.
27. Dominic Cavendish, “Ten Billion, Royal Court Upstairs, review,” *The Telegraph*, 19 July 2012, <<http://www.telegraph.co.uk/culture/theatre/theatre-reviews/9412339/Ten-Billion-Royal-Court-Upstairs-review.html>> (accessed 4 June 2016).
28. Paul Taylor, “Ten Billion, Theatre Upstairs, London,” *The Independent*, 23 July 2012, <<http://www.independent.co.uk/arts-entertainment/theatre-dance/reviews/ten-billion-theatre-upstairs-london-7965767.html>> (accessed 15 July 2016).
29. Georgina Brown, 29 July 2012, and Dominic Maxwell, 19 July 2012, “Review: *Ten Billion*,” *Royal Court Theatre*, <<http://www.royalcourttheatre.com/whats-on/ten-billion/?tab=4>> (accessed 17 July 2016).
30. Garner, *Bodied Spaces* 44.
31. Chris Goodall, “Stephen Emmott’s popular book is unscientific and misanthropic,” *The Guardian*, 9 July 2013, <<https://www.theguardian.com/environment/2013/jul/09/stephen-emcott-population-book-misanthropic>> (accessed 14 June 2016).
32. Michael Shermer, “Book Review: 'Ten Billion' by Stephen Emmott; 'Countdown' by Alan Weisman,” *The Wall Street Journal*, 4 Oct. 2013, <<http://www.wsj.com/articles/SB10001424052702304213904579095371970506930>> (accessed 17 June 2016).
33. Diamond 108.
34. Diamond 110.
35. Joel Achenbach, “The Age of Disbelief,” *National Geographic* (March 2015): 44.
36. Achenbach 44
37. Achenbach 47. See also, Compass’s website at <<http://compassblogs.org/blog/2012/09/13/about-us-liz-neeley/>> (accessed 5 July 2016).
38. Andrew J. Hoffman, *How Culture Shapes the Climate Change Debate* (Stanford: Stanford UP, 2015) 6.
39. “Public Understanding of Science, Technology & Economics,” *Alfred P. Sloan Foundation*, <<http://www.sloan.org/major-program-areas/public-understanding-of-science-and-technology/theater>> (accessed 5 Oct. 2016).
40. A real life scientist on stage in many ways is a throwback to a bygone era, noted by Joe Kember, John Plunkett, and Jill Sullivan, editors of *Popular Exhibitions, Science, and Showmanship, 1840-1910* (Pittsburgh: U of Pittsburgh Press, 2012). Their book includes many examples of how science and performance intersected in the nineteenth century, often in ways that illustrated science’s ability to become a part of consumer/popular culture. These scientific-like shows also hearken back to previous centuries, like I noted in discussion of *An Experiment with An Air Pump*, or that I have written about in the inspiration of Mary Shelley’s *Frankenstein* and the popularity of galvanism-animal displays in her day. I mention these various shows, because some of the criticism directed at Emmott also repeats the criticism made about performative science shows at various points in history: are they examples of good science or even science at all? See, Alan S. Brown, “The Science that Made Frankenstein,” *Inside Science*, 27 Oct. 2010, <<https://www.insidescience.org/content/science-made-frankenstein/1116>> (accessed 9 July 2016).
41. Billington, “Ten Billion.”

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42. John Cook, "Yes, there really is scientific consensus on climate change," *Bulletin of the Atomic Scientists*, 13 Apr. 2016, <<http://thebulletin.org/yes-there-really-scientific-consensus-climate-change9332>> (accessed 9 July 2016).
43. Cook, "Consensus."
44. Rushkoff 2.
45. Rushkoff 4.
46. Rushkoff 4.
47. There are many articles and books dedicated to the ways in which technology and the digital age affect us as humans. This includes Mark Bauerlein's *The Dumbest Generation: How the Digital Age Stupefies Young Americans and Jeopardizes Our Future* (New York: TarcherPerigree, 2009); Nicholas Carr's *The Shallows: What the Internet Is Doing to Our Brains* (New York: W. W. Norton & Company, 2011); or Sherry Turkle's *Alone Together: Why We Expect More From Technology and Less From Each Other* (New York: Basic Books, 2012).
48. Janet Maslin accurately assesses of Rushkoff's book, "[it] is one of those invaluable books that make sense of what we already half-know." See, Macklin, "Out of Time: The Sins of Immediacy: 'Present Shock' by Douglas Rushkoff," *New York Times*, 13 Mar. 2013, <http://www.nytimes.com/2013/03/14/books/present-shock-by-douglas-rushkoff.html?_r=0> (accessed 10 Aug. 2016).
49. David Wiles, *Theatre & Time* (New York: Palgrave Macmillan, 2014) 60. Wiles is citing David Harvey, *The Conditions of Postmodernity* (Hoboken, NJ: Wiley Blackwell, 1990) 240.
50. Moira Buffini, Matt Charman, Penelope Skinner, and Jack Thorne, *Greenland* (London: Faber and Faber, 2011) 89. All future citations will be parenthetical.
51. Wiles 67.
52. Rushkoff 49.
53. This may be why Oklahoma Senator Jim Inhofe drew so much attention for his theatrics of bringing a snow ball on the senate floor, stating, "In case we have forgotten, because we keep hearing that 2014 has been the warmest year on record, I ask the chair, 'You know what this is?' ... a snowball, from outside here. So it's very, very cold out. Very unseasonable." While many news outlets derided Inhofe and his stunt for its misunderstanding of what global meaning means for temperature and weather instability, his antics are not so far-fetched from the common critique of global warming that rings in statements that can be overheard during a mild winter such as, "If this is what global warming feels like, I'll take it." See Kate Sheppard, "Watch a U.S. Senator Use a Snowball to Deny Global Warming," *Mother Jones*, 27 Feb. 2015 <<http://www.motherjones.com/blue-marble/2015/02/inhofe-snowball-climate-change>> (accessed 25 Sept. 2016).
54. Rushkoff 51. As I wrote these words prior to the studies and research done after the 2016 election, the abundance of "fake news," particularly shared on Facebook, has garnered attention. Currently, it is not only a matter of stories being disseminated and shared that are not highly journalistic, but now many do not have the intention of being true.
55. Rushkoff 8.
56. Rushkoff 170.
57. Adam, *Time* 146.
58. States 180.
59. Suzanne Goldenberg and Allegra Stratton, "Barack Obama's speech disappoints and fuels frustration at Copenhagen," *The Guardian*, 18 Dec. 2009, <<https://www.theguardian.com/environment/2009/dec/18/obama-speech-copenhagen>> (accessed 25 Sept. 2016).
- 60, Michael Billington, "Greenland-review," *The Guardian*, 1 Feb. 2011, <<https://www.theguardian.com/stage/2011/feb/02/greenland-review>> (accessed 12 Sept. 2016).

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61. Billington, "Greenland."
62. Paul Taylor, "Greenland, National Theatre: Lyttelton, London," *The Independent*, 2 Feb. 2011, <<http://www.independent.co.uk/arts-entertainment/theatre-dance/reviews/greenland-national-theatre-lyttelton-london-2202512.html>> (accessed 12 July 2016).
63. Matt Wolf, "In London, Climate Change Comes to the Stage," *New York Times*, 8 Feb. 2011, <<http://www.nytimes.com/2011/02/09/arts/09iht-lon09.html>> (accessed 9 July 2016).
64. Wolf.
65. Black holes are not empty space, but rather a great amount of matter packed into a small space, where "the result is a gravitational field so strong that nothing, not even light, can escape." "Black Holes," *NASA Science: Astrophysics*, <<http://science.nasa.gov/astrophysics/focus-areas/black-holes/>> (accessed 15 July 2016). Here perhaps the analogy is that the stage is a space that is not empty, instead full of a great amount of matter and story, but that nothing, not even human life, will escape it.
66. Rushkoff 13.
67. Rushkoff 36-37.
68. Surely, theatre has had its interventions with postmodern approaches that shy away from the plot linearity of Aristotle to which Rushkoff refers. I add here that although some theatre scholars welcome and embrace the age of technology in the theatre, I remain ardent that while we can have those performances and nights that include its use, we might urge our audiences, like Rushkoff says, to have time for this and remain undistracted.
69. Rushkoff 265.
70. Hoffman 42-43.
71. Climate Fiction, or Cli Fi, has received more attention in the last five years. J.K. Ullrich for *The Atlantic* cites that there are as many as 1,300 titles on Amazon in the genre, and unlike "traditional sci-fi [...] the pivotal themes are all about Earth."⁷¹ J.K. Ullrich, "Climate Fiction: Can Books Save the Planet?," *The Atlantic*, 14 Aug. 2015 <<http://www.theatlantic.com/entertainment/archive/2015/08/climate-fiction-margaret-atwood-literature/400112/>> (accessed 10 Sept. 2016).
72. Seamus McGraw, *Betting the Farm on a Drought: Stories From the Front Lines of Climate Change* (Austin: U of Texas P, 2015) 3.
73. Robert Wuthnow similarly describes that in America, what is worth more preservation than the environment is "economic well-being, jobs, familiar lifestyles, and the freedom for market forces to continue functioning with minimal government interaction," and that global warming is often taken in "stride, using the best in American ingenuity to combat it" (170).
74. McGraw 27.
75. Naomi Klein, *This Changes Everything: Capitalism vs. The Climate* (New York: Simon & Schuster, 2014) 12. Klein continues this line of thinking in her chapter, "No Messiah," suggesting that billionaires like Warren Buffet understand the severity of climate change, but nevertheless invest in coal-burning utilities, while having "large stakes in ExxonMobil and the tar sands giant Suncor" (234).
76. E. Ann Kaplan, *Climate Trauma: Foreseeing the Future in Dystopian Film and Fiction* (New Brunswick: Rutgers UP, 2016) 146.
77. Elizabeth Kolbert, *The Sixth Extinction: An Unnatural History* (New York: Henry Hold and Company, 2014) 18.
78. Kolbert 107-108. Kolbert's book, as Kaplan describes, offers "no solution" to these problems, and that "Kolbert prefers us to come to terms with the reality that change is impossible" (Kaplan 146).
- 79 Kolbert 268.

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80. Georges Poulet, "The Phenomenology of Reading," *New and Old History* 1.1 (Oct. 1969): 54.
81. Poulet 57.
82. Jennifer Roswell, "Toward a Phenomenology of Contemporary Reading," *Australian Journal of Language and Literary* 37.2 (2014): 117-128. Roswell's essay makes some interesting points about the embodied actions in digital reading (swiping, scrolling, touching apps versus flipping a page). She concludes that people today "make and produce texts as much as they consume them," referencing the use of social media to write (125). Of course, the problem with this is what are people saying as they write on social media—is this just self reflective or "bubbles" of knowledge, and if climate change is not in this sphere for a person, do they ever read or write about it?
83. Roswell 125.
84. "Two-thirds of Facebook users (66%) get news on the site, nearly six-in-ten Twitter users (59%) get news on Twitter, and seven-in-ten Reddit users get news on that platform," reports Jeffrey Gottfried and Elisa Sherer in "News Use Across Social Media Platforms 2016." See the article on *Pew Research Center*, 26 May 2016, <<http://www.journalism.org/2016/05/26/news-use-across-social-media-platforms-2016/>> (accessed 11 Jan. 2017).
85. Again, this idea has drawn increasing more attention after the 2016 political elections. A much-debated topic was "information bubbles" or "filter bubbles," such as that "highly personalized news feeds dish up a steady stream of content that reinforces users' pre-existing beliefs." Julia Carrie Wong, Sam Levin, and Olivia Solon, "Bursting the Facebook bubble: we asked voters on the left and right to swap feeds," *The Guardian*, 16 Nov. 2016, <<https://www.theguardian.com/us-news/2016/nov/16/facebook-bias-bubble-us-election-conservative-liberal-news-feed>> (accessed 27 Dec. 2016).
86. Bijan Stephen, "You Won't Believe How Little Americans Read," *Time*, 22 June 2014, <<http://time.com/2909743/americans-reading/>> (accessed 11 Jan. 2017).
87. According to a 2013 Huffington Post poll (which mirrors other polls and studies performed through other organizations, including the National Endowment for the Arts), out of 1000 U.S. adults, 42% had not read a nonfiction book in the past year and 28% of adults did not read a book at all. "Poll: 28 Percent of American Have Not Read a Book in the Past Year," *Huffington Post*, 7 Oct. 2013, <http://www.huffingtonpost.com/2013/10/07/american-read-book-poll_n_4045937.html> (accessed 11 Jan. 2017). I add to this the caveat that less people are reading plays, and theatre has for decades fought against the notion of it being a dying art form. I just also happen to think given theatre's liveness, embodiment, and communal experience, it as an art form can become both precious and more valued in the twenty-first century.
88. Last several quotes, States 28-29.
89. David Krasner, "Empathy and Theater," *Staging Philosophy: Intersections of Theater, Performance, and Philosophy*, eds. David Krasner and David Z. Saltz (Ann Arbor: U of Michigan P, 2009) 256.
90. Mike Bartlett, *Earthquakes in London* (London: Methuen Drama, 2011) 4 and 5. All future citations will be parenthetical.
91. This happens in the real world, evident in the sharp critiques Klein makes extensively in her book, which takes aim at many people, governments, and organizations. She illustrates time and again if the choice is profits or the climate, profits will win. Rob Nixon for the *New York Times* writes of Klein's book, "In democracies driven by lobbyists, donors and plutocrats, the giant polluters are going to win while the rest of us, in various degrees of passivity and complicity, will watch the planet die."⁹¹

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92. The politics behind Heathrow's possible third runway expansion has continued to draw debate for the past ten years.
93. Charles Spencer, "Earthquakes in London, National Theatre, review," *The Telegraph*, 4 Aug. 2010, <<http://www.telegraph.co.uk/culture/theatre/theatrereviews/7929004/Earthquakes-in-London-National-Theatre-review.html>> (accessed 12 Sept. 2016).
94. Michael Billington, "Earthquakes in London," *The Guardian*, 4 Aug. 2010, <<https://www.theguardian.com/stage/2010/aug/05/earthquakes-in-london-michael-billington>> (accessed 12 Sept. 2016).
95. Billington, "Earthquakes."
96. Aleks Sierz, "Earthquakes in London, National Theatre," *The Arts Desk.com*, 4 Aug. 2010, <<http://www.theartsdesk.com/theatre/earthquakes-london-national-theatre>> (accessed 5 Sept. 2016).
97. Hudson 265.
98. Raghu Karnard, "Why We Do Not Hear the Waters: Amitav Ghosh's 'Great Derangement,'" *The Wire*, 12 July 2016, <<http://thewire.in/50791/why-we-do-not-hear-the-waters-amitav-ghoshs-great-derangement/>> (accessed 22 Sept. 2016); Ghosh 121.
99. Wuthnow 170.
100. Hoffman 86.
101. I have the same strange uncanny feeling when seeing images or artifacts of dinosaurs. It is almost mentally incomprehensible to see them and think they were once the dominant species on the planet, and that we humans could ever end up like them.
102. Wendy Arons and Theresa May, eds., *Readings in Performance and Ecology* (New York: Palgrave Macmillan, 2012) 2.
103. Una Chaudhuri, "The Fifth Wall: Climate Change Dramaturgy," *Howl Round*, 17 Apr. 2016, <<http://howlround.com/the-fifth-wall-climate-change-dramaturgy>> (accessed 7 Aug. 2016).
104. Kirsten Shepherd-Barr, *Theatre and Evolution from Ibsen to Beckett* (New York: Columbia University Press, 2015) 284.
105. Chantal Bilodeau, "As the Climate Change Threat Grows, So Does a Theatrical Response," *American Theatre*, 30 Mar. 2016, <<http://www.americantheatre.org/2016/03/30/as-the-climate-change-threat-grows-so-does-a-theatrical-response/>> (accessed 25 Sept. 2016).
106. David Biello, "Cities to the Rescue," *Scientific American* (Dec. 2014): 15 and 19.
107. Tracey Moore, "Why Theater Majors Are Vital in the Digital Age," *The Chronicle*, 3 Apr. 2016, <<http://www.chronicle.com/article/Why-Theater-Majors-Are-Vital/235925>> (accessed 8 Sept. 2016).
108. Moore, "Digital."
109. Buffini, et.al 50.

Conclusion: Culture Transformations

Time lives an unparalleled life in the theatre, as this dissertation has substantiated. There are the realities of time needed for the production of a play, and there is the time of the performance itself to which an audience must surrender. The experience of time in the theatre is always one of phenomenological interest due to its collision of real time and theatrical time. The story of a play can be set in a different tense from the real present, it can jump between timelines and moments in time, and it can collapse divisions of tense altogether. Comparing the phenomenology of theatre to the phenomenological experience of other scientific representations, science plays have heightened expectations given their demand of an audience's attention and the directed control by theatre makers to the phenomena an audience engages with. This, I posited, adds to the efficacy of a play as a presentation of scientific ideas and concerns due to our presentist cultural orientation of time, where we otherwise are distracted all too easily. Added to this unique phenomenology of the theatre is the element of embodiment, which I have claimed helps us when watching science plays relate to scientists, reminding us of the human dimension of science that is often forgotten in the headlines about new scientific discoveries or scientific debates.

Of course, in science plays, time also operates uniquely under the many ways in which I explored specifically in this dissertation. In examining many science plays, I established that time is critically important to the nature of these scientific dramatizations and adds to the beauty, cultural significance, and intelligence of these works. The titles I have analyzed covered a vast array of ideas about time, science, and culture, including the arrow of time, causality, ethics of science and research ethics, the role of gender in science, possible structures of the universe, the history of science, the implications and dangers of the atomic bomb, fear that advances in science may change time and our culture, hope that science will

save us, fear of running out of time due to climate change, and the impact of presentism and tense demarcations on how we view significant scientific ideas and events. As I wrote in the introduction, the purpose of this dissertation is to explore the relationship between culture, time, and science that distinctively manifests within science plays, answering the question that if science has (or has not) affected the way we think and behave, why that might be so. To answer: yes, science has changed the way we think and behave. This is evident in science plays. Playwrights have responded to science in ways that both celebrate its wondrous possibilities and articulate concerns about its practices and implications. These playwrights are responding to cultural attitudes—as playwrights always are—thereby proving that science affects the way we think and behave as a culture. These plays demonstrate the hopes and fears that people can feel toward science, its imparted knowledge, and its consequences. The critical response and public reception of these plays have been varied, but it is clear that when a science play is successful, its impact is something that leaves the audience reconsidering our cultural role with science.

However, a lot can change in a short amount of time, particularly in our culture. Even as I write these words and I have gone back to work on parts of this dissertation over the span of the past year, I have come across my own scholarly naiveté. In early 2016 I could not foresee that climate change or nuclear weapons would become quite so threatening, given our new political climate and the policies and beliefs of many of the most powerful people in this country and world. Today as I write these words President Trump has said he wants to ensure that the U.S. stays at the “top of the pack” with our nuclear arsenal, and there have been many headlines in recent weeks about nuclear weapons and new U.S. responses to the Iran nuclear treaty and North Korea nuclear missile testing.¹ The fears of nuclear war have been more frequently provoked in recent weeks. Writing about atomic bombs and the ways in which we trust those making decisions about their use, I did not think it would become such a

pertinent conversation under the presidency of Donald Trump. The Doomsday Clock has since moved to two and half minutes away from midnight, the closest it has been in sixty-four years; the only time it has been closer was in 1953 when the U.S. and the Soviet Union were testing thermonuclear bombs.² Months ago, I did not expect to read articles about scientists having to protect environmental data, and that “Since Mr. Trump’s election, about 50 scientists at universities around the country have volunteered their time — and computer servers — to save and store government data stored on the websites of the Environmental Protection Agency, NASA, NOAA, and the United States Geological Survey.”³ I did not anticipate Scott Pruitt, who has many ties to the fossil fuel industry, heading the Environmental Protection Agency, and that many environmental groups would decry this as potentially devastating to the fight against climate change. I did not think there would be discussion of a Science March in Washington D.C. on April 22, 2017 to combat “An American government that ignores science to pursue ideological agendas [that] endangers the world.”⁴ I was focused on interdisciplinary bias and the ways in which we should know more about science, that I did not fully understand that I was in a culture battle, where many would soon have to argue vehemently against scientific ignorance, anti-intellectualism, and the avoidance of reality and truth. In my earlier research I did not understand that culture was about to shift, and maybe it had already been shifting, and I, like many, had simply not seen it coming. In the face of how science is currently being treated, let alone the arts and education, it is hard not to think these are frightening times.

A second on Earth lasts the same amount of time that a second did in 2016, 2015, 1812, 1799 and in the years ahead and the years before. There is a comfort to be found in time’s stability, and perhaps more accurately, our desire to believe in time’s stability. Yet, time is also not this simple: time experientially changes as we change. Our culture continues to transform, science continues to progress, and theatre artists will continue to respond. In the

next few years it is hard to say precisely what difficulties science will face, but it appears they will be significant ones, and ones predicated on how our culture values and believes in science despite contrary messaging. Science plays in the next few years will continue to be culturally relevant in dispelling the idea that science does not matter to how we think, behave, and perhaps even survive. There is more work to be done in analyzing science plays, doing so in theoretical and scholarly ways that have not yet been applied to these theatrical works. There is more work to be done by science playwrights that will emerge in the coming years, responding to the advancements of science as knowledge and the battles that science as a discipline and cultural force will face that it has not yet before. Time will only tell what these challenges will be.

Adam Frank writes, “By recognizing that we have invented and reinvented time, we give ourselves the opportunity to change it yet again.”⁵ To conclude, my work this past year proves to me that we can be the makers of this change in positive ways. As theatre artists and theatre scholars, and through our productions and analysis of science plays, we can do our best to ensure that science is valued in our culture, and valued in such a way where the truth matters and time is on our side as a species. That is a future I look forward to, and one we all should be ardently interested in preserving and working toward.

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 2. Robinson Meyer, “The Doomsday Clock’s Most Dire Warning Since the Cold War,” *The Atlantic*, 26 Jan. 2017, <<https://www.theatlantic.com/science/archive/2017/01/the-doomsday-clocks-new-and-dire-warning/514544/>> (accessed 15 Feb. 2017).
 3. Coral Davenport, “With Trump in Charge, Climate Change References Purged From Website,” *New York Times*, 20 Jan. 2017, <https://www.nytimes.com/2017/01/20/us/politics/trump-white-house-website.html?_r=0> (accessed 24 Feb. 2017).
 4. Sean Rossman, “First women, now scientists to march on Washington,” *USA Today*, 26 Jan. 2017, <<http://www.usatoday.com/story/news/nation-now/2017/01/26/first-women-now-scientists-march-washington/97079742/>> (accessed 12 Feb. 2017).
 5. Frank 319 and 333.

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Appendix: Images



Image 1: An old sign, now located on a walking tour, which illustrates the main attractions of the Los Alamos area. Photo by author.

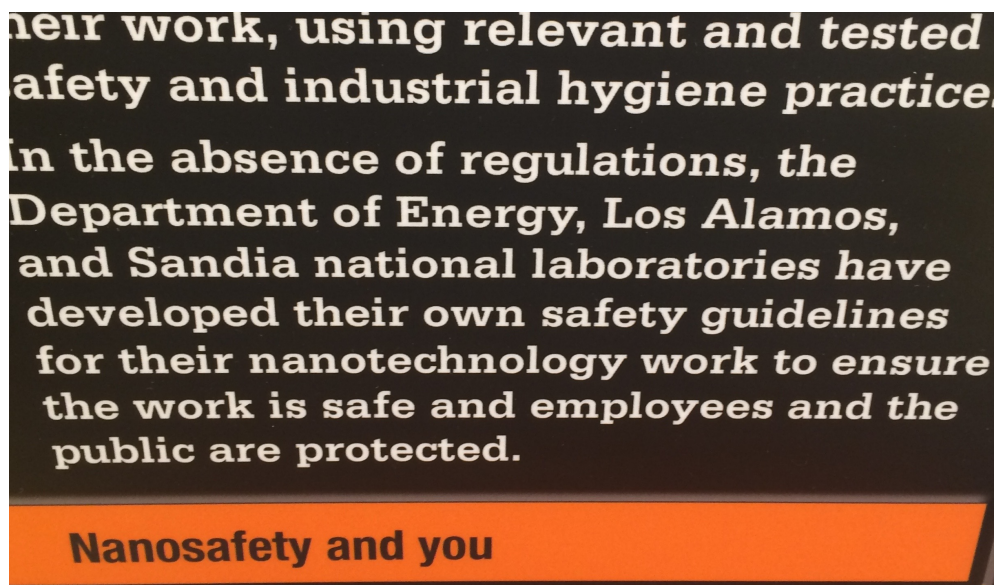


Image 2: An Exhibit Placard at The Bradbury Science Museum, which explains the safety regulations of nanotechnology. This is a short distance from the atomic bomb display. Photo by author.



Image 3: In Heritage Park at the National Museum of Nuclear Science and History there are several different full sized atomic devices and weapons on display. This is a casing of a Mark 17—one of the first mass produced hydrogen bombs. Photo by author.