LITERATURE AND SCIENCE:

A STUDY OF SELECT SCIENCE PLAYS

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A thesis submitted for the partial fulfillment of
the degree of Doctor of Philosophy

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FEBRUARY 2024

To my teachers, parents and God

Declaration

The work presented in this thesis has been carried out by me under the guidance of DR. ADRENE FREEDA DCRUZ at the Indian Institute of Science Education and Research Mohali. This work has not been submitted in part or in full for a degree, a diploma, or a fellowship to any other university or institute. Whenever contributions of others are involved, every effort is made to indicate this clearly, with due acknowledgement of collaborative research and discussions. This thesis is a bona fide record of original work done by me and all sources listed within have been detailed in the bibliography.

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In my capacity as the supervisor of the candidate's thesis work, I certify that the above statements by the candidate are true to the best of my knowledge.

DR. ADRENE FREEDA DCRUZ
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Acknowledgements

This dissertation is a product of years of effort. My heartfelt gratitude to my supervisor at the Department of Humanities and Social Sciences, IISER Mohali, Dr Adrene Freeda Dcruz, who fostered and nurtured my research enthusiasm, patiently dealt with my many shortcomings, and despite all odds, continued to work with me. I also thank my Thesis Committee members, Dr Ritajyoti Bandopadhayay, Dr Parth Chauhan and Dr Debdulal Saha, for their constructive feedback, constant support, and encouragement. My deep gratitude to Dr Anu Sabhlok and Dr V Rajesh for providing a healthy research environment in the department. I am also grateful to the library team of IISER Mohali, especially Dr P Visakhi, who made available the necessary books and articles very swiftly. The IISER Mohali institute fellowship financially supported the entire duration of this research project.

The support of my friends and colleagues made my doctoral journey at IISER Mohali a pleasant experience. Shilpa, Ankur, Manisha, Akash, Shriya, Yezad, Rajesh, Jayalakshmi, Nidhin, and Navdeep graced me with their company and their insights. Special thanks to Shriya for patiently discussing various topics and ideas that made into this thesis.

This journey would not have been possible without the constant support of my family. I am incredibly grateful to my parents, Sushma and Kailash Nath Pathak, for their unwavering support and love, and Vani, who is the source of my strength.

Vaibhav Pathak

Literature and Science: A Study of Select Science Plays

Abstract

The "Two Cultures" debate encapsulates the nuances of mutual interactions between literature and science. The present work situates itself in the field of literature and science by analysing select science plays spanning over the different branches of science. This research work explores the following plays: Bertolt Brecht's *Life of Galileo* (1943), Jerome Lawrence and Robert E Lee's *Inherit the Wind* (1955), Heinar Kipphardt's *In the Matter of J Robert Oppenheimer* (1964), Mohan Maharishi's *Einstein* (1996), Michael Frayn's *Copenhagen* (1998), Shelagh Stephenson's *An Experiment with an Air Pump* (2000), and Carl Djerassi and Roald Hoffmann's *Oxygen* (2001). The thesis addresses the issue of authority in science plays and investigates the responsibilities on scientists, their agency to dissent and the interaction of scientific authority with military, religious and judicial authorities. It also undertakes a literary analysis of the plays, focusing on literary devices and techniques such as allusions, wordplays, rhetoric, prosody, alliteration, humour, and sarcasm. Further, the work examines the utilisations of stage props, costumes, and other scenographic elements in science plays. The thesis is attentive to the lack of representation of women scientists and women playwrights in this field. The final part of this research work explores the lives and struggles of Rosalind Franklin in Anna Ziegler's *Photograph 51* (2015), Henrietta Leavitt in Lauren Gunderson's *The Silent Sky* (2015), and Emelie Du Chatelet in *Emilie* (2019). As there is a scarcity of scholarly work on science plays in literature and science, this thesis establishes a case for studying these plays as a viable medium of research by providing unique viewpoints for exploring the thespian art.

Synopsis

In exploring new ways of studying the thespian art, the thesis titled *Literature and Science: A Study of Select Science Plays* situates itself in the broader field of literature and science. Within this field, science plays, in particular, feature scientists or engage with scientific principles or ideas. The thesis seeks to explore such an interplay by analysing ten science plays, namely Bertolt Brecht's *Life of Galileo* (1943), Jerome Lawrence and Robert E. Lee's *Inherit the Wind* (1955), Heinar Kipphardt's *In the Matter of J Robert Oppenheimer* (1964), Michael Frayn's *Copenhagen* (1998), Mohan Maharishi's *Einstein* (2001), Shelagh Stephenson's *An Experiment with an Air Pump* (2001), Carl Djerassi and Roald Hoffmann's *Oxygen* (2001), Lauren Gunderson's *Silent Sky* (2015), Anna Zeigler's *Photograph 51* (2015), and Lauren Gunderson's *Emilie* (2019). The field of literature and science emerged as more than just an academic interest during the eighteenth century when these two subjects individually established themselves as interpretive authorities. The scientific revolution, led by figures such as Isaac Newton and Galileo Galilei, signalled the advent of modern science. This eventually gave way to curiosity and experimentation, leading to the analysis of works by authors such as John Donne, Jonathan Swift, and Johann Wolfgang von Goethe.

The history of literature and science can be traced from ancient cosmology to the works of Dante Alighieri, Geoffrey Chaucer, Christopher Marlowe, Francis Bacon, Alexander Pope, Isaac Newton, Samuel Taylor Coleridge, and Mary Shelley. In the late nineteenth century, Mathew Arnold's Rede Lecture responded to Thomas Henry Huxley's call for a more scientific education by arguing for an inclusive approach that encompassed literature and science. This debate took place as both literature and science were being institutionalised academically. In the twentieth century, scholars from non-literary backgrounds, such as CP Snow and J Bronowski, contributed to the field by exploring the intersections between literature and science. Snow's "Two Cultures" idea sparked debates and discussions, while other scholars

like FR Leavis, Aldous Huxley, and Sir Peter Medawar offered their responses and perspectives. The "Two Cultures" debate eventually led to the "Science Wars," which gained public attention in 1996 through the Sokal Hoax. The debate revolved around critiques of science criticism and the relationship between scientists and humanists.

Despite these conflicts, scholars aimed to find common ground and promote understanding between the sciences and humanities. Literary scholars and scientists further institutionalised the field of literature and science through their research and publications. Marjorie Hope Nicolson's work on British poets, particularly her exploration of Newton's influence on English poetry, played a significant role in establishing the field's credibility. The Modern Language Association (MLA) recognised the field by creating a division for literature and science in 1939.

In the 1970s, the field of literature and science gained increased interest through conferences and publications. However, scholars like GS Rousseau raised concerns that aimed to balance historical and theoretical analysis in the field, which divided scholars but appealed to a younger generation of theory-oriented students. The MLA published important scholarly works on literature and science in the 1980s, including *Interrelations of Literature* (1982) and *The Relations of Literature and Science: An Annotated Bibliography of Scholarship, 1880-1980* (1987). The Society for Literature and Science (SLS) was established in 1985 as an independent organisation, branching out from the MLA Literature and Science Division. The British Society for Literature and Science (BSLS), founded in 2002, has significantly promoted interdisciplinary dialogues and collaborations in the field.

There are debates and discussions among scholars regarding the nomenclature and typology of science plays. Kirsten Shepherd-Barr is a professor at Oxford and her concept of "science on stage" is inclusive, encompassing plays that portray the lives of scientists and those that portray scientific concepts. Carl Djerassi was a professor and playwright, and his idea of

"science-in-theatre" focuses on didactic plays that are true to both science and history. This thesis aims to analyse science plays by considering elements from both camps, seeking a comprehensive understanding of the field.

The thesis comprises four chapters that delve into unexplored aspects of science plays. The first chapter, titled "The Idea of Authority in Science Plays," examines the representation of authority, morality, and the responsibility of scientists in these plays. The chapter also explores the erosion of scientists' agency in an authoritarian environment. The second chapter, titled "The Use of Literary Devices in Science Plays," conducts a literary analysis to explore playwrights' employment of literary techniques. It examines formalised language, literary allusions, wordplays, dramatic structure, setting, sarcasm, poetic embellishments, historical context, and humour. The third chapter, "Props and Scenography in Science Plays," investigates the utilisation of stage properties in a written text, settings, directions, costumes, and lighting in creating an immersive experience in science plays. This chapter provides a much-needed scenographic study that has been lacking in the field. The fourth and final chapter, "Representation of Women in Science Plays," addresses the underrepresentation of women scientists and women playwrights in the field. It analyses three science plays written by women and featuring women scientists, exploring the limited opportunities, exclusion, and gender-based reduction faced by women in science. It also examines the societal limitations imposed on women pursuing science. This aspect has been largely overlooked in academic research on science plays. By addressing these four aspects, the thesis aims to fill the academic gap in the field of literature and science. The comprehensive analysis of authority, literary devices, scenography, and the representation of women contributes to a deeper understanding of science plays and their significance in the intersection of literature and science.

The first chapter, titled "The Idea of Authority in Science Plays," examines a selection of plays exploring the theme of authority within the realm of science and scientific discoveries.

Each play offers unique insights into different aspects of authority and poses thought-provoking questions about the ethical dilemmas faced by scientists and the repercussions of their choices. In Kipphardt's *In the Matter of J Robert Oppenheimer*, the focus lies on non-scientist's authority to pass judgment on scientific actions and the erosion of a scientist's ability to dissent within an authoritarian environment. The play portrays Oppenheimer as both an authoritative figure in his field and a victim of control by higher authorities over his beliefs and actions. Brecht's *Life of Galileo* showcases the oppressive power of religious authority and the challenges that Galileo encounters as he endeavours to disseminate his scientific knowledge. The play highlights various types of authority, such as religious, academic, political, and financial, which uphold the status quo and stifle dissent. Stephenson's *An Experiment with an Air Pump* explores the transition of authority from traditional and religious sources to scientific and rational thinking. The play sheds light on the male-dominated academic gatekeeping prevalent at the time and raises questions about the ethical boundaries of scientific research and innovation. Maharishi's *Einstein* depicts the clash between religious and academic authorities, emphasising the significance of dissent and questioning within both science and religion. The play also recognises the authority established by influential scientists throughout history, the role of journals, and the peer-review process. Djerassi and Hoffmann's *Oxygen* examines the ethics of scientific discovery and the associated authority. The play examines power dynamics within scientific committees, the pursuit of being the first in groundbreaking advancements, and the influence of public authorities. Frayn's *Copenhagen* explores themes of authority and ethics in the field of nuclear physics during World War II. It provides insights into the moral and ethical dilemmas faced by scientists involved in the development of nuclear weapons and the influence of state authorities on scientific research. Lawrence and Lee's *Inherit the Wind* focuses on the conflict between religion and science, highlighting the clash of authorities and the struggle between established academic authorities and religious beliefs. The

play underscores the importance of individual agency and dissent when faced with formidable opposition from religious, political, and judicial authorities. Overall, these plays provide nuanced explorations of authority within the realm of science, raising vital questions about the responsibilities of scientists, the limits and possibilities of challenging authority, and the ethical boundaries of scientific research. They invite audiences and readers to reflect on the intricate dynamics between science, authority, and morality within various historical and contemporary contexts.

The second chapter, titled "The Use of Literary Devices in Science Plays," examines the utilisation of various literary devices to engage readers and bring their stories to life. Kipphardt effectively portrays Oppenheimer's life and struggles effectively using formal language, literary allusions, wordplay, rhetoric, and irony. These elements not only delve into the personal ordeals of the renowned physicist but also explore deeper themes of ethics, morality, and the responsibilities of a scientist. On the other hand, Brecht's *Life of Galileo* utilises poetic embellishments, comic relief, and the inclusion of various languages to captivate the audience. His use of malapropism, sarcasm, and humour provides moments of relief amidst the play's serious themes. Furthermore, Brecht addresses the issue of language in scientific communication and emphasises the importance of vernacular language in reaching a wider audience. These plays demonstrate the effectiveness of literary techniques in theatrical works, creating engaging narratives that entertain while provoking thought and discussion. They stand as timeless works of art, showcasing the power of literature to convey complex ideas and emotions while shedding light on the lives and struggles of important historical figures. Mohan Maharishi's *Einstein* exemplifies the importance of collaboration between scientists and playwrights, echoing CP Snow's vision. The play stands out for its bilingualism, incorporating both English and Hindi in a unique manner. Maharishi skillfully employs literary techniques such as meta-theatricality, euphemism, and references to literary personalities to enhance the

play's impact. Similarly, in Djerassi and Hoffmann's *Oxygen*, the integration of language and literary devices highlights the complexities of scientific nomenclature and the role of women in science. These plays serve as exemplary works that merge form and content, setting a precedent for future science dramatists in India and beyond. *An Experiment with an Air Pump* and *Copenhagen* exemplify the intersection of science and literature in the realm of drama. Stephenson employs imagery, allusions, metaphors, satire, and sarcasm to create a science play that blurs the boundaries between science and literature. The inclusion of biblical allusions, literary references, and precise and engaging language bridges the gap between the two cultures. Similarly, Frayn's *Copenhagen* explores the uncertainty principle and uses metaphors to depict the condition of the characters. Frayn also addresses the issues of language and comprehension, exposing the challenges of communication in the context of scientific development. Both plays showcase the collaboration between playwrights and scientists demonstrating the potential for science and literature to inform and enrich each other. Lee and Lawrence's play *Inherit the Wind*, with its documentary-style approach and the use of various literary devices, offers a thought-provoking exploration of the clash between religion and science. The playwrights skillfully depict the deep-seated prejudices and heated debates surrounding the Scopes trial through biblical allusions, sarcastic humour, and vivid imagery. The characters' dialogues, filled with dogmatic language and scientific references, exemplify the ideological divide and the struggle between tradition and progress. By incorporating verse, metaphors, and nuanced language, Lee and Lawrence create a unique and impactful theatrical experience that sheds light on the complex relationship between faith and reason.

The third chapter, "Props and Scenography in Science Plays," explores the significant role of stage instructions, props, and costumes in conveying themes and messages in selected plays. Kipphardt's *In the Matter of J Robert Oppenheimer* effectively uses props, costumes, and documentary elements to recreate the trial and ethical dilemma faced by the physicist. The

incorporation of evidentiary materials, symbolism, and projectors enhances the appeal and gravity of the play. Brecht's *Life of Galileo* employs props such as models, instruments, and visual aids to convey scientific concepts and challenge traditional beliefs. Maharishi's *Einstein* utilises a range of props to enhance communication and symbolise themes. These props serve as powerful tools in storytelling, evoking emotions and highlighting the interplay between science and society. *Oxygen* showcases the significance of stage setting and costumes in creating an immersive laboratory atmosphere and conveying the relationship between science and ethics. Stephenson's *An Experiment with an Air Pump* utilises theatre scenography, lighting, and props to explore the interplay between art and science. *Copenhagen* captivates audiences through minimalist theatrical elements, allowing for creative staging techniques and introspective exploration of scientific inquiry and human relationships. *Inherit the Wind* employs stage instructions, props, and costumes to dramatise the clash between religion and science, emphasising the larger societal implications of the conflict. Overall, these plays demonstrate the vital role of theatrical elements in conveying themes, enhancing the dramatic experience, and fostering a deeper understanding of the profound ideas within each work.

The last chapter, "Representation of Women in Science Plays," delves into the representation of women scientists in science plays written by female playwrights. Through the analysis of three distinct dramas, the chapter sheds light on the challenges faced by women in the scientific field. These challenges include limited opportunities, marginalisation by male colleagues, gender-based gatekeeping, sexism, misogyny, societal pressures, character defamation, and a lack of recognition. The playwrights skillfully expose the multifaceted predicaments experienced by women scientists, narrating their enduring struggles. The chapter examines how the playwrights depict women scientists who are reduced to their gender, marginalised by their male counterparts, burdened by patriarchal norms, and subjected to misogyny, all while persevering in unfavourable working conditions. The selected science

plays featuring real-life women scientists provide valuable insights into the lives of these accomplished individuals. The playwrights' emphatic portrayal of women scientists offers a deeper understanding of their experiences. While there are numerous science plays that include women scientists as characters, this selection of plays enables a nuanced exploration of women's representation in science.

In conclusion, the thesis comprises four chapters that delve into various aspects of authority, morality, and responsibility within the realm of science and scientific exploration. It explores the erosion of scientists' agency to dissent in authoritarian environments, the influence of political and religious authorities on scientific development, and the ethical dilemmas scientists face during conflict. The thesis also sheds light on the challenges and contributions of women in science, highlighting their limited opportunities, gender-based discrimination, and overlooked achievements. Furthermore, the thesis analyses the literary devices employed in science plays, such as formalised language, literary allusions, and wordplay, which add depth and richness to the narratives. It examines how these plays explore the intersection of science, politics, and language and how they utilise metaphors, non-linear plots, and uncertainty to raise questions and provoke thought. Moreover, the thesis explores the use of props, costumes, stage designs, lighting, projections, and documentary elements in creating immersive scenography. These theatrical elements contribute to understanding the plays' themes and contexts, enhancing storytelling and engaging the audience in thought-provoking experiences. The thesis showcases the ability of literature and theatre in exploring complex themes related to science, authority, morality, and the representation of women in the scientific field. It highlights the importance of interdisciplinary approaches and the use of theatrical elements in conveying profound ideas and fostering a deeper understanding of literature and science.

Contents

Introduction

Post eighteenth century, the field of "literature and science" established itself as a formalised academic endeavour that aimed to capture the varied interactions between humanities and sciences. Undertaking an analysis of selected science plays, the present thesis situates itself in the juncture between these two fields of knowledge. With the advent of modern science, the field of literature and science also developed. During the seventeenth century, the founding figures of the scientific revolution, such as Sir Isaac Newton and Galileo Galilei, among others, together with the establishment of scientific bodies such as the Royal Society and the French Academy of Sciences, signalled the advent of modern science in Europe. This new field was viewed with much discomfort, as is evident from the works of John Donne, the debates between the Ancients and the Moderns, the Encyclopaedists, and also later figures such as Johnathan Swift and the romantics such as Johann Wolfgang von Goethe. The initial discomfort and anxiety later gave way to curiosity and experimentation as scholars of literature and science started analysing the works of Donne, Swift and Goethe.

Charting the history of literature and science, John H Cartwright and Brian Baker trace the interaction of the two subjects all the way from the fourteenth century to modern times. They discuss Aristotelian cosmology, Dante Alighieri's *Divine Comedy* (1308- 1321), Christopher Marlowe's *Doctor Faustus* (1592), the works of Chaucer, Francis Bacon, Margaret Cavendish and The Royal Society, and from Alexander Pope and Isaac Newton to Samuel Taylor Coleridge and Mary Shelley. Mathew Arnold marked the first milestone in the field of literature and science in his 1882 Rede Lecture, which he gave on his tour of America. Critiquing and replying to Thomas Henry Huxley's *Science and Culture* (1880), Arnold argued for a more inclusive education. Huxley, in his work, envisioned a new scientific school where there would be no place for "mere literary instruction and education" (216). Arnold was against exposing young students to a singularly focused curriculum, either scientific or literary, as on

their own, both would be equally futile. Arnold's response to Huxley consisted of two main points: first, literature does not encompass only works of canonical literature but includes written texts from all fields, including mathematics and science. Second, literature caters to our sense of humanity and beauty. According to him, if the students wish to understand themselves and the world comprehensively, they must read the best ideas expressed across history. The Arnold – Huxley debate took place at a crucial time in history when both literature and science were being institutionalised academically, particularly in Great Britain, Europe and America. Both these subjects were being taught at universities and scholarly societies, and multiple academic bodies were being established. The American Association for the Advancement of Science was founded in 1848, and the American Philological Association and the Modern Language Association (MLA) were established in 1869 and 1883, respectively.

From the twentieth century onwards, scholars from non-literary backgrounds made significant contributions to the field of literature and science by addressing broader cultural issues. Scientists CP Snow and J Bronowski's works added to the interdisciplinary field by highlighting the intersections between literature and science. Snow's seminal idea of the "Two Cultures", the literary intellectuals and scientists, elicits discussion and debate even to this day. Scholars from both sides have subjected the idea to much criticism as the topic continues to shape debates in the field of literature and science. The "Two Cultures" debate became institutionalised in North America and England and garnered much public attention. The literary scholar and critic FR Leavis strongly opposed Snow's views and accused him of elitism and alignment with the Oxbridge power structure. Other notable response to Snow was that of Aldous Huxley, who differentiated between private (literary) and public (scientific) discourses. Additionally, Sir Peter Medawar, the Brazilian – British biologist and writer, argued that since imagination is quintessential to science and poetry, these fields may not be separate cultures after all. Their most important contribution is the inclusion of the idea of the "Two Cultures"

into the public imagination, which prompted further discussions on the relationship between literature and science.

The "Two Cultures" debate later gave way to the cultural phenomenon known as "Science Wars". An academic debate garnered public attention in the spring of 1996 and was termed the "Sokal Hoax", which later became the "Science Wars". Alan Sokal, a physicist, wrote an article in the journal *Social Text* in which he supposedly applied postmodernist perspectives to physics and mathematics. However, the physicist later revealed the article to be a parody and a ruse that helped expose the inability of the cultural studies community to distinguish between serious scholarship and deliberate nonsense. The media widely covered the hoax and attracted much attention, both academic and otherwise. New participants entered the fray from both sides, and the debate grew into the "Science Wars", in which both sides were critiquing each other for venturing into fields beyond their areas of expertise. The roots of the discontent were sown much earlier with Steven Weinberg and Lewis Wolpert's critiques of science criticism. The publication of Paul Gross and Norman Levitt's *Higher Superstition: Academic Left and its Quarrels with Science* (1994) further intensified the conflict. Gross and Levitt examined various approaches to science studies, including literary, sociological, and feminist perspectives, and argued that these approaches exhibited intellectual laxity and hostility towards science. In response to this work, several articles were published in *Social Text*, including Sokal's article, furthering the controversy. While CP Snow hypothesised about the irreconcilable differences between the two communities and called for an urgent need for increased communication between the two fields, the "Science Wars" proved his hypothesis. To this day, the debate is relevant for scientists and humanists as it touches on deep and longstanding problems. The field of literature and science demonstrates the importance of serious engagement and the possibility of finding a common ground between practitioners of science and scholars of literature. Overall, these debates explore the relationship between

science and other fields of knowledge, raising questions about objectivity, the nature of scientific knowledge, and the cultural influences on scientific research. By delving into these discussions, scholars hope to advance the debate and promote a better understanding between the sciences and humanities.

Notwithstanding the "Two Cultures" debates and the science wars, literary scholars and scientists furthered the institutionalisation of literature and science. One early example is Carson Duncan's publication titled *New Science and English Literature* (1913). Another example is IA Richard's *Science and Poetry* (1926), which focuses predominantly on poetry's superiority to science. A substantial body of scholarship that recognised "literature and science" as a field emerged through Marjorie Hope Nicolson's research on British poets from the seventeenth and eighteenth centuries. Nicolson initially collaborated with Arthur O. Lovejoy, the founder of the "History of Ideas" school, and taught at Smith College before joining Columbia University. Her notable work includes *Newton Demands the Muse: Newton's 'Opticks' and the Eighteenth Century Poets* (1946) which explores the influence of Newton's ideas on English poetry. Nicolson's scholarship influenced similar projects on authors ranging from Chaucer to Thomas Hardy, ultimately lending credibility to the field. Another significant work in this genre is Douglas Bush's *Science and English Poetry: A Historical Sketch, 1590-1950* (1950), which provides a historical account of the interaction of science and British poetry. The Modern Language Association (MLA) observed the increasing specialisation among its members, and therefore, specific interest groups or divisions were formed. Literature and science gained recognition as one of the first MLA divisions in 1939, thanks to Nicolson's contributions. However, literature lagged institutionally in its connection to science compared to history and philosophy. The History of Science Society was formed earlier in 1924, and the Philosophy of Science Association in 1933. Other interdisciplinary groups also emerged, such as the American Association for the History of Medicine (1925), the Society for the History of

Technology (1958), the Society for the Social Studies of Science (1975), and the Society for Philosophy and Technology (1980). Each of these groups established journals and annual conventions to promote communication and legitimacy within the scholarly community.

In the 1970s, as the number of conferences and publications increased, so did the interest in literature and science. Simultaneously, prominent scholars like Prof GS Rousseau, who worked in the field of literature and science, expressed concerns about its legitimacy and rigour. Rousseau was a student of Nicolson and aimed to balance historical and theoretical analysis in literature and science. His method divided the scholars but appealed to a younger generation of theory-oriented students. Sessions at MLA meetings in the mid-1980s facilitated discussions on these issues. To cater to the rising interest in literature and science, MLA published two significant scholarly works in the 1980s: Jean-Pierre Barricelli and Joseph Gibaldi's edited work *Interrelations of Literature* (1982) which included a chapter titled "Literature and Science" by George Slusser and George Guffey and Walter Schatzberg's *The Relations of Literature and Science: An Annotated Bibliography of Scholarship, 1880-1980* (1987) which contained essays from G.S. Rousseau, Stuart Peterfreund, E.S. Shaffer, and John Neubauer. These essays captured the perceptions and directions of literature and science studies during that period. Other than these publications, numerous conferences on literature, science, technology, and culture took place in the 1980s. These conferences explored the interactions between various fields, attracting scholars from different disciplines. Notably, the Society for Literature and Science (SLS) was established in 1985 (later Society for Literature, Science and Arts, SLSA) as an independent organisation, branching out from the MLA Literature and Science Division.

SLSA aimed to engage with both literary and scientific scholars although literary scholars received more recognition in terms of rewards for presentations and publications. In 1987, Walter Schatzberg, who had long been involved in editing the MLA-sponsored

bibliography in literature and science, published *The Relations of Literature and Science: An Annotated Bibliography of Scholarship, 1880-1980*. This series is an encyclopaedia on the topic and provides valuable insights into the then state of literature and science. It was featured in the first few editions of the journal titled *Configurations*, the mouthpiece of the SLSA. N. Katherine Hayles played a significant role in bridging literature and science as a form of cultural studies with her book *The Cosmic Web: Scientific Field Models and Literary Strategies in the Twentieth Century* (1984). Her work explored the interactions of literature and science with respect to field models and literary strategies. Literature and science studies provide tools for characterising contemporary culture, where science and technology play complex roles. Many scholars in this field find themselves engaged in interdisciplinary programs that address broader critical and cultural topics, even without explicit "literature and science" labels. Founded in 2002, the British Society for Literature and Science (BSLS) is one of the recent academic organisations that has played a significant role in promoting interdisciplinary dialogues and fostering collaborations between these two traditionally distinct fields. The society organises numerous conferences and seminars annually and publishes the Journal of Literature and Science (JLS), a seminal journal in the field. Due to its diverse and fluid nature, the field of literature and science is likely to remain largely unhoused and un-institutionalised. This lack of formal constraints allows for the exploration of various configurations and distinct disciplinary perspectives. The field's practitioners continue to challenge assumptions and analytical patterns in both disciplines, creating fruitful interactions and energising new avenues of research.

The genre of science plays falls within the field of literature and science. Of the various interactions between literature and science, some scholars choose to explore the ones exhibited in plays. These plays can incorporate science or scientific principles in various manners. Firstly, there are plays that feature scientists and focus on the lives and times of these scientists.

These plays can portray the personal or professional lives of scientists. The portrayal can be true to history or can be fictional. Apart from this, some plays portray scientific principles or ideas or, at times, even scientific discoveries. These plays may or may not depict scientists in the plot of the play. These plays stay true to the science depicted in the play; in other words, the portrayal of ideas or principles is scientifically accurate. The playwrights who seamlessly interweave scientific ideas within the thespian medium achieve a commendable merging of form and content. At this stage of the introduction, it is important to establish that the plays that depict fictional scientific ideas or imaginary scientific concepts fall under the category of Science Fantasy Fiction (SFF) or Science Fiction (SF). Science Fiction Studies is a completely different field of literary analysis and is not the subject of this thesis. To distinguish his novels from the works of Science Fiction, Carl Djerassi named them "Science-in-fiction", where the plot is fictional but the science is not. The plays selected for analysis in this thesis belong to the field of science plays and not Science Fiction Studies.

The academic opinion on the nomenclature and the typology of science plays is a matter of heated debates and discussions among scholars in the field. Broadly, there are two groups or schools of thought. Kirsten Shepherd-Barr heads the first camp and is a Professor of English and Theatre Studies at St Katherine's College, Oxford University. She has written *The Cambridge Companion to Theatre and Science* (2020), *Modern Drama: A Very Short Introduction* (2016), *Twentieth-Century Approaches to Literature: Late Victorian into Modern* (2016, co-edited with Laura Marcus and Michele Mendelssohn), and *Theatre and Evolution from Ibsen to Beckett* (2015). Her magnum opus, however, is *Science on Stage: From Doctor Faustus to Copenhagen* (2012). In this work, she establishes what she calls "science on stage." This work features an appendix titled "Four Centuries of Science Plays: An Annotated List" containing around one hundred and twenty-five science plays. The list contains plays that portray the lives of scientists as well as those that portray scientific concepts. Shepherd-Barr's

idea of "science on stage" is inclusive and encompasses multiple kinds of plays. Her book and the appendix are indeed very informative starting points for every scholar in the field.

Late Professor Carl Djerassi heads the other school of thought. Prof Djerassi was an Austrian-born Bulgarian-American Chemist, playwright and novelist. For his contribution to the development of the oral contraceptive pill, he is named the "father of the pill." He was a professor at the Department of Chemistry, Standford University and wrote several plays and novels. His novels include *Cantor's Dilemma* (1989), *The Bourbaki Gambit* (1994), *Marx, Deceased. A Novel* (1996), *Menachem's Seed. A Novel* (1997), and *NO. A Novel* (1998). He also wrote multiple plays, including *Foreplay: Hannah Arendt, the Two Adornos, and Walter Benjamin* (2011), *Chemistry in Theatre: Insufficiency, Phallacy or Both* (2012), *An Immaculate Misconception: Sex in an Age of Mechanical Reproduction* (2000), *Oxygen* (2001, co-authored with Roald Hoffmann), and *Newton's Darkness: Two Dramatic Views* (2004). His contributions to the field of chemistry and literature make him a suitable candidate for bridging the gap between Snow's "Two Cultures." Djerassi devised the term science-in-theatre to describe science plays. However, his conception of a science play differs from that of Shepherd-Barr. According to him, a science play is didactic and is true to both science and history. Additionally, in his work *Chemistry in Theatre: Insufficiency, Phallacy or Both*, he also shared his vision and method of writing a science play. These ideas that is, "science-in-theatre" and "science on stage", differ from each other. However, considering the nascent stage of the field, there is scope for development on both sides of the aisle. This thesis focuses on elements from both camps for the selection of science plays for analysis by focusing on a comprehensive understanding based on inputs from both "science-in-theatre" and "science on stage".

Before moving on to the selection of plays, it is important to establish yet another aspect of this research. The fields of drama, theatre and performance studies are three distinct fields

of analysis. Drama focuses on the written aspect of a play, that is, the script or the text of the play. Performance studies focus solely on the performative aspect of the play, that is, the physical manifestation of the script on a stage and theatre focuses on both the written text as well as the performance of the play. This research limits itself to the analysis of the play's written text, which means that it falls under the category of drama studies. While discussing the merits of thematic approach in literature and science, Robert C Goldbort in "Science in Literature: Materials for a Thematic Teaching Approach" states:

> The use of thematic units permits a broadening of pedagogical concerns in English studies beyond those of genres, periods, and particular authors and works. The thematic approach reflects a concern with the personal growth of the reader/writer versus an emphasis on specific literary works such as objects worthy of study for their own sake. In the context of historical tension between the two cultures, thematic reading and writing experiences can be used to encourage students to confront, and thereby refine, their own developing views of the intellectual and practical relationships between the arts and the sciences. (72)

While there is tremendous scope to analyse the performative aspect of science plays, such a project will be beyond the scope of this thesis. Therefore, this thesis limits its focus to the written script of the selected plays. This project began by short-listing four science plays for analysis. However, the complexity, variety and width of the field are such that such a scant selection would not be able to do justice to the project. Finally, a total of seven plays were selected. These plays are the following: Heinar Kipphardt's *In the Matter of J Robert Oppenheimer* (1964), Bertolt Brecht's *Life of Galileo* (1943), Carl Djerassi and Roald Hoffmann's *Oxygen* (2001), Mohan Maharishi's *Einstein* (1996), Shelagh Stephenson's *An Experiment with an Air Pump* (2000), Michael Frayn's *Copenhagen* (1998), and Jerome Lawrence and Robert E Lee's *Inherit the Wind* (1955). These plays were selected because they

represent a wide range of fields and issues which the thesis explores. However, despite the best efforts, the research could not find enough material from amongst these plays to analyse the representation, or lack thereof, of women scientists as well as women playwrights. Therefore, three additional plays were added to the list. These are Lauren Gunderson's *Silent Sky* (2015) and *Emilie* (2019), and Anna Zeigler's *Photograph 51* (2015). These three plays are written by female playwrights and portray the real lives of women scientists. The thesis will undertake an in-depth exploration of the selected science plays. The chapters discuss different ideas that the playwrights portray in these plays. The qualitative analysis of the plays will employ close reading of the texts to provide a descriptive exploration. The common thread across the four chapters is the selection of these texts as science plays which provide four different viewpoints for analysing a science play.

Heinar Kipphardt's *In the Matter of J. Robert Oppenheimer* is a fictionalised account of the 1954 security hearing held for J. Robert Oppenheimer, a renowned physicist who is one of the key figures in the development of the atomic bomb during World War II. The play centres around Oppenheimer's struggle during the hearing, where he is interrogated about his political beliefs and associations. The Atomic Energy Commission conducted the hearings as part of the McCarthy-era investigations into alleged communist sympathies and loyalty concerns. Oppenheimer's alleged involvement with left-wing organisations and his opposition to the development of the hydrogen bomb raised suspicions about his loyalty to the United States. Kipphardt's play examines the complex moral and ethical dilemmas Oppenheimer faced during the hearing. It delves into his personal struggles, the tension between his scientific responsibilities and his political beliefs, and the choices he made during the critical time of the Manhattan Project. The play presents Oppenheimer as a morally conflicted figure caught between his loyalty to his country and his concerns about the devastating power of nuclear weapons. It explores themes of responsibility, accountability, and the cost of scientific

advancement. Through its powerful and thought-provoking narrative, the play raises broader questions about the role of scientists in society and the consequences of their work. The play questions the scientists' authority and their culpability in the development of a weapon of mass destruction. The play is not a factual account of the hearing but rather a fictionalised portrayal that portrays Oppenheimer's dilemmas and the moral complexity of nuclear weapon development. Kipphardt's play provides a nuanced exploration of Oppenheimer's character and the profound impact that his involvement with the atomic bomb had on his personal and professional life. The play has been explored well as an example of documentary theatre. Laureen Nussbaum's "The German Documentary Theater of the Sixties: A Stereopsis of Contemporary History", published in the *German Studies Review,* analyses the play as an example of document theatre. Dan Isaac puts forth similar research in the article "Theatre of Fact" in *The Drama Review*. John T Dorsey explores the idea of a scientist's responsibility in his article "The Responsibility of the Scientist in Atomic Bomb Literature", published in the *Comparative Literature Studies*.

Bertolt Brecht's *Life of Galileo* explores the life and struggles of the Italian scientist Galileo Galilei, one of the most influential figures in the history of science. The play is set in seventeenth century Italy, during a time when the Catholic Church held significant power and authority. Galileo, known for his advancements in astronomy and his support for the Copernican heliocentric model, finds himself in conflict with the Church's teachings and dogma. The play follows Galileo's journey as he grapples with his scientific discoveries, societal pressures, and the consequences of challenging the prevailing religious beliefs. Brecht's play focuses not only on Galileo's scientific achievements but also on the social and political contexts in which he operated. It explores the themes of power, knowledge, and the clash between scientific progress and institutional authority. Galileo's struggle to reconcile his scientific discoveries with the religious establishment forms the core of the play. Brecht's

writing style emphasises a critical and didactic approach, seeking to provoke thought and encourage the audience's engagement. *Life of Galileo* employs a technique known as "epic theatre," which aims to distance the audience from the emotional aspects of the story and encourage intellectual reflection on the social and political implications. Throughout the play, Galileo faces numerous challenges and dilemmas, including personal sacrifices, censorship, and the suppression of scientific truth. The play presents Galileo as a complex and flawed character who must navigate the conflicting demands of truth, personal ambition, and societal expectations. *Life of Galileo* serves as a commentary on the tensions between scientific progress and established institutions, raising important questions about the role of science in society and the responsibility of scientists. Brecht's play highlights the potential conflicts between scientific advancement and political or religious forces, prompting the audience to reflect critically on the complexities of scientific discovery and the impact of science on society. In summary*, Life of Galileo* is a moving play by the German playwright that delves into the life and struggles of Galileo in the face of religious authority. Through its exploration of power dynamics, intellectual conflict, and the clash between scientific progress and institutional control, the play prompts audiences to reflect on the role of science and the societal implications of scientific discovery. MA Cohen's "History and Moral in Brecht's 'The Life of Galileo'" (1970) studies the issue of morality in this historical drama. Georgios Sarantopoulos explores the integration of science and drama in "'Have We Not Seen How Disbelief Can Move Mountains?': Brecht's Theory for a Theatre of the Scientific Age" (2019). In his article "Bertolt Brecht, Politics, and Comedy" (2012), Marc Silberman analyses the play's mix of comedy and politics.

Oxygen is a play written by Carl Djerassi, a chemist, playwright and novelist, and Roald Hoffmann, a chemist and Nobel laureate. The play explores the complex relationship between science and art, particularly focusing on the discovery of oxygen and its impact on society. Set

in the late 18th century, *Oxygen* centres around the rivalry between renowned scientists Antoine Lavoisier, Carl Wilhelm Scheele and Joseph Priestley, who independently discover oxygen. Lavoisier, a French chemist, Scheele, a Swedish Apothecary and Priestley, an English natural philosopher, all play key roles in unravelling the mystery of this vital element. The play explores these scientists' personal and professional lives, highlighting their differing approaches, perspectives, and controversies surrounding their work. It also looks into the social and political contexts of the time, including the French Revolution and the clash between the French and English scientific communities. Through the characters of Lavoisier, Scheele and Priestley, the play explores broader themes such as scientific discovery, the interplay between science and society, and the human desire for recognition and validation. In examining the human dimensions of scientific pursuit, including the sacrifices and ethical dilemmas that scientists face in their quest for knowledge, Djerassi and Hoffmann bring their scientific expertise to the play, infusing it with accurate and engaging scientific content. They skillfully intertwine scientific concepts and historical events with dramatic storytelling, resulting in a compelling narrative. *Oxygen* prompts the audience to reflect on the social and cultural implications of scientific advancements, as well as the interactions and conflicts between scientists and society. It raises questions about the nature of scientific discovery, the responsibility of scientists, and the impact of scientific breakthroughs on the wider world. Overall, it is a captivating play that explores the intertwined worlds of science and scientists, shedding light on the fascinating story behind the discovery of oxygen and those who made it possible. Through its exploration of history, science, and human ambition, the play invites audiences to contemplate on the complex relationship between scientific progress and its societal implications. Eva-Sabine Zehelein's article "Carl Djerassi's Seed" (2008) undertakes a critical analysis of the play. P Balaram also discussed the play in his article titled "Oxygen, Lavoisier and Revolution" (2002).

Shelagh Stephenson's *An Experiment with an Air Pump* is a thought-provoking play based on Joseph Wright of Derby's oil-on-canvas, *An Experiment on a Bird in the Air Pump* (1768). Set in two distinct time periods, the play intertwines the stories of two groups of characters separated by over two centuries, connected by a common scientific experiment. The play is set in 1799 and 1999, showcasing the contrast between the past and the present. Through the characters and their interactions, Stephenson explores themes such as scientific progress, ethics, morality, and the consequences of human actions. The play raises questions about the responsibility of scientists and the ethical dilemmas they face in their pursuit of knowledge. It also delves into the tensions between scientific advancement and the potential harm it can cause. As the play unfolds, the audience witnesses the parallels and divergences between the two time periods. Stephenson skillfully weaves together the narratives, examining the implications of scientific discovery and the lasting impact it can have on individuals and society. *An Experiment with an Air Pump* offers a commentary on the human condition and the progress of science throughout history. It challenges the audience to contemplate the repercussions of scientific advancements and the implications of our choices as individuals and as a society. The play also highlights the intersection of science and ethics, exploring the moral responsibilities of scientists and the potential consequences of their experiments. Stephenson presents a nuanced portrayal of the complexities inherent in scientific research, shedding light on the personal and societal implications of scientific discovery. *An Experiment with an Air Pump* that juxtaposes two different time periods to explore the intertwining themes of science, ethics, and the human condition. Through its rich characters and thought-provoking narrative, the play encourages audiences to reflect on the consequences of scientific progress and the moral dilemmas faced by those in pursuit of knowledge. "A Moral Dialectic: Shelagh Stephenson's *An Experiment with an Air Pump*" (2002) by Claudia Barnett explores the interaction of ethics and experimentation in science. Marguerite Helmers's "Painting as

Rhetorical Performance: Joseph Wright's 'An Experiment on a Bird in the Air Pump'" (2001) analyses the oil-on-canvas painting on which the play is based.

Michael Frayn's *Copenhagen* delves into the historic meeting between two prominent physicists, Niels Bohr and Werner Heisenberg, during World War II. The play takes place in the afterlife, where the characters reflect on their past actions and engage in a profound conversation about the moral and scientific implications of their choices. Frayn's play explores the enigmatic meeting that took place in Copenhagen in 1941 between Bohr, a Danish physicist, and Heisenberg, a German physicist. The exact nature and purpose of this meeting have been the subject of intense speculation and debate. Frayn uses this historical event as a launching point for a deep exploration of scientific ethics, the uncertainty principle, and the consequences of scientific discovery. The play weaves together elements of history, science, and personal relationships to create a complex and thought-provoking narrative. As Bohr and Heisenberg re-examine their motivations and actions, they grapple with questions of responsibility, loyalty, and the role of science in wartime. Frayn delves into the intricate connections between science, morality, and human relationships through the characters' dialogue and interactions. The play challenges the audience to consider the implications of scientific advancements and the moral dilemmas faced by scientists working in turbulent times. *Copenhagen* is a dense and intellectually stimulating play that engages with profound philosophical and scientific concepts, including the uncertainty principle and the nature of reality. Frayn expertly intertwines these complex ideas with the personal stories and motivations of the characters, creating a compelling and thought-provoking narrative. Overall, the play is a masterful exploration of the intersection of science, history, and morality. Frayn's play invites audiences to contemplate the profound impact of scientific discoveries, the complexities of human relationships, and the ethical responsibilities of scientists. It provides a fascinating glimpse into the minds of two brilliant physicists and encourages a deeper

understanding of the implications of their work. Nicholas Ruddick's "The Search for a Quantum Ethics: Michael Frayn's *Copenhagen* and Other Recent British Science Plays" (2000) explores the ethical framework of quantum research. Karen C. Blansfield's article "Atom and Eve: The Mating of Science and Humanism" (2003) uses the play as one of many examples of integrating the Two Cultures. Reed Way Dasenbrock studies the play as a historical play in "*Copenhagen*: The Drama of History" (2004), and Richard Hornby studies it as a problem play in "The Social Problem Play" (1999).

Inherit the Wind is a powerful and iconic play written by Jerome Lawrence and Robert E Lee. Inspired by the Scopes Monkey Trial of 1925, the play explores the tension between science and religion, freedom of thought, and the pursuit of knowledge. Set in a small town, the play centres around the fictionalised trial of Bertram Cates, a high school teacher who is accused of teaching evolution in his classroom, which was illegal at the time. The trial becomes a battleground between two titanic legal figures: Henry Drummond, a defence attorney representing Cates and advocating for intellectual freedom, and Matthew Harrison Brady, a renowned orator and prosecutor defending the biblical account of creation. Through the courtroom drama, Lawrence and Lee delve into larger themes of intellectual freedom, censorship, and the clash between tradition and progress. The play serves as a critique of the McCarthy era and the suppression of ideas and beliefs deemed to be against the prevailing social norms. The characters in the play are richly developed and represent different perspectives on the conflict between science and religion. As the trial unfolds, personal beliefs and motivations are tested, challenging the characters to confront their own biases and prejudices. Lawrence and Lee's play confronts the audience with the complexities of the human experience and the challenges faced when traditional beliefs clash with scientific advancements. The dialogue between the characters delves into the philosophical and moral implications of the conflict, questioning the nature of truth, the role of education, and the limits

of personal liberty. Through its compelling narrative and memorable characters, *Inherit the Wind* provides a platform for reflection on the enduring tension between faith and reason, the importance of critical thinking, and the need for open dialogue in society. Overall, the play is a thought-provoking play that continues to resonate today. Its examination of the clash between science and religion, freedom of thought, and the pursuit of truth encourages audiences to question their beliefs and consider societal pressures' impact on intellectual growth and progress. In "Tennessee v. Scopes versus *Inherit the Wind*: The Trial in the Play and the Film" (2005), TT Taylor compares the portrayal of the trial across different media and Susan Harkless studies the play as a historical play in her article "The Scopes Trial: *Inherit the Wind*" (1988).

Lauren Gunderson's play, *Silent Sky* is a poignant exploration of the life and achievements of Henrietta Leavitt, a pioneering astronomer. Set in the early 20th century, the play follows Leavitt's journey as she joins the Harvard Observatory's team of "human computers," a group of women tasked with analysing astronomical data. Leavitt, played by the brilliant protagonist, is driven by her passion for the stars and her desire to contribute to scientific knowledge. Despite facing gender discrimination and societal expectations, she perseveres in her work, driven by her insatiable curiosity and determination. As Leavitt immerses herself in the world of astronomy, she discovers a ground-breaking pattern in the brightness of certain stars, which later becomes known as the "Leavitt Law." This discovery would revolutionise the field of astronomy and lay the foundation for measuring the vastness of the universe. While *Silent Sky* focuses on Leavitt's scientific achievements, it also portrays her personal struggles and relationships. The play explores the challenges she faces in balancing her love for science with her longing for personal connection and romantic fulfilment. Through her interactions with her sister Margaret, her colleagues at the observatory, and a potential love interest, Peter Shaw, Leavitt grapples with the sacrifices and choices that come with pursuing her dreams. Gunderson's play not only sheds light on Leavitt's remarkable

contributions to astronomy but also celebrates the unsung women scientists who played vital roles in advancing our understanding of the universe. It challenges societal norms and highlights the importance of gender equality and recognition in the scientific community. *Silent Sky* is a beautifully written play that weaves together science, personal narratives, and societal challenges. It offers a thought-provoking exploration of the human spirit's quest for knowledge, the pursuit of one's passion against all odds, and the significance of female voices in the scientific world. Through heartfelt performances and powerful storytelling, the play reminds us of the often-unseen heroes who shape our understanding of the universe and inspires us to reach for the stars, no matter the obstacles in our path.

Anna Ziegler's *Photograph 51* provides a captivating glimpse into the life and work of scientist Rosalind Franklin and her pivotal role in the discovery of the structure of DNA. Set in the early 1950s, the play explores Franklin's contributions to the field of molecular biology and the challenges she faced as a woman in a male-dominated scientific community. The story revolves around the intense race to unlock the secrets of DNA, with Franklin at the center of the action. Her ground-breaking X-ray crystallography technique captures "Photograph 51," a critical image that holds the key to understanding the structure of DNA. However, her work is overshadowed by the ambition and competitiveness of her male colleagues, including James Watson and Francis Crick, who ultimately take credit for the discovery. The play delves into the complex dynamics of scientific discovery and the ethical implications of taking credit for another's work. It raises thought-provoking questions about gender inequality, the pursuit of recognition, and the sacrifices made by individuals in the pursuit of scientific breakthroughs. Ziegler's play offers a nuanced portrayal of Franklin, portraying her as a brilliant and fiercely independent scientist determined to make her mark in a field dominated by men. It also portrays the personal struggles Franklin faces, including the challenges of balancing her career aspirations with societal expectations and the inherent biases she encounters along the way.

Photograph 51 serves as a reminder of the importance of acknowledging the contributions of marginalised voices in scientific advancements. It sheds light on the often-overlooked achievements of women in science and challenges the prevailing narratives that have historically diminished their roles. Through compelling storytelling and intricate character development, the play provides a powerful and thought-provoking exploration of the intersection of science, gender, and ambition. It urges audiences to reflect on the need for equality and recognition within scientific communities and the lasting impact of individual contributions on the advancement of knowledge. Philip Ball's "Theatre: Lab's Labour's Lost" (2015), published in *Nature,* reviews the play and categorises it under science-in-theatre.

Lauren Gunderson's *Emilie* explores the life and remarkable achievements of Emilie du Châtelet, an influential 18th-century physicist, mathematician, and philosopher. Set in Enlightenment-era France, the play explores Emilie's ground-breaking contributions to science, her personal relationships, and the challenges she faced as a woman in a male-dominated intellectual society. *Emilie* takes audiences on a journey through the passionate mind of its eponymous protagonist. Emilie du Châtelet, a brilliant and unconventional woman, defies societal expectations and fervently pursues her intellectual passions. She engages in a passionate love affair with the renowned philosopher Voltaire while striving to expand her scientific knowledge and challenges the prevailing theories of her time. The play interweaves Emilie's personal life with her scientific pursuits, exploring her work in areas such as mathematics and physics and her translation and interpretation of Isaac Newton's work. Through witty dialogue and vivid storytelling, Gunderson brings to life Emilie's insatiable curiosity, her struggles for recognition in the scientific community, and the barriers she faces due to her gender. The play sheds light on the importance of women's contributions to science and the obstacles they have historically faced. It examines the biases and prejudices of the era, highlighting the limited opportunities available to women seeking intellectual pursuits and

recognition for their work. The play challenges traditional notions of femininity and celebrates the brilliance and resilience of Emilie du Châtelet and other trailblazing women who defied societal norms. Gunderson's play invites audiences to reflect on the timeless themes of gender equality, intellectual freedom, and the pursuit of knowledge. It reminds us of the value of diverse voices in the scientific realm and the importance of recognising the achievements of women who have shaped our understanding of the world. *Emilie* is a captivating and thought-provoking play that intertwines science, love, and societal challenges. It offers a compelling narrative that celebrates the indomitable spirit of a remarkable woman and encourages us to re-evaluate our perspectives on gender, intellectual freedom, and the power of passion and curiosity to transcend societal barriers.

The thesis consists of four chapters that study the unexplored aspects of science plays. The first chapter, titled "The Idea of Authority in Science Plays", analyses the representation of authority along with exploring the ideas of morality in science and the responsibility of scientists. The chapter argues that the authority of science emanates from the authority of scientific methodology and the authority of the scientist as a public figure. During the course of the analysis, the chapter examines the scientists' agency to dissent and the erosion of that agency in an authoritarian environment, as portrayed in the plays. While researchers have taken up the issue of ethics in science, there has been a dearth of works on authority in science plays.

The second chapter, titled "The Use of Literary Devices in Science Plays", undertakes a literary analysis of science plays to explore the employment of literary techniques by the playwrights. It explores the use of formalised language, literary allusions, wordplays, dramatic structure, setting, sarcasm, poetic embellishments, comic relief, and humour in these plays. Scholarly work on science plays has focused on the representation of the scientist and science, but an analysis of literary devices in science plays was missing. The chapter, thus, analyses the use of literary devices in select science plays, portraying their employment in this niche genre.

The third chapter, titled "Props and Scenography in Science Plays", explores the utilisation of stage properties, stage settings, stage directions, costumes, and lighting in science plays that create an immersive experience. This chapter provides a scenographic study of science plays which was much scantly represented in this field. There are a number of stage properties, costumes, and stage setups that are peculiar to science plays. By analysing these props, costumes and settings, this chapter adds a new dimension to research on science plays.

The last chapter, titled "Representation of Women in Science Plays", was added after much deliberation as it was evident that the representation of women scientists and women playwrights in the field was scant. This chapter analyses the three science plays written by women playwrights featuring women scientists. The chapter discusses the limited opportunities, exclusion, and ridicule faced by women in science. It also explores the reduction of women in science to their gender and the limitations imposed on women who pursued science. While analysing science plays, the academic research on these four aspects was found to be inadequate. With the help of these four chapters, this thesis aims to bridge that research gap in the field of literature and science.

Chapter 1: The Issue of Authority of Science Plays

Introduction

Chapter one explores the themes of authority, morality, and responsibility in select plays. Sociologists, philosophers, and political theorists have studied the phenomenon of authority and their unique standpoint on this phenomenon emanate from their respective methodologies. Additionally, when it comes to science, the scholars belonging to the fields of Science and Technology Studies (STS) and Literature and Science also investigate the interaction of authority and science. It is important to briefly discuss the prevalent ideas on authority. The sociological analysis of authority delves into the social sources that legitimise authority and political theory details the forms of authority that are normatively justified. These perspectives on authority are made available to us by the works of the sociologist Max Weber, the philosopher, political theorist Hannah Arendt and the normative political theorist Joseph Raz. Arendt, a political philosopher and a holocaust survivor, is a prominent theorist of totalitarianism and authority. Regarding the origin of the word "authority", Arendt states:

> The word auctoritas derives from the verb augere, "augment," and what authority or those in authority constantly augment is the foundation. Those endowed with authority were the elders, the Senate or the patres, who had obtained it by descent and by transmission (tradition) from those who had laid the foundations for all things to come, the ancestors, whom the Romans therefore called the maiores. The authority of the living was always derivative, depending upon the auctores imperii Romani conditoresque, as Pliny puts it, upon the authority of the founders, who no longer were among the living. (Arendt 1954, 18)

Max Weber contemplated on authority from a point of view to understand the epistemic underpinnings of the social order. Weber differed from Marx when it came to understanding the social order and took into account different social actors and the corresponding social phenomenon. Demarcating power from authority, Weber opines that while power is a general, whereas authority is relative to an institution. Based on legitimacy, Weber describes three types of authority – Traditional, Rational-Legal and Charismatic.

In her essay, "What is authority?", Arendt contrasts authority from power by asserting the following:

> Since authority always demands obedience, it is commonly mistaken for some form of power or violence. Yet authority precludes the use of external means of coercion; where force is used, authority itself has failed. Authority, on the other hand, is incompatible with persuasion, which presupposes equality and works through a process of argumentation. (92)

For Hannah Arendt, "Authority emerges as a form of compulsion which is distinct from violence, yet has something in common with it because it requires unquestioned obedience" (Haugaard 6). Differentiating authority from power, Robert Wolff, in *In Defence of Anarchism* (1970) writes:

> Authority is the right to command, and correlatively, the right to be obeyed. It must be distinguished from power, which is the ability to compel compliance, either through the use or the threat of force. When I turn over my wallet to a thief who is holding me at gunpoint, I do so because the fate with which he threatens me is worse than the loss of money which I am made to suffer. I grant that he has power over me, but I would hardly suppose that he has authority, that is, that he has a right to demand my money and that I have an obligation to give it to him. (4)

This chapter solely focuses on the idea of authority for analysing the selected texts. Scientific authority emanates from the authority of the scientist and that of scientific methodology. The authority of the scientist takes into account his or her position as a social actor and the resultant position of privilege and power they command in society. The authority of the scientist is backed by the authority of scientific methodology, which positions itself as an objective, unbiased and evidence-based episteme of knowledge. The perennial struggle for social hegemony and tacit acceptance puts science in conflict with other social forces that are rooted in the fields of religion, law, politics, public policy, and economics. The chapter also studies simultaneous interactions of multiple non-exclusive authorities represented in the plays.

The interdisciplinary fields of Science and Technology Studies (STS) and Literature and Science too have produced works on the relationship between science and authority. In order to better understand the portrayal of authority in science plays, it is imperative to analyse the works produced by two interdisciplinary fields. Scholars such as Wiebe E Bijker, Roland Bal, Martin W Bauer, Sheila Jasanoff, Richard Whitley, Robert P Crease, and Theodore L Brown have made valuable contributions to the academic understanding of authority in relation to science. From an empirical sociological perspective, authority is a type of power that accompanies a position, to which the general public consents, it is this empirical sociological perspective that this chapter employs to look at science plays to understand the idea of authority.

Kipphardt's *In the Matter of J Robert Oppenheimer* is set during the proceedings against Oppenheimer, a nuclear physicist hesitant to lead the development of the American hydrogen bomb. Kipphardt, a German writer known for using documentary theatre, employs factual reports and interviews to construct the play. The play delves into the complex power relations within science and society. The playwright problematises Oppenheimer's authority as a scientist, his agency to dissent, and the ethical implications of his role in developing and using

atomic weapons. The chapter discusses the influence of political ideologies on scientists and the erosion of their agency in an authoritarian environment. Through Oppenheimer's character, the playwright questions the intersection of multiple authorities and the consequences of dissenting against them. Ultimately, the chapter aims to illuminate the intricate dynamics of authority and the moral complexities faced by scientists in the play. Bertolt Brecht's *Life of Galileo* presents the life of the renowned Italian polymath and astronomer Galileo Galilei and his conflict with religious and political authorities. The chapter delves into the portrayal of different forms of authority in the play, ranging from religious and academic authorities to state-endorsed scholars and scientific methodology. Brecht's depiction of these authorities highlights their role in perpetuating the status quo, suppressing dissent, and upholding the established worldview. The chapter explores how the clash between scientific and religious authority unfolds, the subjugation of evidence and objective reasoning, the influence of patronage, and the implications of questioning given truths. The chapter also examines the historical context of the Scientific Revolution, paradigm shifts, and the implications of Galileo's recantation as an act of dissent. By analysing the interplay between science and authority in *Life of Galileo*, the chapter provides insights into the complex dynamics that shape the pursuit of knowledge and the resistance encountered along the way.

Stephenson's thought-provoking play *An Experiment with an Air Pump* interrogates the multifaceted concept of authority within the realms of science. Set in two different time periods, 1799 and 1999, the play navigates through the intricate connections between past and present while exploring the shifting dynamics of power and knowledge. Stephenson skillfully weaves together a narrative that raises questions about the authority of scientists, the public's perception of science, the role of gender, the influence of religion, and the ethical boundaries of scientific progress. Through vivid dialogues and evocative scenes, the chapter aims to challenge our understanding of authority and its impact on scientific discourse and societal

values. The next section discusses Maharishi's bilingual play *Einstein,* which serves as a rare example of an Indian science play. The play showcases the collaboration between playwrights and scientists, and sheds light on the issue of authority in religion and science. With characters such as Albert Einstein, Aristotle, Nicolaus Copernicus, and Galileo Galilei, the play explores the conflicting authorities and their interplay. This section sets the stage for a captivating exploration of the various forms of authority: religious, academic, scientific and mathematical. It highlights the roles of theoreticians and experimentalists in the scientific community.

Carl Djerassi and Roald Hoffmann's *Oxygen* delves into the discovery of oxygen, problematising the concept of scientific discovery and raising ethical questions surrounding it. With a dual timeline set in 1777 and 2001, the play explores the authoritative dynamics in both periods, shedding light on the ethics of authority in the scientific community. This section examines the various manifestations of authority portrayed in the play, including the authority of discovery, publication, peer review, historical research, and public recognition. Furthermore, it delves into the imbalance of authority across different countries, the hierarchy of knowledge systems, and the struggle for priority and recognition in the scientific race. Through these explorations, the chapter highlights the complex interplay between authority, ethics, and the pursuit of scientific knowledge. Michael Frayn's renowned memory play *Copenhagen* questions the intricate issues of authority and ethics within the realm of science. Focusing on the pivotal 1941 meeting between physicists Niels Bohr and Werner Heisenberg, the play sheds light on the complex moral dilemmas faced by scientists during and after World War II, particularly in the context of nuclear physics. Frayn presents a non-linear and repetitive plot structure, oscillating between physics and politics as the central conversation unfolds. Within this framework, the playwright explores the influence of geopolitical events on the lives of scientists, the power wielded by state authorities over scientific research, and the complicated relationship between nationalistic sentiments and scientific duty. Through the characters of

Bohr and Heisenberg, Frayn portrays the varying responses and agency of scientists involved in developing nuclear weapons, challenging the notion of a scientist's moral right to engage in such work. By examining the relative authorities of scientists, the role of scientific methodology, and the impact of public imagination on scientific advancement, *Copenhagen* provokes critical reflection on the profound responsibilities and ethical considerations inherent in scientific pursuits. Jerome Lawrence and Robert E. Lee's courtroom drama, *Inherit the Wind*, delves into the infamous Scopes Trial of 1925 (the Monkey Trial) where a high school teacher faced criminal charges for teaching evolution. This section explores the clashes between various authorities within the play, including religious, political, administrative, and legal figures. Through the characters of Matthew Brady, Henry Drummond, EK Hornbeck, and Rachel Brown, the playwrights depict the struggle between religious dogma and scientific inquiry, the influence of public opinion on science, and the ultimate authority of the law and individual dissent. This chapter highlights the ongoing conflict between religion and science and the significance of freedom of thought and education in society.

In the Matter of J Robert Oppenheimer

In the Matter of J Robert Oppenheimer (1964) dramatizes the proceedings against the nuclear physicist for his hesitation and unwillingness to lead the development of the American hydrogen bomb. Kipphardt was a German writer famous for using documentary theatre and spearheaded the genre along with Peter Weiss and Rolf Hochhuth. Erwin Piscator and Bertolt Brecht established documentary theatre or theatre of fact in which the playwrights utilise factual reports, speeches and interviews to produce a play. Kipphardt was trained in medicine and also served in the German Army on the Russian Front during 1942-44. He practised medicine after the Second World War and later wrote plays, short stories, poetry and a novel.

Ruth Speirs translated Kipphardt's *In the Matter of J Robert Oppenheimer* into English and the prologue to the play details the documentary evidence used to write the play.

The play is set entirely in Room 2022 at the Atomic Energy Commission office where the Personnel Security Board's proceedings take place. In the first scene, Kipphardt introduces the members of the Board: Thomas Morgan, Ward Evans and Gordon Gray. Evans is a Chemistry professor, Morgan is the President of the Sperry Gyroscope Company and is acting as the Chairman of the Board, and Gray is a newspaper editor who used to be an Army Secretary. The counsel for the Atomic Energy Commission is Roger Robb and CA Rolander, and the counsel for Oppenheimer is Lloyd Garrison and Herbert Marks.

The philosophical issue of authority and its relationship with science is central to the play as the playwright explores power relations and their manifestations. The plot of the play unfurls with Senator McCarthy's infamous speech which begins with the following line, "If there are no Communists in our government, why do we delay the hydrogen bomb by eighteen months while our defense services report day after that the Russians are feverishly stepping up on the H-bomb?" (10) Despite the cessation of hostilities after the second world war, political figures used the threat of war to stir political fervour. Senator McCarthy's statement echoes Hannah Arendt's assertion that authority is a form of legitimation of political power (Arendt 2006, 111). At the heart of the play are the issues related to various facets of authority, morality and responsibility of scientists.

Using Oppenheimer's preference for practitioners of science on the board, the playwright asserts the authority of the scientist and scientific methodology. The board constituted to examine the complex duties of a physicist consists of a professor of chemistry, a president of a gyroscope company, and a newspaper editor. Oppenheimer laments the lack of practicing scientists on the committee. His preference for a committee comprising scientists questions the authority of a non-scientist to judge the actions of a leading nuclear physicist.

The constitution of a committee is itself a display of authority as it makes the readers question who sits on judgment over whom. The authority of rigorous scientific training is also contrasted against the authority of the spoken word in good faith as the testimonies presented before the committee are under oath. The playwright contrasts the authority of an oath against the authority of a scientist. The readers grapple with the question of special authority that formal training in science provides.

The issue of the authority of a scientist is further complicated by contrasting ideas of a scientist's individual responsibility with their collective responsibility. In the play, Robb refers to Oppenheimer as the Father of the Atom Bomb. Such a title consolidates the efforts of a large number of scientists, scholars and technicians and heaps praise on a singular individual, inadvertently making them the authority in that field. As Oppenheimer explains in the play, a large number of people were involved in the project from different countries, but the title of the Father of the Atom Bomb is given to him. He explains to Robb:

> ROBB. You have been called the Father of the Atom Bomb, Doctor?
>
> OPPENHEIMER. In magazines. Yes.
>
> ROBB. You would not call yourself that?
>
> OPPENHEIMER. It isn't a very pretty child – and it has about a hundred fathers, if we consider the basic research. In several countries. (12)

Robb, the counsel for the atomic energy commission, asks Oppenheimer, "then you dropped it on Japan, did you not?" (13). Robb portrays Oppenheimer as the authority on the atomic bomb and simultaneously blames him for the destruction that it caused. Oppenheimer explains to the committee that the decision to use the nuclear weapon was political and not a personal one. The conversation which follows informs the readers about the process and the logic behind the selection of cities for the bomb drop.

ROBB. You produced it in a fantastically short time, you tested it, and then you dropped it on Japan, did you not?

OPPENHEIMER. No.

ROBB. You did not?

OPPENHEIMER. The dropping of the atom bomb on Hiroshima was a political decision – it wasn't mine.

ROBB. But you supported the dropping of the atom bomb on Japan. Or didn't you?

OPPENHEIMER. What do you mean by "supported"?

ROBB. You helped to select the targets, did you not?

OPPENHEIMER. I was doing my job. We were doing our job. We were given a list of possible targets…

ROBB. Would you name them?

OPPENHEIMER. Hiroshima, Kokura, Nigata, Kyoto…and we, as experts, were asked which targets would be most suitable for the dropping of the atomic bomb, according to the experience we had gathered from tests. (13)

Later, Robb enquires about the process of selection of cities for dropping the atomic bomb.

ROBB. What kind of target did you consider to be of the desired suitability?

OPPENHEIMER. According to our calculations, the area had to be at least two miles in diameter, densely built up, preferably with wooden buildings – because of the blast, and the subsequent wave of fire. Also, the selected targets had to be of a high military and strategic value, and unscathed by previous bombardments.

ROBB. Why, Doctor?

OPPENHEIMER. To enable us to measure exactly the effect of a single atomic bomb. (13-14)

At this juncture, Kipphardt provides an important point to consider. Any scientist who chooses cities for nuclear weapon detonation based on the maximum probability of death and destruction cannot absolve themselves of the moral responsibility for the loss of human lives by reasoning that it was a political decision and they were simply doing their job. While it is true that he was doing the job assigned to him by the military and political authority, his own authority as a scientist and an expert in the field makes him culpable for his actions as he did in fact have the agency to choose otherwise.

The idea of scientists' authority is intertwined with that of their independence and their agency to dissent. At the beginning of the first scene, Oppenheimer quotes Einstein's statement, "If I had the choice again I'd rather be a plumber or a pedlar, if only to enjoy some small measure of independence" (11). The quote drives home the issue of the scientist's agency to dissent. According to Oppenheimer, an advisory council of nuclear physicists was formed for the purpose of selecting the city most suitable for dropping the bomb. The playwright highlights the authority of nuclear physicists on a matter of warfare. Discussing the original intent behind the development of the bomb, Oppenheimer states that they developed the bomb with the intent of preventing its use. He explains that there was a threat of a German nuclear bomb during the Second World War.

> MORGAN. Did you not make it in order to use it and win the war with it?
>
> OPPENHEIMER. We made it in order to prevent it being used. Originally, at any rate.
>
> MORGAN. You spent two billion dollars of the taxpayers' money on the bomb in order to prevent it being used?
>
> OPPENHEIMER. To prevent it being used by Hitler. In the end it turned out that there wasn't any German atomic bomb project….But then we used it all the same. (160)

Oppenheimer also hints at the possibility of using nuclear energy for peaceful purposes.

OPPENHEIMER. Yes…It is the kind of schizophrenia we physicists have been living with for several years now.

ROBB. Would you elucidate that?

OPPENHEIMER. The great discoveries of modern science have been put to horrible use. Nuclear energy is not the atomic bomb.

ROBB. You mean it could be exploited industrially, and so forth?

OPPENHEIMER. It could produce abundance, for the first time. It's a matter of cheap energy. (15)

The agency of the scientist is also apparent when Oppenheimer says that he opposed the development of the hydrogen bomb on moral grounds. Authority is dynamic and has varying manifestations. The scientific authority that enables Oppenheimer to lead the development of the first atomic bomb also enables him to dissent against the hydrogen bomb project. Such dissent is not without repercussions as the political, military, and public authorities label him a traitor. He asserts that there have been people who have put the blame for the geopolitical crisis on so-called traitors like him. The playwright uses the play's plot to portray the manifestation of multiple authorities and the simultaneous interactions of these authorities. In the monologue at the end of scene one, Robb says that Oppenheimer was his idol growing up. It shows the reverence that scientists are given in society. However, the allegations against Oppenheimer soon changed "the idol into a sphinx" (21). In the play, Kipphardt depicts a scientist's deification and a later fall from grace for using his agency to dissent against the authorities.

In such an authoritarian environment, a scientist's agency to dissent erodes. Oppenheimer's character presents us with one way of maintaining the agency to dissent. He offers to resign from the General Advisory Committee as a protest when his objections to the hydrogen bomb project went unheeded. It is because of his ethical stand that he is left with some agency to dissent. However, one can also analyse the degradation of agency due to his

work on the Los Alamos project. Once Oppenheimer dons the uniform, his agency erodes. His dissent comes at the cost of his character and reputation. His opposition to the hydrogen bomb is looked at as an attempt to "limit the national sovereignty of United States" (81). Notwithstanding claims about his character, Oppenheimer is an influential and authoritative figure in his field who brought together great scientists like Enrico Fermi, Hans Bethe and Edward Teller for the project. While the prosecutors believe that Oppenheimer used this authority to delay the development of the hydrogen bomb, Oppenheimer believes that he did what he thought was right as, according to him, there was no need for the development of the hydrogen bomb after Hiroshima.

The committee's authority over Oppenheimer's personal views and affairs is asserted when he is questioned regarding the time spent with a "communist woman" in a hotel. Kipphardt makes the influence of political ideologies on scientists evident by raising the question of a scientist's personal beliefs. At the beginning of the second scene, Oppenheimer expresses his sympathies for the communist ideology and how it cooled down after the Russo-Nazi pact in 1942. The scientist, for the committee, is a tool of the state which has overwhelming authority over his private and personal affairs. While expressing his views on the issue of the privacy of scientists, Rolander says, "They have no claim to absolute justice and immaculate morality. They are practical. That is why I am disturbed by these ideological exercises here, this flogging of principles about the sacredness of privacy, a thing that dates back to the last century" (38). The play depicts the Committee's authority over the political opinions of scientists at the end of scene five when Morgan says:

> We should make it clear to the scientists that we don't dictate opinions to them, and we don't intend to boot them out because they hold this opinion or that opinion. But we must insist a sharp dividing line between their subjective views and their objective work, because modern nuclear policy is possible only on that basis. (43)

Talking more about this division, he says, "No matter how extreme, the subjective views of a physicist are his own private affair as long they don't interfere with his objective work. This dividing line bears upon the principles of our democracy" (43). The scientist thus is a deified tool that exists only for its vocation and is desirable as long as they have no personal views that are contrary to that of the authorities.

Evans discusses the scientific profession's militarisation in his monologue at the end of the second scene. He states, "On the other hand, it was the physicists themselves who started the whole thing when they turned their profession into a military discipline, Oppenheimer in particular, Los Alamos was his idea" (25). Oppenheimer informs the readers of Neils Bohr's opinions on the militarisation of science. He says, "He was furious with us. He said we were turning science into an appendage of the military, and the moment we gave an atomic cudgel into their hands they'd let fly with it. It worried him a great deal" (54). On the fifth day of the proceedings, while responding to a question by Thomas Morgan, Oppenheimer explains how the decision to recruit scientists lay with Colonel Lansdale. Kipphardt makes the oversight of the military over scientific matters evident when Major Radzi is called in to testify before the committee. Radzi says that he has been "specially trained to deal with scientists" (49). His recommendation that Oppenheimer should be removed from the programme portrays military oversight over scientists and scientific activity. Radzi's own views on military and political oversight are thus, "They should be made to realize that, nowadays, they are experts working within one vast enterprise. They have to do their own particular share of the work and then hand it over to the other experts, the politicians and the military, who then decide what is to be done with it" (58). The readers might be intrigued as to who does "we" refer to when Radzi says, "From a scientist of such stature we must demand absolute loyalty" (57). Herbert Marks, the counsel for Oppenheimer, reflects on the proceeding of the committee and points out the authority of the judiciary and military over scientific issues. He says, "If Oppenheimer is

condemned here, our present-day security system will have passed judgment on itself, the subjugation of science to the military will have been proclaimed, and in their ranks, there will be no room for independent spirits, for people who call a spade a spade" (31). Marks's monologue questions the importance of scientific objectivity and its subjugation to military authority. Prof John T Dorsey, in his article titled "The Responsibility of the Scientist in Atomic Bomb Literature", states the following: "Considering the theme of the responsibility of the scientist related to the atomic bomb as a whole, we note that the scientist is cast in a Faustian role" (280). Regarding the interaction with military authority, he asserts, "Accordingly, the scientist makes a pact with the military ties who promise to provide him with unlimited funds, facilities on the condition that he serve them and deliver research exclusively to them" (280). Regarding the nature of such work, he comments:

> The scientist then finds that laboratories, computers, and other scientific equipment, as well as supporting teams of researchers and engineers, are placed at his disposal, and he enthusiastically pursues a Faustian question: the nature of matter and energy, the ultimate foundations of the universe. From the outset, however, there is something inhuman, rather than superhuman, about the scientist's work. He finds himself in an ideal research laboratory, but he is imprisoned there, isolated from society and from the international community of scientists. His individual rights are denied, in particular his right as a scientist to publish his findings and to read the publications of others because the enemy (the Germans) will take advantage of his research. Ultimately, the scientist's love affair with the atom culminates in scenes of hell on earth: the destruction of two enemy cities (not German but Japanese), but he is told in a Mephistophelian way that although he is indirectly responsible for the deaths few hundred thousand people, he has saved more than a million ending the war. (280-81)

The amalgamation of the authority of science and the military is perfectly depicted in the character of David Griggs. He is a geophysicist and the Chief Scientist of the Air Force. His assertion that he was ordered by the Air Force to present himself in front of the committee speaks volumes about his position as a scientist and as an employee of the Air Force. His testimony stays true to the state's authoritative view regarding the situation.

Kipphardt also investigates the relationship between science and state authority. Evans asserts, "I don't know, perhaps my liberal views are outmoded; perhaps science too, must bow to the absolute claims of the state" (25). Such a relationship with state authority is counter-productive for science as non-conformity is essential for scientific advancement. Marks contemplates bringing Oppenheimer's case out in the open and putting everything in front of all the scientists. In such a scenario, Oppenheimer and his actions will be judged by the whole body of scientists and it will remind them of the power wielded by the political, judicial, and military authorities. Organisations like unions also exert their authority on scientists. The play presents an example of the same when Oppenheimer informs about the Scientists' and Engineers' Union and its influence on a fellow scientist Eltenton, whom Oppenheimer regarded as a possible danger. Another character who depicts oversight over scientists is Lansdale who is a lawyer by profession but is the head of security at the Los Alamos project. He is the authority that can grant or reject Oppenheimer's clearance to work. He chooses to grant him clearance but puts him on surveillance.

The play depicts the authority of moral and ethical principles over scientific development. The committee questions Oppenheimer's moral scruples and their timing. Robb argues that since the project stemmed from Oppenheimer's ideas, his moral scruples regarding the development of a hydrogen bomb are unfounded and questionable. Oppenheimer submits in the report that due to ethical reasons it would be fallacious to initiate the development of a hydrogen bomb. The members of the committee question Oppenheimer based on the letter from

the Atomic Energy Commission. They lay serious allegations against the scientist based on the contents of the letter. In case a scientist faces moral or ethical issues, their loyalty to the authorities might be questioned. Gray openly asks Oppenheimer if his loyalties are divided. He asks if Oppenheimer is more loyal to the government or to mankind. Kipphardt depicts the absurdity portrayed by the supposed exclusiveness of the two categories. Should moral and ethical principles have a say over issues of scientific development? This is one of the central questions that Oppenheimer seems to grapple with during the course of the play. For a scientist, authority has to be absolute and so should loyalty be.

According to the committee, Edward Teller, a scientist, can be an authority on and about a fellow scientist's ideology and mindset. The physicist Teller is called in to answer questions regarding Oppenheimer's security clearance and his ideological positions. Teller's position on a scientist's responsibility varied from that of Oppenheimer. He believes, "Discoveries in themselves are neither good nor evil, neither moral nor immoral, but merely factual. They can be used or misused. This applied to the internal combustion engine, and it applies to nuclear energy" (94). The bombing of Hiroshima and Nagasaki had an authoritative impact on the scientists working on the project. Hans Bethe, in his testimony, says "We had been working for several years under rigorous military conditions, and none of us had really stopped to think of those consequences. But Hiroshima put us face to face with the consequences – and, from then on nobody could work on these weapons without being aware that they would actually be used" (98). Just like Oppenheimer, Bethe uses his limited agency to dissent by quitting the Los Alamos project and taking up a teaching position. He was one of the scientists who appealed to the President of the United States against the weapon. Teller and Bethe have contradictory views on the development of atomic weapons but the committee considers them to be a reliable source of information on Oppenheimer's ideology and mindset.

Kipphardt portrays intersecting domains of authority when it comes to different committees. Hypocritically, the committee formed to probe the working of a nuclear physicist questions the appropriateness of a scientific committee's views on political and military matters. In the second scene of the second part of the play, Evans asks Issac Rabi if he thought it was appropriate for the General Advisory Committee to comment on political, diplomatic, and military considerations. This appears to question the authority of a scientific advisory committee on matters not related to their field of expertise. It is noteworthy that the committee does not question the reverse. Rabi's assertion, "I must say I think that our generation, Dr Oppenheimer's and my other friends, created American physics", shows the authority of Oppenheimer and his peer group in the field (113). Ironically, during the speeches made by the prosecution, Gray states, "it is our arduous duty to examine whether the safety of this country, in a field as important as nuclear energy, rests secure in his hands" (116). The committee is going to judge whether a scientist is trustworthy enough to work on scientific projects. Kipphardt showcases the irony of the situation as Oppenheimer expresses, "Political opinion, no matter how radical or how freely expressed, does not disqualify a scientist from a high career in science; it does not impugn his integrity nor his honour" (122). The play ends with passionate last remarks by Oppenheimer and a declaration that he will never work on war projects again.

Scientific authority emanates from the authority of the scientist and of scientific methodology. *In the Matter of J Robert Oppenheimer* portrays the stand taken by the scientific authority against an onslaught of political, judicial and military authorities. Kipphardt's play enables the researchers to analyse the mutual interactions of these authorities and the resultant erosion of agency to dissent. Oppenheimer's ordeal serves as a guiding light to scientists who will face similar ethical and moral dilemmas in the future.

Life of Galileo

Bertolt Brecht's historical play *Life of Galileo* portrays the life of the Italian polymath and presents the astronomer's conflict with papacy. Brecht wrote fiction, plays, poetry, and theoretical works. He also propounded the concepts of epic theatre and the defamiliarisation effect. Brecht moved from Germany to the United States during the Nazi era. In the United States, he was under the FBI's radar and had to depose before the House Un-American Activities Committee for charges of alleged communist sympathies. His exile and his subsequent persecution during the McCarthy Era influenced his opinions and his works. *Life of Galileo* depicts the astronomer working on his ideas and experiments and facing a range of problems from financial penury to opposition from religious authorities.

Brecht portrays various kinds of authorities in the play, the most prominent being Christian religious authority. The employment of faith as an authority appears in Galileo's lengthy monologue where he states "For where faith has been enthroned for a thousand years doubt now sits. Everyone says: right, that's what it says in the books, but let's have a look for ourselves. That most solemn truths are being familiarly nudged; what was never doubted before is doubted now" (7). Challenging the authority of the heavenly order, Galileo asserts "The heavens, it turns out, are empty. Cheerful laughter is our response. But the waters of the earth drive the new spinning machines, while in shipyards, the ropewalks and sail-lofts five hundred hands are moving together in a new system" (7). The regressive social order is held in place by the priests enforcing its rules and regulations, who are eager to correct anyone straying away from the path of righteousness. Mrs Sarti, Galileo's housekeeper, says to Galileo "You surely can't tell him [Andrea] such stories? Making him trot all out at school so the priests come and see me because he keeps on coming out with blasphemies. You should be ashamed of yourself, Mr Galilei" (10). Mrs Andrea is a representative of a large group of individuals who were tacit

upholders of the status quo and her distaste towards Galileo's work is evident. On authority, Arendt states, "Its Hallmark is unquestioning recognition by those who are asked to obey; neither coercion nor persuasion is needed" (Arendt 1970, 45). Under the threat of the Inquisition, the citizens begin to self-censor. Brecht portrays such self-censorship in the conversation between Galileo and Andrea where Galileo forbids him to talk to others about their discussions.

Brecht depicts the varied and simultaneous interactions of non-exclusive authorities. The academic authorities complement the religious authorities in perpetuating the status quo. The playwright portrays the procurator of the university as an example of such an authority. He dictates terms to academicians regarding the type of work that will be performed and that too, always in accordance with the scriptures. To showcase his and the university's generosity he boasts, "In Padua we even admit Protestants to our lectures. And give them doctors' degrees too." Later he states, "That should mean something to you, being an astronomer, that's to say operating in a field where for some time now the doctrines of the church have hardly been treated with proper respect." The threat, thinly veiled in this conversation, becomes evident when he asserts, "Incidentally, however free we are, I wouldn't go around openly citing a name like his [Giordano Bruno], which is subject to the express anathema of the church: not even here, not even here." Warning Galileo of the consequences, he suggests, "What use would it be to have limitless spare time for research if any ignorant monk in the Inquisition could just put a ban on your thought? Every rose has its thorn, Mr Galilei, and every ruler has his monks" (15). The Inquisition's threat of burning people who do not fall in line with the scriptures' authority forces people into subjugation. In the fourth scene, the mathematician and the philosopher hark back to ancient philosophers' works to back their claim and discredit Galileo. The mathematician says "I take it you are familiar with the opinion of the ancients that there

can be no stars which turn around centres other than the earth, nor any which lack support in the sky?" (38). The philosopher ropes in Aristotle stating the following:

> The universe of the divine Aristotle, with the mystical music of its spheres and its crystal vaults, the orbit of its heavenly bodies, the slanting angle of the sun's course, the secrets of the moon tables, the starry richness catalogued in the southern hemisphere and the transparent structure of the celestial globe add up to an edifice of such exquisite proportions that we should think twice before disrupting its harmony. (39)

The authority of the ancients only cements the authority of the theological heads. It becomes easier for the authorities to discredit any new idea if it does not sit well with the ancients' opinion. The philosopher discredits Galileo citing Aristotle and states "If Aristotle is going to be dragged in the mud – that's to say an authority recognized not only by every classical scientist but also by the chief fathers of the church – then any prolonging of this discussion is in my view a waste of time" (42). The Vatican has theological astronomers who aid the theocratic authorities. In the play, Father Christopher Clavius is the chief astronomer of the papal college in Rome. His job is to uphold the worldview according to the scriptures but, being an astronomer, he cannot ignore the evidence that proves otherwise. He judges Galileo's observations to be true; however, his opinions are not valued much when the Inquisition judges Galileo. This displays the relative standing of scientific and academic authority with respect to theological authority. Religious authority resonates with the authority of traditional scholars but counters scientific authority. The state-endorsed scholars, astronomers, and philosophers are the bedrock of the state's authority. The state relies on the natural philosophers of the time and religious scholars to ensure strict compliance with the state-approved worldview. They are further supported by monks who uphold the scriptures' sanctity. A lean monk in the sixth scene argues, "What do the scriptures say? 'Sun, stand thou still on Gibeon and thou, moon in the valley of Ajalon' How can the sun stand still if it never moves at all as suggested by this heretic?

Are the scriptures lying?" (52). Ironically, even the religious authorities cannot ignore the practical applications of Galileo's works and inventions. The cardinals discuss the utility of Galileo's theoretical observations for maritime trade and navigation and hypocritically, Cardinal Bellarmin comments, "We must move with the times, Barberini. If the new star charts based on a new hypothesis help our mariners navigate, they should use them. We only disapprove of such doctrines that run counter to the Scriptures" (59). The religious authorities can discredit Galileo's work but cannot deny its practical applications.

Scientific authority and the authority of the scientific methodology stand in direct confrontation with religious authority. The Papal authorities fear that objective reasoning and rational inquisitiveness may be harmful to their control over the masses. The Roman Inquisitor says "…they [heretics like Galileo] have put their faith in a brass ball they call a compass, not in God…God anyhow is no longer necessary to them, but what kind of miracle is it to be?" (92). Authorities aim for the status quo and fear a change of guard. The changing worldview means discarding old views in favour of new ones, as the old ones are not compatible with the new ones. The old and the new paradigms cannot communicate with each other. Thomas Kuhn, the historian and philosopher of science, referred to this phenomenon as incommensurability. Kuhn theorised extensively about the progress of scientific knowledge and established the theoretical concepts of paradigm shift, normal science, transcendental nominalism and incommensurability. The play also questions the end result of scientific activity in general. Galileo believes that he goes on to work so that he can make people understand. For him, it is the dissemination of scientific knowledge that drives him. For the traders and men of commerce like Vanni, the end result of scientific activities is the monetary benefit, and for men of authority like the Chief Papal Astronomer, Cardinals and the Pope, the purpose of science is to maintain the status quo.

Galileo echoes the role of objective facts and evidence in upholding the authority of scientific methodology. He says "The sum of the angles in a triangle cannot be varied to suit the Vatican's convenience. I can't calculate the course of flying bodies in such a way as also to explain witches taking trips on broomsticks" (68). Galileo asserts that objective truth cannot be moulded to suit the doctrines of the church. Scientific authority emanates from the authority of the scientist and that of scientific methodology. Patricia R. Paulsell in her article "Brecht's Treatment of the Scientific Method in His 'Leben des Galilei'"(1988) discusses the idea of proof and use of reason in the play. She states:

> What exactly is Galileo calling 'proof' here? What is 'reason'? 'Proof' seems to be the observation of something in the physical world which apparently confirms one's preconceived notions. 'Reason' is a deductive process which has not necessarily been exposed to rigorous determination of the logic of its cause and effect statements. Galileo then announces his intention to go to Florence and invite the scholars to look through the telescope, where even the monks will be 'seduced by proofs' when Galileo asks them to 'trust the evidence of their eyes'. (276)

While Galileo bets on the authority of evidence to back his theories, Sagredo believes that the religious and political authorities will not even listen to any argument about evidence. Towards the end of the third scene, Sagredo laments:

> Galileo, I see you embarking on a frightful road. It is a disastrous night when mankind sees the truth. And a delusive hour when it believes in human reason. What kind of person is said to go into things with his eyes open? One who is going to his doom. How could the people in power give free rein to somebody who knows the truth, even if it concerns the remotest stars? Do you imagine the Pope will hear the truth when you tell him he's wrong and not just hear that he's wrong? Do you think that he will merely note in his diary: January 10th 1610 – got rid of heaven? How can you propose to leave

> the Republic with truth in your pocket, risking the traps set by monks and princes and brandishing your tube. You may be a sceptic in science, but you're childishly credulous as soon as anything seems likely to help you pursue it. You don't believe in Aristotle, but you do believe in the Grand Duke of Florence. (33)

This scene represents the authority of evidence in scientific methodology and the utter disregard of the authorities towards it. The play also features a discussion on scientific method. Brecht depicts Galileo choosing observation as a scientific method. The telescope's importance as a scientific instrument is that it allows Galileo to observe extra-terrestrial bodies and prove the theories put forth by Copernicus. Brecht discusses the concept of proof in the play when Galileo says that he requires proof for his theories and he is going to provide it (29, 32). In doing so, the play introduces the readers to the scientific method of hypothesis formulation and testing.

The play depicts the role of patronage and the authority of funding agencies in sciences. The second scene showcases Galileo presenting the telescope to the Doge and other state officials. The eloquent wordings of salutation to the officials hide the underlying need for constant financial support from these officials. During Galileo's time, science was not institutionalised as an academic profession. It was the pursuit of "amateur" natural philosophers and they completely relied on patronage for their work. The patrons who support the research work also act as authority over the end product and the means of innovation. The political scientist Mark Haugaard asserts, "Authority emerges as a form of compulsion which is distinct from violence, yet has something in common with it because it requires unquestioned obedience" (6). However, confrontation with the authority can also result in a violent end.

Questioning the given truths was deemed an act of dissent. The inventions that Galileo and other men of science of the age made ushered in an era of exploration and inquisitiveness that interrogated the truths ordained by the authorities. Countering the old model of the

universe, Galileo remarks "And the earth is rolling cheerfully around the sun, and the fishwives, merchants, princes, cardinals and even the Pope are rolling with it" (8). While the old-world order supported the old social order, breaking free from the old-world order's authority also meant dissenting against the old social order. The circulation of ideas is also restricted under such threats. The playwright portrays the coercive nature of authority with the constant threats of violent outcomes. Galileo and the readers are repeatedly reminded of Giordano Bruno's fate, who was burnt at the stake for cosmological theories that furthered the Copernican model (24, 53). Galileo's friend Sagredo advises him to continue teaching the old model just like Copernicus. In order to avoid a gruesome end, Galileo agrees to teach the dogmatic view of the universe, as he could not prove his theories at the time.

The play is set at an important juncture in the history of science. The progress of science at the time corresponds to Thomas Kuhn's concept of paradigm shift. The Scientific Revolution was the time period when scientific advancements frequently questioned the given knowledge and challenged the established authorities. This revolution was facilitated by paradigm shifts which occur when normal science becomes incompatible with a phenomenon and thus a new paradigm is required. The scientific activities of the day were incompatible with the religious paradigm, which was the normal science of the day, so a paradigm shift was in order. In the play, Brecht depicts a time period that coincides with the spread of the Plague in Europe. The iron trader Vanni who supports Galileo and offers to smuggle him away comments "The same sort of people as are trying to block you are stopping the Bologna doctors from dissecting bodies for medical research" (87). All forms of scientific explorations face hurdles from religious authorities. However, it was also a time of great fervour in medical research when scientific ideas spread like the plague all across the continent.

When confronted by the Inquisition, Galileo recants his findings. Faced with brutal theocratic authority, Brecht chooses to retain his agency to dissent by recanting. He moves to

a secluded country house in Florence where he is put under constant supervision but he secretly manages to continue working on his manuscript. At that time, Books were written in Latin which was the ordained language of the Holy Roman Empire but Galileo chose to write his manuscript in Italian, which was the language of the masses. He instructs Andrea to smuggle out and circulate his manuscript. Galileo maintains that he recanted as he was afraid but it provided him with the ability to finish his work. His instruction to smuggle the manuscript and the decision to write in Italian were his acts of dissent against the theocratic authorities.

The multiple methodologies and various means and ends of scientific activities bring to the fore the question of science and authority's relationship. Brecht highlights the nuanced nature of authority and portrays the interactions of the different manifestations of scientific authority and theocratic authority.

An Experiment with an Air Pump

Stephenson is an accomplished British playwright whose work often features new advances in science. She has written multiple plays for BBC Radio. Her first play *The Memory of Water* (1997) won the Lawrence Olivier Award and her second play *An Experiment with an Air Pump* (2000) (hereafter *An Experiment*) won the Peggy Ramsay Award. Set at the turn of the century in two different time periods, *An Experiment* is divided into two acts, and frequently shifts between 1799 and 1999. Joseph Wright of Derby's *An Experiment on a Bird in the Air Pump* (1768) is at the heart of the play. The 1799 timeline details the tale of the physician Dr Joseph Fenwick, his wife Susannah Fenwick, their daughters Harriet and Maria, their servant Isobel Bridie, and two young men named Peter Mark Roget and Thomas Armstrong. Fenwick, Armstrong and Roget have a discussion regarding scientific lectures and demonstrations on New Year's Eve while there are riots on the streets outside. Isobel discusses her spine deformity which intrigues Armstrong. Armstrong deceives Isobel into believing that he loves her. Harriet,

to her mother's dismay, expresses her wish to be a physician. Roget and Armstrong discuss the dissection of a stolen corpse. Roget comes to know about Armstrong's machinations about Isobel and confronts him. Armstrong admits his treachery and reveals his ill intentions, unaware of the fact that Isobel is listening. In the fifth scene, Maria finds Isobel's body hanging from the ceiling. The 1999 timeline portrays the tale of a geneticist Ellen, her fellow geneticist Kate, her husband Tom, and a construction surveyor named Phil. The action in both timelines takes place in the same house. In the latter timeline, Ellen is trying to sell the house and has called Phil, the surveyor. The plan is to restore the house and sell the house to a company that will rebrand it as a heritage corporate hospitality unit. Along with the two periods portrayed in the play, the house has witnessed multiple historical events. Ellen states, "Lavoisier visited this house. Tom Paine was given secret readings in this very room. It's a big, plain, solid house, it's not quaint or charming. The history of this house is the history of radicalism and dissent and intellectual inquiry and they are going to turn it into a tin of souvenir biscuits" (26). Phil and Ellen engage in a discussion about science and research. Kate informs Phil of her company's work in the field of genetics. Ellen shares her hesitations about joining Kate's company with Phil. Tom walks in and shares with others the discovery of bones in kitchen cupboards. In the second act's second scene, the readers get to know that some parts were missing from the skeleton. Ellen takes the job, and Kate and Tom get into an argument about the ethics of genetic manipulation.

Stephenson portrays the authority of a scientist's depiction in matters of art. The issue of the authority of science and scientist is at the core of the play. In the first dialogue of the prologue, Ellen asserts that she likes the painting by Joseph Wright of Derby as "it has a scientist at the heart of it, scientist where you usually find god" (5). This depiction showcases the shift of authority from God to a scientist. The scientific revolution upended the prevailing world order. God was not the center of the universe anymore, it was reason. Similarly, religion

was slowly being replaced with rational thinking as a mode of inquiry into the natural phenomenon. Elaborating upon the same, Ellen states, "Here, centre stage, is not a saint or an archangel, but a man" (5). The shift from theological authority to scientific authority is evident here. Ellen's assertion that she wanted to be God is an affirmation of the same.

The readers come across an apt depiction of male academic gatekeeping wherein they act as self-anointed authority over science, deciding who gets access to knowledge and who does not. At the end of the prologue, Armstrong makes a misogynistic comment saying, "Keep infants away from the fireplace and women away from science" (7). Women's exclusion from sciences is also portrayed in the second act's first scene when Harriet informs her family of her decision to be a physician and her mother says, "Did I hear her correctly? Did she say physician? Has she taken leave of her senses?" (51). Thus, gatekeeping is not just academic but begins at the family level. Based on legitimacy, the sociologist Max Weber has divided authority into three types – traditional, rational-legal, and charismatic. These statements of Armstrong and Susannah further the traditional authority of patriarchy as according to the traditional patriarchal worldview, there is no place for women in science and women cannot be physicians. Stephenson also highlights the work done by people to aid the scientist that usually goes unacknowledged. The physician, as a patriarch, asserts his authority at home as well. While complaining that Fenwick has refused to see their play, Harriet says, "We have spent hours labeling every piece of your useless bric-a-brac, arranging in alphabetical order your rhinoceros horn, your dried walrus flipper, tooth of hippopotamus, pointless chucks of volcanic lava, even the hair balls of an ox…". To this, Maria further adds, "He even made us attend the dissection of a dear little spaniel" (17). The play hints at the fact that since science was not an institutionalised endeavour, the contribution of a large number of people particularly women who aided such natural philosophers was never acknowledged or rightly attributed.

Stephenson portrays the authority of experiments and demonstrations in the field of science. In the first scene, we see Armstrong, Roget and Fenwick discussing a number of proposals for the New Year lectures. Armstrong informs the other two about Dr Farleigh's demonstration by and they discuss the work of Rev Jessop and Mr Charleston's paper. The criteria for selecting the New Year lecture appear to be scientific content and its public dissemination. The playwright also highlights the practice of public science demonstrations that was prevalent in the eighteenth century. Amateur natural philosophers and performers used to travel from town to town showcasing their experiments. These experiments had less science and more showmanship. The scene portrayed in Joseph Wright of Derby's *An Experiment on a Bird in the Air Pump* is of a similar performance. Stephenson presents the public or the general audience as one of the authorities on matters of science when Roget states that Mr Charleston's paper was "very popular with the ladies…" (11). Here, Stephenson hints at the field of popular science. Such an authority falls under the category of charismatic authority as per Weber's distinction of authority on the grounds of legitimacy. Choosing a popular paper for the New Year lecture is in line with the tradition of public demonstrations by amateur scientists and performers during the time.

Even within the fold of science, the issue of the relative superiority of various branches is present. Stephenson portrays the same when Armstrong, a physician, states, "I think botany does come within the brief of Literary and Philosophical" (10). Fenwick, discrediting the work of Rev Jessop, says, "What he practices is not science, but a branch of theology" (11). Stephenson depicts the authority of peers and the impact of religion on science. She also highlights the fact that a large number of early practitioners of science were not professional scientists but persons engaged in other activities who did science as amateurs.

The playwright incorporates in dialogues the depiction of various authorities in the play. Harriet, explaining the plot of the play she presents in front of her family, says, "Maria

represents the past, and I represent the future." In her very next dialogue, she says, "I am empire. Industry, science, wealth and reason." (15). The company that Kate works for represents the authority of industry and wealth. They have the required capital to undertake research in prominent areas and to market the research as a commodity. The character of Dr Fenwick represents the authority of wealth and science. The well-off patriarch is a physician who commissions public lectures on science. As science was not established as an institutionalised endeavour during that period, it was majorly undertaken by wealthy individuals or by amateur natural philosophers with the aid of patrons. Tom and Roget represent the authority of reason as they feature as the voice of caution and humanity in the play. Ellen, the geneticist, depicts the authority of science and Kate, the geneticist and corporate employee, depicts that of wealth and science. Stephenson efficiently portrays the various authorities simultaneously at play with one another in these dialogues.

The public authority over science also stems from the public imagination of science. Interestingly, Fenwick's wife is immune to his authority as a man of science. She says, "…physicians never cure anything. That's a well-established fact. None of you know what you're talking about" (19). People's opinion of scientific research is highly dependent on what they understand about that research. The playwright highlights the public understanding of science in the latter timeline of the play when Phil, a construction surveyor, states, "I tell you something, black holes, I like the sound of them, it's like the bloody X-Files….Now, I wouldn't mind researching them" (27). Phil's character succinctly portrays the prevalent public imagination of science. While talking to Tom, he states, "Like you know, if they can map your genes before you're born, they'll soon be wanting a little plastic card with your DNA details on. And if it says anything dodgy, it'll be like your credit blacked." Highlighting the idea that people are always suspicious of what they do not understand, Phil replies, "You see that's why people don't trust scientists. They're always up to something" (31). The public imagination of

science and scientific discoveries exert their authority in their unique way as depicted by Phil's character.

Scientific authority emanates from the authority of the scientist and that of scientific methodology. In the third scene, Roget invokes the authority of methodology and states, "I'm a good physician because I'm methodical and intermittently inspired" (35). Evidence plays a crucial role in scientific methodology and therefore contributes immensely to its authority. In her reply to Phil, Ellen invokes the importance of evidence in scientific research and asserts, "It's not a matter of belief. It's a matter of evidence, and I don't have any that persuades me they exist" (28). Invoking the authority of scientists in the latter timeline, Ellen says to Kate, "You still want to be god" (30). This assertion mirrors her assertion in the prologue and highlights the upended world order where the centre is not occupied by God but by science.

Fenwick asserts the authority of science and technology over nature. He discusses his vision for the future of the town and exclaims, "Huge, graceful bridges. Triumphs of engineering. Hymns to invention and the conquest of nature" (36). Further, he states, "…and how will we get there? By the relentless, irresistible advance of science and the consequent wider dissemination of knowledge" (37). Connecting the pursuit of science with political authority, he asserts that science is inextricably linked with democracy. He hopes that by the end of the century, the monarchy will cease to exist in Britain. Stephenson also highlights the authority science provides people over their own bodies and that of others. Kate asks Phil, "If, very very early in your wife's pregnancy, you were able to discover in your child the gene for say, Alzheimer's disease, or asthma, or maybe something more alarming like schizophrenia, would you be grateful for that information?" (31). Also, the supposed hierarchy of diseases is noteworthy where some disease are "more alarming" than others. The play questions the intrusion of science in one's life as well as the afterlife. Tom raises the same question when he asks, "So what's the difference? At what stage does it stop being disturbing and start being

archaeology?" (41). While discussing the ethics of the research she is about to undertake, Ellen explains to Tom, "But I don't have a problem working with pre-embryos. I'm sorry but I don't. What I do have a problem with is you thinking I'm some murderess because of that" (43). Here, the playwright directs our attention to the issue of human life and foetus development. Ellen's assertion nudges the readers to question at what stage does life begin and when does an embryo become a human? Tom's concern regarding the research seems valid as he explains, "It's totally a commercial operation. Kate's firm exists to make money above and beyond everything else." He further adds, "Can you imagine what insurance companies will do with that information? Mortgage companies? Health insurers?" (44). In such a scenario, as depicted by the playwright, companies will have unprecedented authority over the bodies of people and it will impact their everyday lives.

In Stephenson's play, the authority to draw a line lies with the private company undertaking the research and the scientists working for them. The central theme of the whole play can be well summarised in this dialogue by Tom, when he asks Kate, "So where would you draw the line?" (71). Towards the end, when Armstrong is questioned by Roget on the heinous deed that he has done, he replies, "Discovery is neutral. Ethics should be left to philosophers and priests" (58). He outrightly rejects the authority of ethics over science. The playwright shows Isobel's coffin transform into a cage drawing a parallel to Joseph Wright of Derby's *An Experiment on a Bird in the Air Pump* (1768) where the bird dies gasping for breath. Commenting on the ending of the play, Claudia Barret in her article "A Moral Dialectic: Shelagh Stephenson's *An Experiment with an Air Pump*", states:

> The play ends with the same tableau as it began, 'but this time Isobel, in her coffin, has taken the place of the bird in the air pump' (231). Things do change. And while this change is fatal for Isobel, it is stimulating for Fenwick and, more significantly, for the audience. 'What is 'natural' must have the force of what is startling,' writes Brecht (71).

> The first tableau, mimicking a familiar painting, is natural, but the second, with its morbid substitution, is startling. This second *gestus* is rife with commentary on the first…In these terms, allegory occurs when the last scene of the play doubles the first – and it also occurs when the first scene doubles Wright's painting and when the present-day scenes double the past. Stephenson's allegory works dialectically, as she employs it not only for alienation effects but to draw connections. It operates backwards and forwards. In the past allegorizes the present, the first scene allegorizes the last, and the painting *An Experiment with an Air Pump* allegorizes the play. (14)

Using the painting as a starting point, Stephenson builds a play that questions the ethical boundaries of scientific innovation.

Einstein

Maharishi's *Einstein* (1996) is a rare example of a bilingual play Indian science play. Maharishi was a professor at Panjab University and later became the director of the National School of Drama, New Delhi. The play presents us with an example of collaboration between playwrights and scientists to develop a play. In the preface to the play, Jayant Narlikar calls it a boon to the field of Indian theatre.

The play features the characters of Albert Einstein, Aristotle, Nicolaus Copernicus, and Galileo Galilei. The first scene of the first act begins with an old Albert Einstein at his home in Princeton. He states his distaste for religion and explains his initiation into science. The play then introduces a young child who, in a metatheatrical way, is to play the role of young Einstein. Einstein has an extensive discussion with this child, and they talk exhaustively about science, particularly about travel at the speed of light. The second scene of the first act introduces us to a younger Einstein called Einstein 1. Einstein 1 is portrayed talking to his older self. Einstein 1 belongs to the year 1896 and Einstein belongs to the year 1948. They both talk about the

growth of physics and the concept of ether. Later in the scene, we see a magician, a girl and a fat lady. The magician wants to bring to life a number of people who have contributed to the field of science. So Einstein prepares a list of the most prominent men of science in history. The second act of the play begins with Max Talmud teaching Einstein in his childhood. The play ends with a discussion between the two Einsteins about the theory of relativity.

The issue of the authority of religion features prominently in the play. The characters of the Christian teacher and Rabbi, and their contradictory ideas set the tone for the conflict of authorities (10). As depicted in the play, the two religious authorities are at loggerheads with each other. Maharishi provides the readers with an example of conflict between two authorities of the same kind. The playwright depicts the gradual but absolute replacement of religious authority with academic authority who demand complete adherence.

Academic authority exerts itself in the form of Bernstein's books that are handed over to Einstein by uncle Max. Such works stand in direct opposition to the teachings of the religious authorities. Einstein states in the play, "After reading those books, I realized that the teachings of Bible are wrong" (11). The play depicts the authority of religion in the discussion of scientific progress before and after the birth of Christ, and the resultant division of time into BC and AD. Maharishi presents the simultaneous interactions of multiple non-exclusive authorities with one another. Einstein copies his teacher and mockingly says, "Why did you not solve the problem as given in the holy book of geometry?" (13). Non-adherence to the traditions laid down by the authority and dissent is abhorred in both religion and science. The readers come across the authority of mathematics in science and the authority of experiment when Einstein instructs the child to prove "it using mathematics and using a thought experiment" (15). The young child challenges the authority of adult Einstein by saying, "you think how can a child ask such questions" (16). The young child mirrors the character of

Einstein and constantly challenges the authorities that be, including Einstein. As per Max Weber's classification, Einstein is both a charismatic as well a rational-legal authority.

Scientific authority emanates from the authority of the scientist and that of scientific methodology. In this case, according to a distinction based on legitimacy, a scientist's authority results in charismatic authority and scientific methodology's authority results in legal-rational authority. These are exhibits of simultaneous interactions of non-exclusive authorities represented in the play. Reminiscing about his childhood, Einstein states that the book on geometry that he had contained Euclid's straightforward formulae of geometry without any proof (18). The play mentions the scientific authority of an author in the form of Phopel's textbook on electrodynamics (37). Prof Heinrich Beaver portrays the hindering kind of authority in science that prohibited Einstein from performing his experiments (38). Einstein's affirmation of the genius of Newton and his work on motion and gravitation establishes Newton as an authority in the field. The inclusion of the formulae $F = ma$ and $F = G\frac{M1\,M2}{d^2}$ portrays the role of mathematical formulae in science and the importance of mathematical proof in scientific methodology (39). The authority of Euclid on geometry is such that a particular mathematical system is termed Euclidean Geometry. Another authoritative figure in mathematics mentioned in the play is Pythagoras, whose followers were called Pythagoreans. The magician depicts the position of authority that the named scientists, that is, Euclid, Democritus, Pythagoras, Ptolemy, and Archimedes, enjoy not just in the field of science but also in the public imagination. She refers to Aristotle as "the big shot Aristotle", thus portraying his authoritative position (27). Einstein pays regard to Copernicus, Brache and Laplace and their work, thus recognizing them as authorities in the field (44, 50). Einstein 1's assertion that Hertz's work on electrodynamics is authoritative depicts the nature of authority certain leading figures of science enjoy (35). Few scientific figures such as Einstein, Newton, Galileo, Hertz and the like exert legal-rational authority as well as charismatic authority. Public imagination

of science and its practitioners not just establishes them as authorities but also motivates the common population to dissent against dogmatic ideas. Galileo relied on the authority of objective evidence produced by experiments to challenge the prevailing thought. Galileo even falsifies Aristotle's assertion that constant force is required to keep a body in the state of motion. Einstein's statement regarding "the ghostly substance" ether highlights the paradigmatic shifts in the field of science (37). Einstein's conceptualisation of the paradigm of ether could not stand the test of scientific scrutiny and the paradigm was replaced.

Maharishi points out the relative importance of theoreticians and experimentalists in the second scene of the first act which features a conversation between Einstein and Einstein 1. Einstein 1 informs that in the year 1948, a lot of work has been done in experimental physics, but theory has lost steam.

> EINSTEIN. Are you happy?
>
> EINSTEIN 1. A lot! I secured admission in the Polytechnic today. And you?
>
> EINSTEIN. I am good too. Here, at Princeton.
>
> EINSTEIN 1. Physics would have developed a lot by now?
>
> EINSTEIN. Yes. There has been some good work in experimental physics but theory has gotten weak. I feel that good brains have lost their way in the narrow alleys. Here at Princeton, people call me old and senile. I am a museum relic. (21-22)

Such an expression depicts the conflict for authority amongst theoreticians and experimentalists in science in general and physics in particular. A similar conflict is portrayed by Djerassi and Hoffmann in *Oxygen* (2001) where chemists debate the relative authority of theoreticians and experimentalists.

Another figure of authority that the playwright portrays is the Gypsy magician. The magician derives authority from dogma and magical mumbo jumbo. The play contrasts the scientific world of Einstein with the magical world of the Gypsy. Einstein has legal-rational as

well as charismatic authority but the Gypsy magician only has charismatic authority. When the character of the fat lady requests the magician to bring to life eminent scientists, it portrays the opposition of science and dogma as authorities, as the lady calls all scientists criminals for speaking against religion and God.

The idea of people gazing at the stars without permission and then interpreting what they saw in ways they deemed fit was detrimental to the authority of religion as well as the established science of the time. Even observing the skies can be an act of dissent. According to Theophrastus, the people challenged Aristotle's authority when they observed the stars "without permission" and saw them revolving in elliptical paths (29). The established science of the time followed the principles of Euclid and the physical world was made to follow the same as well. Aristotle states, "We only believe in Euclid. We believe in straight lines. We accept completely round objects only. Nature's truth lies in beautiful round figures, straight lines and triangles" (29). In the play, Aristotle declares that the authority of Euclid finds support five hundred years later, when a scientist named Ptolemy writes *Almagest*. Copernicus later challenges the prevalent thought and says, "Earth is not stationary, Sun is. Earth is revolving around the sun" (30). More often than not, there was no difference between the religious and the political authorities of the time. The religious and political authorities of the time persecuted the likes of Copernicus, Kepler and Galileo, for dissenting and for upending the status quo that these authorities were upholding.

One of the three disciples accuses Galileo of being against the Bible and God. Galileo is forced to recant under pressure from theocratic authorities.

> THIRD. Fool – friendship with a slave? Catch this spy. He is against God. He is a spy. He is a traitor. He is against the Bible. You are a scoundrel. What was it that you were handing over to that boy?
>
> GALILEO. Nothing. I was just asking for directions.

THIRD. Asking for directions? Or were you giving directions?

GALILEO. No.

THIRD. You must have told him something!

GALILEO. Nothing at all.

THIRD. Really? Answer this then. What kind of a person was Kepler? Wasn't he a liar? And Copernicus? Wasn't he a liar?

FIRST. Let him be. He doesn't know anything.

SECOND. You shut up!

THIRD. Answer me!

GALILEO: They both were liars. (33)

As portrayed in *The Life of Galileo*, Galileo's act of recantation in face of certain death can be seen as means of dissent as well. His recantation provided him the required time to write down his works in Italian. He got his books smuggled out of Italy for wider dissemination.

Towards the end, highlighting the spirit of enquiry, Einstein 1 asserts, "We are science students. We cannot be idol worshippers" (46). This spirit is the guiding authority of science. Finally, Einstein's theory of relativity was published in the journal titled *Annalen der Physik*. The playwright hints at the authority of journals in all academic fields and that of the peer-review process. Maharishi's bilingual play provides the scholars with an example of collaboration between scientists and playwrights and also implores to search for more science plays in regional languages.

Oxygen

Djerassi and Hoffmann's *Oxygen* (2001) investigating the discovery of oxygen, problematises the concept of discovery and raise important questions about the ethics of discovery. Djerassi was a chemist, a novelist and a playwright. He was renowned for his work

on the oral contraceptive pill. Hoffmann was a poet, a playwright and a Nobel Laureate in Chemistry. Their play *Oxygen* significantly contributes to bridging the gap between the two cultures of sciences and humanities. The play portrays the quest of being first in science and discusses the problems of experimentation and publication. The play is set in two different time periods – 1777 and 2001. The former tells the tale of chemists Antoine Lavoisier, Joseph Priestley and Wilhelm Scheele, and their wives Marie Lavoisier, Mary Priestley and Sara Pohl. The latter details the story of the professors Bengt Hjalmarsson, Sune Kallstenius, Astrid Rosenqwist and Ulf Swanholm, and Ulla Zorn, a graduate student of History of Science. The earlier time period tells the story of the discovery of oxygen as the chemists and their wives stake their respective claims in the royal court of King Gustav III. The later time period tells the story of a retro-Nobel committee trying to find the truth of various aspects of the discovery of oxygen by the aforementioned chemists.

In the 2001 timeline, we see the proceedings of the retro-Nobel committee. The committee has been authorized to find a suitable candidate for a Nobel prize to be given for a past contribution in the field of chemistry. The committee members are respected authorities in their field and enjoy privileges of the same. While talking about the reason for being on the committee, Bengt Hjalmarsson says, "I like the power…and the gossip" (11). Further, lamenting over the fact that the recipient of this retro-Nobel will be a dead person, he says, "The dead don't repay favours" (11). Such positions do provide authority and associated privileges. Astrid Rosenqvist as the chair of the committee exercises her privilege by appointing Ulla Zorn, a historian, as committee secretary or amanuensis. While deliberating on the contribution for which the committee should award the prize, Bengt reminds the committee members of the Will of Alfred Nobel which describes the criteria for granting the prize (14). Alfred Nobel's Will acts as a guiding principle for the committee. This portrays the authority of the award committees and grant-awarding agencies. When Ulf states that in science, prizes

are given to people and not to discoveries, he hints at the authority that rests with the prize-awarding institutions.

The playwrights portray the varied facets of authority in the earlier timeline and the readers come across different authorities simultaneously manifesting themselves. At the beginning of the play, Mme Lavoisier introduces Antoine Lavoisier as a tax collector for the agency of the crown (5). Lavoisier exercises a lot of authority over the people as a tax collector, but it also depicts that the scientific profession had not been institutionalised till then. Antoine is the scientific authority in the laboratory, but he is dependent on Mme Lavoisier for the translation of books, letters and transcripts (9). She exerts her authority over the communication aspect of Antoine's work and her influence is depicted clearly when she translates Priestley's comments partially, conveniently withholding the part about the new gas. The same is evident when she withholds the letter that Scheele wrote to Antoine about the discovery of a new gas. The play depicts the contributions of people who aided the natural philosophers but were never credited for it as science was not institutionalised.

Amongst the Nobel laureates, there is an imbalance when it comes to nationality. Ulf Svanholm expresses his displeasure in awarding the retro-Nobel to an American (14). This shows the differences in the development of research programs in various countries and the resultant advantage that those countries have. Interestingly, there is a marked dominance of Euro-American scientists when it comes to the recipients of the Nobel prize in Chemistry. The differential levels of advancement in research, the varied representation across the world in award committees, and the resultant difference in authority in the field of chemistry are evident here.

The playwrights portray the authoritative position occupied by the phlogiston theory at one point in the history of chemistry. In the fourth scene, Astrid states, "For all of them, phlogiston represented the 'Grand Unified Theory' of the chemistry of their time" (29). As per

this theory, during a substance's combustion, an element called phlogiston, which is already present in that substance, is released into the air. It also reflects the fact that in science, theories are tested and retested, and are valid only until they can withstand this litmus test. This is in line with the philosopher Kuhn's concept of the phases of paradigm shift as discussed in the previous sections. This validation of scientific principles is an authority in itself. The concept of phlogiston was incommensurable with other paradigms of Chemistry that were being developed. Bengt clearly explains the phases of paradigm shift when he asserts that the phlogiston theory "was rudely punctured…by Lavoisier's revolutionary insight…that during the process of burning…something is taken from the air. And that 'something' is oxygen!!" (30). With its discovery, oxygen captured the authoritative position that phlogiston once occupied and ushered in the chemical revolution. The chemical revolution refers to the reconceptualisation of chemistry in the seventeenth and the eighteenth century which resulted in the formulation of the theory of combustion and the law of conservation of mass. While suggesting the candidates for the retro-Nobel, Ulf suggests John Dalton for his atomic theory. Sune counters by arguing that in order for the atomic theory to be promulgated, "oxygen had to be discovered first and its role in chemistry understood!" (16). In the latter timeline, Astrid asserts along similar lines, "that without the discovery of oxygen there would've been no Chemical Revolution" (28). This depicts the critical position occupied by the discovery of Oxygen in the history of chemistry.

The play portrays the perceived hierarchy of knowledge systems. Ulla Zorn, a historian, acting as an amanuensis makes notes of everything that occurs in the meetings. The chair authorizes her to do so, and thus Ulla's record will be the final word as to the committee's proceedings. When Astrid asks Sune what is wrong with historians, he says history is, "a thing scientists do when they can't do science anymore" (16). To this Bengt adds, "What would they (historians) know about science? You might as well search the web" (17). As the play

progresses, the importance of history becomes crystal clear to all members of the committee. To get insights into the lives of the three men of science in question, the committee turns its attention toward the wives of the scientists as they can provide authoritative information on the scientists (32). The committee members are able to find the truth about the discovery of oxygen using historiographical methods and archival research. Here the playwrights hint at the authority and importance of the history of science. Notwithstanding the chemists' lukewarm attitude towards history and historians in the early part of the play, they realize the importance of historical methods and historical archives. The committee rummages through the Lavoisier archives in France and the archives at the French Academy of Sciences to find historical evidence of their respective claims. This perceived hierarchy also exists in the field of Chemistry (and science in general), as there is a rift between theoreticians and experimentalists. The experimentalists portray themselves as the authority in the field, as is evident from Sune's assertion, "In my experience, theoreticians make lousy chairmen" (12). The plot of the play dismantles these perceived hierarchies of knowledge systems as both experimentalists and theoreticians work together to uncover the history of the discovery of oxygen. This also serves as an apt example of bridging the chasm between the two cultures wherein scholars from sciences and humanities come together to solve a problem.

As the scientific profession had not been institutionalised till then, the savants of science were dependent on financial patronage or wealthy donors or support from the state. King Gustav III was the king of Sweden during the 1777 timeline of the play. He was a patron of science and arts. The question of the discovery of Oxygen came to King Gustav's court and he was to be the deciding authority. The play portrays the authority of the monarch over scientific matters. The monarch invites the "savants" to his court to test their claims to "fire air" (24). The playwrights depict the subjugation of the scientific authority to the state authority of a monarch. Lavoisier's question, "Who has the king's ear?", shows that it is not the just

monarch who has authority, but members of his court can have an influence on the matter too (25). In absence of independent institutions of science, all learning was subjected to the authority of patrons and the state. As a tax collector, Lavoisier was pretty well off to conduct his experiments, but both Scheele and Priestley relied on patronage for funding. To this effect, Priestley wished to, "…persuade Lord Shelburne to loosen his purse some more" (57). The patronage need not only be financial. Priestley, on account of being a Unitarian Minister, is not viewed favourably by the British crown, but Scheele has the good wishes of the royal court of Sweden. Before its formalisation as a field of learning, science was dependent on the authority of the monarchs and patrons.

The playwrights highlight various aspects of the peer-review process, the authority exerted by the reviewers, and the preoccupation with being the first. In the latter timeline, the readers get to know of the rift between Ulf and Sune, which resulted Ulf's paper that Sune reviewed. Ulf alleges that Sune deliberately delayed the review of his paper for two months and leaked information to his friends at Stanford University.

BENGT. I don't get it.

ULF. When I wrote up our work and sent it to the journal, Sune got it for review.

BENGT. So?

ULF. He sat on it for two months before refereeing it.

BENGT. (Dismissive) That's par for the course. Do you know how many articles I get to review?

ULF. I wasted another half year getting some damned spectra he wanted. Meanwhile he told his Standford pals in California all about it.

BENGT. (Turns serious) Are you sure?

ULF. Who else could have told them? He knows them … all too well!

BENGT. In research…simultaneous discovery occurs all the time.

ULF. Stop preaching to me!

BENGT. Ulf, calm down! Why not assume they found it by themselves?

ULF. Nonsense!

BENGT. You're obsessed by this. Let go.

ULF. Obsessed? We're always in a race where being first counts for everything. If you're second, you might as well be last. There's only a Gold Medal – in this case the Gibbs Medal – but no silver or bronze.

As the play proceeds, the readers get to know that it was a misunderstanding on Ulf's part. However, this instance depicts the importance of being first in the race that is science. The authority of the reviewers gives way to the authority of being the first in a field. Ulf names this preoccupation with priority "the Nobel Syndrome" and Astrid states that "expecting honours for being first is the occupational disease of scientists" (32, 34). Sune and Ulf's tiff alludes to the conundrum in the 1777 timeline and is an example of mirroring the plot, or parallel plotting.

The play also takes up the question of the low representation of women in the sciences. When Ulla Zorn asks Astrid, "Aren't you the first woman who has ever chaired a Nobel committee?", she is hinting at the lack of women in such committees despite them being the authorities in their respective fields. In the earlier timeline, the female characters are depicted as mere shadows of their male counterparts and serve the purpose of imparting information about their partners. The bleak representation of women is also an issue in the field of science plays. There is a dearth of female characters and female playwrights in the field.

The issue of Scheele's unpublished book highlights the authority of publication in science. If the publisher at Uppsala had published the book on time and not sat on it for a year, Scheele might have had a stronger claim over the discovery of oxygen. While Priestley has the publication of fifty papers and twelve books to his name, his lack of understanding of the gas's functioning weakens his claim. The authority of publication is also hinted at in the tiff of Sune

and Ulf over the publication of Ulf's paper, the review of which was allegedly delayed by Sune. Later in the eighth scene, Ulla Zorn exclaims, "When I see all of you…sniping at each other…worrying about who published…who didn't…This wasn't my idea of science and scientists" (65). Apart from the authority of publication, there is the issue of the authority of an experiment.

In sciences, the reproducibility of an experiment provides validates it. Scheele writes to Lavoisier, requesting him to repeat his experiment. Lavoisier repeating his experiment would have cemented Scheele's claim, but the letter never reached Lavoisier. While deliberating over who discovered the gas first in the court, the charge laid on Lavoisier is that he never actually performed the experiment but simply used Priestley's method. So, it is not just the publication of the results but also the performance of the experiment that wields authority. Scientific authority emanated from the authority of the scientist and the authority of scientific methodology. Performing the experiment asserts the authority of experiment in scientific methodology.

Public authority is portrayed in the play in the form of Samuel Johnson and Edmund Burke. Johnson was a literary doyen who compiled the first English dictionary. Burke was a philosopher and a statesman who wrote seminal works of political science. Both Burke and Johnson were influential public authorities. In the play, Johnson derisively calls Priestley "an evil man", whose "work unsettles everything" and Burke calls the British chemist "the wild gas, the fixed air is plainly broke loose" (58). These examples depict the public criticism that scientific authorities have to face. Public authority also provides public recognition. While discussing the reason for awarding the prize, Ulf says, "Because science is done by humans…not machines…and scientists crave recognition" (109). Along with staking claim to discovering the gas, the three scientists also lay claim to their own nomenclature of the gas. Scheele calls it "elsluft", Priestley calls it "dephlogisticated air" and Lavoisier names the gas

"oxygen". The scientist who discovers the new gas also gets to name it. Thus, public recognition is an important motivator for discovery.

The committee is also faced with the question of the importance of ethics in discovery. In the tenth scene, Bengt says, "Lavoisier's moral failures are clear, yes…but he brought about true change by making chemists pay attention to the balance sheet of nature!" (93). When questioned by Ulla about whether we should completely ignore moral lapses, Bengt says, "It's happened more than once with our regular Nobel Prizes. Good or poor ethics simply can't be weighed on the same scale with good or poor science!" (94). The play showcases the complex relationship between science and ethics that needs much more profound reflection. According to Richard Zare, "Djerassi and Hoffmann capture and amplify the moral dilemma of whether Lavoisier gave sufficient credit to those whose work he used to overthrow the theory of phlogiston" (Zare 1971). The playwrights thus represent the complex interactions between state authority, religious authority, scientific authority, political authority, financial authority, the authority of publication and public authority.

Copenhagen

Frayn's *Copenhagen*, a well-renowned science play, received much deserved critical acclaim. Frayn is an accomplished playwright, novelist, journalist, documentary filmmaker and translator. His best-known include the novels *Towards the End of the Morning* (1967), *Headlong* (1999) and *Spies* (2002), and the plays *Noises Off* (1982), *Democracy* (2003) and *Copenhagen*. The plot and structure of *Copenhagen* are non-linear and repetitive. Focusing on the 1941 meeting between Neils Bohr and Werner Heisenberg, the play throws light on the issues of authority and ethics in science. With the advent of nuclear physics, the role of science and scientists in society got more complicated. As portrayed in *In the Matter of Robert J Oppenheimer* (1964), the moral and ethical qualms faced by nuclear physicists during and after

the second world war are complicated issues that the playwright has represented. The two-act play opens abruptly with a conversation between Bohr and his wife Margrethe. Heisenberg is a former student and colleague of Bohr but is now the head of the Nazi Germany nuclear program. Margrethe likes Heisenberg but is also a little cautious of him because of the political ramifications of the time.

Frayn portrays the power wielded by geopolitical events over the lives of scientists when Margrethe calls Heisenberg "an enemy." While explaining the situation to Bohr, she asserts, "Heisenberg was German. We were Danes. We were under German occupation" (3). She also refers to Heisenberg, a former student for whom Bohr is a father figure, as an alien. Margrethe calls the German Cultural Institute in Denmark as a "Nazi propaganda organization". Frayn uses this instance to portray the influence of cultural institutes of foreign nations. The German occupation of Denmark endows this cultural institution with even more authority. Heisenberg's position is unique as he is a German-Jew nuclear physicist in Nazi Germany at a time when all the Jewish scientists lost their jobs. Bohr's assertion that Heisenberg is a "White Jew" aptly describes his position which complicates his relationship with his former mentor.

During the entirety of the play, just as the readers move to and fro between the repeated scenes, the emphasis of the conversation shuttles between physics and politics. The play represents the intricate situation of Jewish German theoretical physicists. Bohr, to some extent, does understand Heisenberg's complicated position and explains to Margrethe that the reason Heisenberg won't leave Germany is that "He [Heisenberg] wants to be there to rebuild German science when Hitler goes" (9). This reasoning reveals Heisenberg's standing in the scientific community and the duty he feels towards his country's scientific establishment. Bohr sums up the situation perfectly when he explains:

BOHR. I realise that we must always be conscious of the wider audience our words may have. But the lack of cyclotrons in Germany is surely not a military secret.

HEISENBERG. I have no idea what's a secret and what isn't.

BOHR. No secret, either, about why there aren't any. You can't say it but I can. It's because the Nazis have systematically undermined theoretical physics. Why? Because so many people working in the field were Jews. And why were so many of them Jews? Because theoretical physics, the sort of physics done by Einstein, by Schrodinger and Pauli, by Born and Sommerfeld, by you and me, was always regarded in Germany as inferior to experimental physics, and the theoretical chairs and lectureships were the only ones that Jews could get.

MARGRETHE. Physics, yes? Physics.

BOHR. This is physics.

MARGRETHE. It's also politics.

HEISENBERG. The two are sometimes painfully difficult to keep apart. (17-18)

Bohr's assertion explains the presence of a large number of Jewish-German theoretical physicists in America and Britain. Both these countries employed the ousted Jewish German theoretical physicists in their nuclear development programs. There was an exodus of theoretical physicists due to persecution or the fear of it.

The playwright portrays Heisenberg's precarious situation and the absolute authority that the state has over scientific research, particularly nuclear weapons research. The state authorities continuously monitor the activities of nuclear scientists. Heisenberg informs Bohr that Gestapo had intercepted Bohr's message regarding their meeting. Bohr explains that the German Gestapo has complete control over Heisenberg's nuclear program, which means that if Heisenberg and his team try to stop the work at their nuclear research facility, they will be arrested. If Heisenberg refuses to work on the development of nuclear weapons, he will be

replaced by Nazi scientists who will make sure the development takes place. Thus, the only way he can make any contribution to stopping the program is to head it himself. Heisenberg's ironic situation is made worse by his nationalistic sentiments as he is wary of the development of nuclear weapons by the Americans as well. State also manifests its authority by exalting nationalistic feelings from its subjects. Heisenberg grew up in a war-ravaged Germany that was on its knees with its economic and scientific institutions in ruins after the first world war. He does not wish to see Germany face the same conditions again. He is against the development of nuclear weapons by both Germany and Allied Forces. Explaining his complicated stand, he says:

> If the Allies are building a bomb, what am I choosing for my country? You said it would be easy to imagine that one might have less love for one's country if it's small and defenceless. Yes, and it would be another easy mistake to make, to think that one loved one's country less because it happened to be in the wrong. Germany is where I was born. Germany is where I became what I am. Germany is all the faces of my childhood, all the hands that picked me up when I fell, all the voices that encouraged me and set me on the way, all the hearts that speak to my heart. Germany is my widowed mother and my impossible brother. Germany is my wife. Germany is our children. I have to know what I am deciding for them! Is it another defeat? Another nightmare like the nightmare I grew up with? Bohr, my childhood in Munich came to an end in anarchy and civil war. Are more children going to starve as we did? Are they going to have to spend winter nights as I did when I was a schoolboy, crawling on my hands and knees through the enemy lines, creeping out into the country under cover of darkness in the snow to find food for my family? Are they going to sit up all night, as I did at the age of seventeen, guarding some terrified prisoner, talking to him and talking to him through the small hours, because he's going to be executed in the morning? (42)

Heisenberg also comments on the American nuclear bomb development program and the bombing of Japan. He critiques the bombing by saying, "You weren't dropping it on Hitler, either. You were dropping it on anyone who was in reach. On old men and women in the street, on mothers and their children" (43). Heisenberg addresses Bohr in this sentence as if he was directly responsible for the bombing. Frayn portrays the complex nationalistic sentiments of the physicist.

Heisenberg uses his agency as the head of the nuclear development program to dissent against the state in his own way. Heisenberg clarifies his stance and says that he never divulged the details of the chain reaction to Nazi officials. He did tell a few things to some minor officials but did not share the full details. Heisenberg reveals his strategy to continue as the head of the program and simultaneously stall the development of the bomb. He requests Nazi government authorities to provide funding to continue the reactor but he asks for so little that no one takes the program seriously and does not disclose the production of plutonium by the reactor.

> MARGRETHE. You don't ask him for the funding to continue?
>
> HEISENBERG. To continue with the reactor? Of course I do. But I ask so little that he doesn't take the programme seriously.
>
> MARGRETHE. Do you tell him the reactor will produce plutonium?
>
> HEISENBERG. I don't tell him the reactor will produce plutonium. Not Speer, no. I don't tell him the reactor will produce plutonium.
>
> BOHR. A striking omission, I have to admit.
>
> HEISENBERG. And what happens? It works! He gives us barely enough money to keep the reactor programme ticking over. And that is the end of the German atomic bomb. (48-49)

He is granted just enough money to keep the reactor running ensuring that the production of plutonium is insufficient for a bomb. By doing so, he remains the head of the nuclear program

and manages to slow down the development of the bomb. This subversive act of dissent of the character of Heisenberg can be contrasted with that of the character of Oppenheimer in Kipphardt's *In the Matter of J Robert Oppenheimer* (1964). While Oppenheimer laments not dissenting against the nuclear program, Heisenberg dissents in a subversive manner, thus retaining his agency despite being painted as the villain. Oppenheimer's dissent and agency can be viewed in comparison with that of Galileo in Brecht's *Life of Galileo*.

Scientists on both sides wielded the knowledge to develop nuclear weapons and they also had the ability to dissent against the authorities. Bohr was part of the American nuclear program for a brief while and like Oppenheimer, he did feel guilty for his participation in the bombing of Japan. They could, in theory, withhold the information or stop the development program altogether. The same feeling is expressed by Heisenberg when he laments, "What I told you in 1941! That the choice is in our hands! In mine – in Oppenheimer's! That if I can tell them the simple truth when they ask me, the simple discouraging truth, so can he!" (44). Discussing the scientists' varied responses to the bombing, Heisenberg states, "Otto Hahn wants to kill himself, because it was he who discovered fission, and he can see the blood on his hands. Gerlach, our old Nazi co-ordinator, also wants to die, because his hands are so shamefully clean. You've done it, though. You've built the bomb" (46). Heisenberg shares with Margrethe and Bohr that after the fall of Nazi Germany, he was treated as a pariah by the scientific community. He informs that the scientists who developed and deployed the bomb, wanted nothing to do with him even though he had not developed any bomb. (47) This comment highlights the cumulative responsibility and different reactions of scientists to the bomb.

The play also portrays the influence of public imagination over scientific advancement. The field of nuclear physics and the topic of nuclear fission invigorate the minds of scientists as well as general audiences. When Margrethe asks Bohr the reason for the continued work in

the field of nuclear fission despite an understanding that no nuclear weapon can be produced in the foreseeable future, Bohr replies, “Because there is an element of magic in it. You fire a neutron at the nucleus of a uranium atom and it splits into two other elements. It’s what the alchemists were trying to do – to turn one element into another” (12). These ideas influence people’s imagination as if there was a magical element to them. This assertion highlights the relationship between public imagination and scientific advancement.

Frayn also portrays the relative authorities of various scientists in their respective fields. Bohr in a conversation with Heisenberg in the second act declares, “I’m the Pope – he’s God – because Einstein has made a relativistic analysis, and it resolves all my doubts” (60). Margrethe also refers to Bohr as the head of the church in Copenhagen. Bohr, along with Heisenberg, were the pioneers of the “Copenhagen Interpretation”. They were the leading authorities on nuclear physics during the time who “put man back at the center of the universe” (71). Heisenberg describes his relationship with Bohr as that of a “chairman and managing director” and “father and son” (5). He also complains that when they worked together, Bohr was very authoritative. He says, “No, the way we work is that you hound me from first thing in the morning till the last thing at night! The way we work is that you drive me mad!” (67). Heisenberg also reveals that at one point, Bohr reduced him to tears, portraying the authority of Bohr over Heisenberg.

Scientific authority emanates from the authority of the scientist and the authority of scientific methodology. In this case, Heisenberg represents the authority of the scientist and the mathematical equation represents that of scientific methodology. Heisenberg does not attempt to solve the diffusion equation as he believes that it would be impossible to obtain that much Uranium-235. The American scientists solve the equation and eventually go ahead with the production but Heisenberg deliberately fails to solve the diffusion equation and successfully

bluffs himself and the Nazi nuclear development team. Heisenberg's authority on mathematics and the authority of the mathematical equation allow him to dissent.

The central question that Heisenberg asks Bohr in their 1941 meeting, around which the whole play is written is, "Does one physicist have the moral right to work on the practical exploitation of atomic energy?" (88). Nicholas Ruddick, in his article titled "The Search for a Quantum Ethics: Michael Frayn's *Copenhagen* and Other Recent British Science Plays" states:

> Strictly, however, Heisenberg, under Gestapo surveillance, did not and could not raise the question at all in 1941. But he was in a position to change the world for better or worse, and consciously or not, for whatever ultimately indeterminable reason, he did what in retrospect can with some certainty be considered the right thing - or, more precisely, he did not do the wrong thing. If there is indeed a quantum ethics, his mode of inaction may serve as a model for a strange new quantum heroics. (133-34)

The playwright questions a scientist's authority to develop something that can potentially kill a hundred thousand people and portrays the interaction between political, state, religious and scientific authorities. Heisenberg is outcasted for stalling the development of atomic weapons while Bohr laments his celebrated part in its development but both grapple with the issue of ethics in science and the role of the scientist.

Inherit the Wind

Jerome Lawrence and Robert E Lee's *Inherit the Wind* is a courtroom drama based on the infamous Scopes Trial of 1925. In the Scopes Trial or the Monkey Trial, a high school teacher named John T Scopes was tried by the Criminal Court of Tennessee for teaching evolution to students. Lawrence and Lee were successful writing companions who together wrote thirty-nine plays and founded the American Playwrights' Theatre. The plot of *Inherit the Wind* follows the ordeals faced by a school teacher named Bertram Cates who is facing a trial

for breaking the law of the land and of the holy book by teaching school kids about human evolution. Matthew Brady, a three-time presidential candidate and a voracious orator is leading the prosecution for the trial. Henry Drummond, the defence attorney, is an ardent believer of reason and freedom of speech. EK Hornbeck is a quick-witted journalist for a renowned daily. Rachel Brown, the daughter of the town's reverend, is Cates's colleague and affectionate friend who is called to testify in the case.

The three-act science play, set in and around the Hillsboro Courthouse, showcases multiple interactions between science and varied authorities. Gad Guterman succinctly describes the play when he writes, "Based on the 1925 Scopes trial, *Inherit the Wind* dramatizes a battle between religious and scientific authorities to control public education - a contest that becomes a media sensation" (Guterman 564). The play epitomises the conflict between religion and science by portraying issues regarding authority, dissent and freedom of thought.

The playwrights portray the influence of dogmatic ideas on young minds in the first scene when Melinda, a twelve-year-old girl, chides Howard, her classmate, for talking about the "sinful talk" of evolution (4). The play focuses on science in education therefore, the depiction of dogmatic views that young people have becomes important. Books play an important role in shaping young children's worldviews.

Scientific textbooks are authorities in themselves when it comes to imparting education. During the trial, Cates refers to Hunter's *Civic Biology* and its chapter on Charles Darwin's *Origin of Species* as the basis for what he taught in the class. Brady is an accomplished attorney and politician but has dogmatic views on science. Brady addresses the classroom teachings about evolution as "heathen dogma" (25). Later in the scene, he refers to the court case as a chance "to test the steel of our Truth against the blasphemies of Science!" (23). Early in the play, the playwrights point out the authority of the state legislature on matters of education.

In a unique display of solidarity, political, religious and administrative authorities come together to oppose scientific teachings in the state. The political authorities prohibit teaching anything that contradicts religious scriptures. Rachel Brown, at the beginning of the first scene, reminds Cates that teaching evolution is against the law in their state. This authority is upheld by prosecutors like Brady who is a renowned attorney and a national political figure. His thoughts about the case are evident when he proclaims in his speech to the town:

> My friends of Hillsboro, you know why I have come here. I have not come merely to prosecute a lawbreaker, an arrogant youth who has spoken out against the Revealed Word. I have come because what has happened in a schoolroom of your town has unloosed a wicked attack from the big cities of the North! – an attack upon the law which you have so wisely placed among the statutes of this state. I am here to defend that which is most precious in the hearts of all of us: the Living Truth of the Scriptures! (20)

Brady is a self-appointed authority who takes up the cause of the perceived onslaught of science. Referring to the advocates of evolution, he states, "Bible-haters, these 'Evil-utionists', are brewers of poison. And the legislature of this sovereign state has had the wisdom to demand that the peddlers of poison – in bottles or in books – clearly label the products they attempt to sell" (70). The political authorities go hand in hand with religious authorities to peddle dogmatic views about scientific teaching. As the religious head of the town, Reverend Brown exclaims that the townspeople will not let Drummond, the defence attorney, enter the town. He refers to Drummond, as "a vicious godless man!" and "an agent of darkness" (27). The mayor of the town agrees with him and looks for some clause in the town ordinances to refuse Drummond entry into town. Brady suggests that the mayor and the reverend should welcome Drummond because "if the enemy sends its Goliath into battle, it magnifies our cause. Henry Drummond has stalked the courtrooms of this land for forty years. When he fights, headlines

follow. The whole world will be watching our victory over Drummond" (29). Brady, the mayor and the reverend are all figures of authority who assert their influence in this court case. Brady, the three-time presidential candidate is a representative of political authority. The mayor of Hillsboro is a representative of administrative authority, and the town reverend is a representative of religious authority.

The authority of public imagination on science issues is portrayed in multiple instances. Before the trial proceedings begin, Brady is endowed with the title of an honorary colonel in the state militia, and the judge refers to Brady as a 'colonel' during the trial. Drummond objects to such a reference as the title paints, in the jury's mind, a prejudiced image of Brady, "astride a white horse, ablaze in the uniform of a militia colonel, with all the forces of right and righteousness marshalled behind him" (42). This conversation represents the authority that titles wield in the public imagination. Drummond also objects to an announcement in the court regarding a prayer meeting as it can influence the townspeople and the jury. Another marker of public imagination is EK Hornbeck, a sarcastic and cynical reporter from the Baltimore Herald. He represents the influence that local newspapers exert. He is a staunch believer in free speech and abhors the dogmatic views of Brady and the townspeople. He uses satire, wit and sarcasm to point out the absurdities of the trial. Later during the trial, Drummond interrupts Brady when the latter opines that the jury should "conform to laws and patterns of the society" (47). This conversation depicts that the jury has to adhere not only to the laws of the land but also to the laws of society which are formed by public opinion on matters of science. After the court recesse, Rachel requests Drummond to call off the proceedings. She wishes Cates to apologise, and agree that he committed a mistake so that the whole ordeal is over. Such an admission would be similar to Galileo's recantation in front of the Roman Inquisition. Rachel says that the reason for such a request is that she cares "about what people in the town think of

him [Cates]" (51). Thus, playwrights portray the authority exerted by popular opinion on matters of science and education.

The playwrights depict the clash of authorities over the issue of evolution. Questioning the young boy Howard, Brady asks if Cates ever taught them about the Book of Genesis. The play contrasts the authority of the Bible with established academic authorities in various fields. During the proceeding, Drummond calls Dr Amos D Keller for questioning. Dr Amos is a zoologist and an authority on the subject of evolution but the judge refuses to hear the expert. The judge also disallows the experts of geology and archaeology to give their statements by stating, "The language of the law is clear; we do not need experts to question the validity of a law that is already on the books" (83). The legal authority, which is hand in glove with the religious authority, disallows the testimony of subject experts, ensuring that the religious authority comes on top in this clash of authorities. In his article "Field Tripping: The Power of *Inherit the Wind*" (2008), Gad Guterman writes:

> Quite compactly, Lawrence and Lee pack the stage with members of society representing diverse social fields to create a cacophony of voices: law, religion, commercialism, education, and entertainment all interact here, because of and inspite of one another. The moment is perhaps the most chaotic in the play, although the clash and interaction among what Pierre Bourdieu would describe as "fields" is at the root of the entire piece. (563)

The jury and the judge come out as the final authority in matters of science and education in the play. When the judge refuses to entertain any authoritative views on evolution, Drummond requests to call as a witness the self–proclaimed authority on the Bible, Matthew Brady. Hinting at a literal interpretation of the Bible, Drummond asks Brady if every word in the bible is true. He goes on to question Brady about incidents mentioned in the Bible that appear contrary to natural law and asks if Copernicus should be banned from schools as well. To this,

Brady replies, "Natural law was born in the mind of the Heavenly Father. He can change it, use it as He pleases. It constantly amazes me that you apostles of science, for all your supposed wisdom, fail to grasp this simple fact" (90). According to his assertion, scientific laws ought to be subservient to religious authorities. Using wit and sarcasm, Drummond traps Brady in a net of his vanity.

BRADY. It is not an opinion. It is a literal fact, which the good Bishop arrived at through careful computation of the ages of the prophets as set down in the Old Testament. In fact, he determined that the Lord began the Creation on the 23rd of October in the year 4004 B.C. at – uh, at 9 A.M.!

DRUMMOND. That Eastern Standard Time? (Laughter) Or Rocky Mountain Time? (More laughter) It wasn't daylight-saving time, was it? Because the Lord didn't make the sun until the fourth day!

BRADY. (Fidgeting) That is correct.

DRUMMOND. (Sharply) The first day. Was it a twenty-four-hour day?

BRADY. The Bible says it was a day.

DRUMMOND. A normal day, a literal day, a twenty-four-hour day? (Pause. Brady is unsure.)

BRADY. I do not know.

DRUMMOND. What do you think?

BRADY. (Floundering) I do not think about things that…I do not think about!

DRUMMOND. Do you ever think about things that you do think about? (There is some laughter. But it is dampened by the knowledge and awareness throughout the courtroom, that the trap is about to be sprung) Isn't it possible that the first day was twenty-five hours long? There was no way to measure it, no way to tell! Could it have been twenty-five hours? (Pause. The entire courtroom seems to lean forward.)

BRADY. (Hesitates – then) It is … possible…(Drummond's got him. And he knows it! This is the turning point)

Drummond tightens his grip over Brady and spectacularly proves his point in the courtroom.

BRADY. How dare you attack the Bible?

DRUMMOND. The Bible is a book. A good book. But it is not the only book.

BRADY. It is the revealed word of the Almighty. God spake to the men who wrote the Bible.

DRUMMOND. And how do you know that God didn't "spake" to Charles Darwin?

BRADY. I know, because God tells me to oppose the evil teachings of that man.

DRUMMOND. Oh. God speaks to you.

BRADY. Yes.

DRUMMOND. He tells exactly what's right and what's wrong?

BRADY. (Doggedly) Yes.

DRUMMOND. And you act accordingly?

BRADY. Yes.

DRUMMOND. So you, Matthew Harrison Brady, through oratory, legislation, or whatever, pass along God's orders to the rest of the World! (Laughter begins) Gentlemen, meet the "Prophet From Nebraska!"

(Brady's oratory is unassailable; but his vanity – exposed by Drummond's prodding – is only funny. The laughter is painful to Brady. He starts to answer Drummond, then turns toward the spectators and tries, almost physically, to suppress the amused reaction. This only makes it worse.)

BRADY. (Almost inarticulate) I – Please – !

DRUMMOND. (With increased tempo, closing in) Is this the way of things? God tells Brady what is good! To be against Brady is to be against God! (More laughter)

BRADY. (Confused) No, no! Each man is a free agent –

DRUMMOND. Then what is Bertram Cates doing in the Hillsboro jail?

Drummond proves Brady wrong and establishes the agency of an individual against religious authorities to learn and teach scientific principles. The jury, bound by the law, still declares Cates guilty of breaking the law and the judge fines him a paltry amount of hundred dollars. The legal decision is an interesting aspect of the clash of authorities. While the judge and jury uphold the legal authority of the state's law and the religious authority of the Bible, the meagre fine subtly conveys that Cates and Drummond have subversively managed to win this clash.

The authority of law and judiciary is evident but the play also portrays the agency of individual dissent using the character of Cates, who held out against the onslaught of religious, political and judicial authorities.

Conclusion

This chapter discussed several plays that explore the theme of authority in the context of science and scientific discoveries. Each play examines different aspects of authority and raises thought-provoking questions about the ethical dilemmas faced by scientists and the consequences of their choices. *In the Matter of J Robert Oppenheimer* focuses on the authority of non-scientists to judge scientific actions and the erosion of a scientist's agency to dissent in an authoritarian environment. The play portrays Oppenheimer as both an authoritative figure in his field and a victim of authorities' control over his beliefs and actions. *Life of Galileo* depicts the oppressive power of religious authority and the challenges faced by Galileo as he tries to spread his scientific knowledge. It emphasises the role of different types of authorities, including religious, academic, political, and financial, in upholding the status quo and suppressing dissent. *An Experiment with an Air Pump* explores the shifting authority from religious and traditional sources to scientific and rational thinking. The play highlights the male

academic gatekeeping prevalent during that era and raises questions about the ethical boundaries of scientific research and innovation. *Einstein* portrays the conflict between religious and academic authorities, highlighting the importance of dissent and questioning in science and religion. The play also recognises the significance of influential scientists throughout history and the authority established through journals and the peer-review process. *Oxygen* raises questions about the ethics of scientific discovery and the authority associated with it. The play examines power dynamics within scientific committees, the pursuit of being the first in advancements, and the influence of public authorities. *Copenhagen* explores the themes of authority and ethics in nuclear physics during World War II. It delves into the moral and ethical dilemmas faced by scientists involved in the development of nuclear weapons and the influence of state authorities on scientific research. *Inherit the Wind* focuses on the conflict between religion and science, showcasing the clash of authorities and the struggle between established academic authorities and religious beliefs. It emphasises the importance of individual agency and dissent in the face of overwhelming opposition from religious, political, and judicial authorities.

Overall, these plays offer nuanced explorations of authority in science, raising important questions about the responsibilities of scientists, the limits and possibilities of challenging authority, and the ethical boundaries of scientific research. They invite audiences and readers to reflect on the complex dynamics between science, authority, and morality in a variety of historical and contemporary contexts.

Chapter 2: The Use of Literary Techniques and Devices in Science Plays

Introduction

In the multidisciplinary field of Literature and Science, science plays occupy a unique position as they present a practical example of the amalgamation of form and content. Additionally, as is observed in the case of multiple plays and their production, science plays provide opportunities for active collaboration between the playwrights and directors on one hand, and scientists and academicians on the other, thereby bridging the chasm between the two ivory towers. In order to seamlessly integrate scientific content into a play, science playwrights employ numerous literary techniques and devices. This chapter aims to find out the various literary techniques and devices used by the playwrights of the seven plays selected for analysis in this thesis. It attempts to exhibit and illustrate the utilisation of these techniques and devices in the field of science theatre. The chapter illustrates the playwrights' application of allusions, sarcasm, satire, metaphors, imagery, prosody, meta-theatricality, and bilingualism, among others in the select plays.

In the field of Literature and Science, the academic consensus on the integration of scientific content in literary works is split. There are works that feature biographical material from the lives of scientists, then there are works that interact with science and scientific content at a cursory level, and finally, there are texts that incorporate science so thoroughly that it becomes difficult to tell one apart from the other. All the plays selected for this thesis belong to the third category. For science plays belonging to the third category, merging the scientific and literary content with the scientific and literary form is effective and effortless. These plays read better than those in which science is merely superimposed or features as a background to

the plot. For such a seamless merging of form and content, the playwrights employ these various literary techniques and devices that will be discussed in the proceeding parts.

In the Matter of J Robert Oppenheimer

Heiner Kipphardt's *In the Matter of J Robert Oppenheimer* portrays the ordeals faced by the renowned physicist at the hands of a security board. The play is a courtroom drama with quick to-and-fro conversation. The play's structure is engaging, with lengthy monologues at the end of each scene.

Since the play is based on documentary sources of the proceedings of the Personnel Security Board constituted by the Atomic Energy Commission, the language of the play is highly formalised and official. Announcing the full names of the respondents and the formal oath-taking procedure are examples of the formalised language used in the play. Gray asks Oppenheimer to take the stand and states, "Julius Robert Oppenheimer, do you swear that the testimony you are about to give the Board shall be the truth, the whole truth, and nothing but the truth, so help you God?" (12) Such use of formal language conveys the tone and tenor of the courtroom setting to readers and the audience. John Austin, a philosopher from Oxford, suggested a new way of looking at language. Instead of just seeing sentences as statements of truth or falsehood, he argued that when we speak, we are not just conveying information. We are also doing things like asking, commanding, persuading, and influencing others. Austin's focus on how speech works in real-life interactions and its impact on social dynamics is mirrored in the scene when Oppenheimer takes this oath.

Literary allusions which refer to ideas, circumstances or historical figures from literature are used liberally in the play. The reference to a golden age and the Land of Cockaigne in the first scene alludes to the old folklore of the land of plenty and an eponymous poem of the mid-fourteenth century (15). An allusion is a literary device that indirectly references an

object or situation. For example, Robb asks Oppenheimer in the first scene if he has come "to set it right", as Hamlet says (16). At the end of the third scene, the reader finds an allusion to Joan of Arc, where Oppenheimer is compared to the illiterate soldier and saint who signed her conviction. She broke gender stereotypes by becoming a military leader during the Hundred Years' War and was hailed as the saviour of France. The religious allusions to Bhagavad Gita (82) and the biblical allusion to the Holy Trinity (84) are also noteworthy. These allusions aid the readers in better understanding the situations faced by Oppenheimer and other characters.

Wordplays utilise the ambiguities of meaning for wit and amusement, and the readers come across multiple such wordplays in the play. Robb's monologue at the end of the first scene, when he says that FBI files have converted Oppenheimer from an idol to a sphinx, meaning a fall from grace, is one example. The use of the word "treason" by Oppenheimer is questioned by Robb, to which Oppenheimer replies, "It is such a hackneyed word, I could tell you the whole history of the word 'treason'." Interestingly, the words "treason" and "tradition" have the same etymological root. The characters also discuss the phrase "ideological treason" in the closing remarks of the proceedings. Another exciting use of a phrase is when Robb refers to Oppenheimer's story as a "cock-and-bull" story. The board members discuss his assertion that Oppenheimer is lying. The playwright uses interesting phrases to portray various degrees of alignment with the communist ideology. Speech-act theory, a significant field within modern philosophy of language and linguistics, focuses more on language as a form of behaviour guided by rules rather than its formal structure. Its goal is to incorporate speech events into a broader theory of action. To comprehend the actions conveyed through language in drama, we look at this theory, which views language as a form of action. When answering why so many physicists of the time were inclined to communist ideas, Oppenheimer says, "they were Pink, not Red" (41). While talking about Chevalier to Evans, Oppenheimer describes him as "Pinkish-red" (44). The description of various shades of ideology using various shades of

colour is noteworthy. This phenomenon of assigning colours to political ideology can be observed in India as well, where the colours saffron and green are integrated into the political discourse, thus highlighting the utilization of ambiguities of meaning using wordplay

Rhetoric, the craft of persuasion, is one of the ancient arts of discourse. Evan's monologue at the end of the second scene is an example of the use of rhetoric to persuade the members of the committee. He exploits this rhetoric to drive home the point that more and more restrictions are being placed on free speech and free thought in universities. He also criticises the overt militarisation of sciences. Of all the accusations he heaps on Oppenheimer, one is that he read communist literature. Evan alleges that such readings, along with other "communist activities" corrupted Oppenheimer. An example of such activity is a literary meeting at Chevalier's house of which Oppenheimer was a part. Using strong rhetoric, Evans overtly paints both science and scientists as communists, and even literature and language cannot escape the colouring brush of ideology.

Readers come across multiple uses of irony in the play. Irony conveys meaning to the readers by stating disparate ideas but juxtaposing them. The irony is rife in the sixth scene when Evans asks Oppenheimer why he "read Communist books in those days, sociology, and that sort of thing?" This was after proclaiming that he had "never read Marx and such people" (42). This goes hand in hand with the dentist joke where Marx is compared to a pain in the tooth. Evans is a committee member who will pass a judgement on Oppenheimer's security clearance. His view that a scientist need not read books on sociology and his views about Marx, whose works he has never read, display the irony of the situation.

In order to portray the life and thoughts of the nuclear physicist Oppenheimer, Kipphardt effectively utilises allusions, rhetoric, wordplay, irony and more. The result is a play which does not merely tell the tale of a scientist but effectively incorporates science in its

content as well as form, thereby allowing the readers to engage with the text at a deeper level and grapple with the issues of ethics, morality and the responsibility of a scientist.

Life of Galileo

Bertolt Brecht's *Life of Galileo* dramatizes the life of the Italian mathematician, philosopher and innovator. The play, divided into fifteen scenes showcases the life and ordeals of the polymath.

Various poetic embellishments adorn the beginning of the scenes. The first scene begins with a quintain, i.e. a five-line stanza that talks of the temporal placement of the scene and the spatial setting. The last line of the quintain sets the tone of the play when it says, "The sun is still, the earth is on the move" (5). Similarly, the quartet at the beginning of the second scene sets the stage for the telescope fiasco. One of the most impactful poetic pieces from the play is the couplet at the beginning of the third scene which reads "January ten, sixteen ten: Galileo Galilei abolishes heaven" (22). A similar couplet is used at the commencement of the eleventh scene to set the stage for Galileo and Virginia's meeting with the Grand Duke. The nine-line poetic piece at the beginning of the last scene has a rhyme scheme of aa bb cc ddd and establishes the scene as the last one by setting the tone of finality when it says,

The great book o'ver the border went
And, good folk, that was the end.
But we hope you'll keep in mind
He and I were left behind.
May you now guard science's light
Kindle it and use it right
Lest it be a flame to fall
Downward to consume us all.

Yes, us all. (110)

Thus, the poetic pieces at the beginning of the scenes accomplish a dual objective. These provide the readers with information regarding the setting and time period of the play. Secondly, these set the tone of the upcoming scene. While the stage directions are useful for the director of the play to enact a performance, such poetic devices enable the reader to imagine the play vividly. We see the use of poetic pieces within the scenes as well. Lorenzo di Medici's poem on transience in the seventh scene, a stanza from the eighth satire of Horace in the eighth scene, the quartet that Andrea sings in the ninth scene and the ballad in the tenth scene are examples of the same. Brecht masterfully assimilates poetry in the play to bring out the desired effect.

Brecht halts the flow of tense action in the play multiple times by providing comic relief. The use of malapropism to introduce Mrs Sarti's character results in comic relief in the play. Malapropism is unknowingly using a similar-sounding word for a different concept, mostly with a witty effect. She calls the astronaut Copernicus as "Copper Knickers" (10). Brecht also uses sarcasm to provide comic relief as is illustrated when Galileo quips to the procurator of the university, "I'm not half as sharp as those gentlemen in the philosophy department. I am stupid" (14). Sarcasm mockingly utilizes irony to a contemptuous effect. Thus, Brecht effectively employs these literary devices to bring comic relief to an otherwise sombre play.

The use of the words "science", "physics" and "physicist" in the play deserves attention. While the words "science" and "physics" did exist in Galileo's time, they were not used in the same context. Natural philosophy was the preferred term for science and the word "physics" was used in the Aristotelean sense. The word "physicist" was coined in the year 1833 by William Whewell and was first used in the March issue of *Quarterly Review* of 1834. The use

of these words by Brecht does not appear true to history. The changing nomenclature points to the evolution of the epistemological enterprise of science.

Galileo takes up the issue of the use of Latin as opposed to Italian as the language of scientific communication. In the fourth scene, when the philosopher voraciously puts his point in Latin, Galileo objects saying that his colleague Federzoni, the lens-grinder does not understand Latin. The same issue resurfaces in the ninth scene when Federzoni says, "How am I to doubt anything? How often do I have to tell you I can't read the books, they're in Latin?" (72) Galileo is unhappy about the use of Latin for scientific communication, and its social and cultural implications. In order to ensure a wider and long-lasting reach for his works, he chooses to write in the vernacular Italian rather than the canonical Latin. He says in the ninth scene "I might write in the language of the people, for the many, rather than in Latin for the few. Our new thought call for people who work with their hands. Who else cares about knowing the causes of things? People who only see bread on their table don't want to know how it got baked; that lot would soon thank God than thank the baker" (79-80). Galileo bats vigorously for the cause of the vernacular language for scientific communication and dissemination.

The issue of the language of communication is also linked to the issue of the language of publication. The printing press was invented during the time of Galileo and the widespread distribution of scientific works was possible. In such a scenario, the choice of language was crucial and as portrayed in the play, Galileo chose the vernacular Italian. In the eleventh scene, the iron-trader Vanni tells Galileo about the number of books being published in England on various subjects (87). Galileo was aware of the benefits of a printing press and deliberately wrote in Italian as books published in Italian would reach a larger audience. For the discussion on form in the field of Literature and Science, the question of language is important. Brecht takes up the question of language in science communication in the play and sides with the use

of vernacular languages. The issue of use of different languages for scientific communication will surface again in the discussion of Carl Djerassi and Roald Hoffmann's *Oxygen*.

Brecht's play is similar to Kipphardt's work which was discussed in the previous section. The use of documentary material related to Galileo and his life points towards the realm of documentary theatre. Documentary theatre makes use of historical evidence and historical materials to create a play. The use of the manuscript, globe, compass, letters, and telescope is evidence for a case of the play as documentary theatre.

Brecht's discussion of language, the use of comic relief and the inclusion of poetry in the play results in a play that one can be read as well as performed effectively. One of the most common questions regarding science plays is regarding their performativity. However, Brecht's use of literary techniques and devices has resulted in a play which has stood the test of time and is rightly included in the canon of classic plays.

Einstein

Mohan Maharishi is the sole Indian playwright in this selection of science playwrights. His play *Einstein* paves the way for active collaboration between scientists and playwrights, in a manner similar to the one envisioned by CP Snow.

Mohan Maharishi's *Einstein* stands out for its bilingualism. The simultaneous use of English and Hindi in the play marks its uniqueness. While the characters' dialogues are in Hindi, all the stage directions and asides are in English such as:

आईंस्टाइन: हमारे दिमाग़ में ख़यालात जड़ जमा लेते हैं।…

Einstein gets up and moves to his table drawer.

तुम जानते हो ये क्या है?

The man in the orchestra pit gets up and plays Mozart.

Such use of two languages is rare in the field of drama. Cherrie L Moraga's *Giving Up the Ghost* (1986) and *Shadow of a Man* (1990) are other examples of such bilingual plays.

Another unique aspect of the use of language in the play is the transcription of English names in the Devanagari script. Names such as Max, Einstein, Aristotle and Galileo are all written in the Devanagari script as मैक्स ,आईंस्टाइन, अरस्तु and गैलीलिओ . We can see a similar example of the use of a different language in Moraga's *Shadow of a Man*:

> MANUEL: I know la Chiquita is waiting for me. She's got a soft heart, mi ni ita. She makes sure her *papacito* comes home safe.
>
> Hortensia: If he doesn't give a damn about himself, why should I care?
>
> MANUEL (going to Lupe): Lupita! . . . *¿Stás durmiendo, hijita*? (He lays his huge man's head on lupe's small shoulder.) You'll never leave me *¿no, mijita*?
>
> LUPE: No, *papi*.
>
> MANUEL: *Eres mi preferida, ¿sabes?*
>
> LUPE: *Sí, papi*.
>
> MANUEL: You're different from the rest. You got a heart that was made to love. Don't ever leave me baby. (33)

The bilingual text of the play provides not just a unique reading experience, but the mixing of the languages will have a unique effect on the performance of the play as well. Maharishi's bilingualism is an example of a recent linguistic phenomenon, often termed Hinglish. Hinglish is a type of amalgamation of Hindi and English that is known as a portmanteau. Such a language entails a macaronic use of the two languages with frequent code-switching.

In the play, we see elements of meta-theatricality which feature in the drama showcasing self-awareness. The readers encounter an example of meta-theatricality when the character of the young boy says that he is playing the role of young Einstein in the play (16). This self-realisation at the level of a character constitutes one kind of meta-theatricality. There are other kinds of meta-theatricality which we covered in the proceeding sections.

We see the use of Euphemism in Helen's dialogue where she refers to the mathematical character "x" as a lost rabbit and the algebraic equation as the bush from which the aforementioned rabbit is to be found (20). Euphemism involves utilising a word or phrase instead of the actual word or phrase to convey a difficult or uncomfortable idea.

The play also features a poem, a joke and references to literary personalities. The second scene of the first act features a poem written by the characters Einstein and Einstein 1 (22). The poem is in Hindi and is about a little doll. The poem alludes to Einstein's first wife Mileva Marić and goes like this:

मेरी प्यारी सी नन्हीं गुड़िया

मैं तेरे लिए क्या लिख दूँ?

बहुत बातें याद आती हैं।

तेरे लाल होंठों पर ….(22)

My lovely little doll,

What should I write for you?

I am reminded of a lot of things,

When I recall you red lips… (self translated)

The stage directions in the early part of the first act read, "A Christian teacher and a Rabbi enter…" (10). These words sound akin to a set-up for a very old joke. The character of Einstein in the play refers to the dilemmas faced by scientists and mentions that he read Bertolt Brecht's *The Life of Galileo* (1943) (33). The play also refers to literary doyens like Honoŕe de Balzac, Charles Dickens and Fyodor Dostoevsky. They are referred to as examples of great personalities from the field of literature.

Maharishi's play is an apt example of merging form and content in a science play. Einstein 1's assertion, "I want to ride the light across the skies", is a powerful scientific metaphor as it hints at the dual nature of light and points to the riddle that Einstein was

grappling with at the time (23). This assertion amalgamates the scientific metaphor with a potent reference to the literary form of drama. The scientific formulae in the text are interestingly written down in English (39). It points out the universalization of English as the language of scientific communication and the merging of scientific content in the text of the play.

The character of the Gypsy Magician contrasts the world of science with the world of magic. Of particular note is the use of rhetorical phrases like “What is the question my lord?”, which allude to a particular kind of street performance which is done for the common masses (24). In certain parts of North India, such performances are called “natak” or “bhaand - natak” and the performers are referred to, sometimes derogatorily, as “bhaand”. Similarly, we see the use of magical mumbo jumbo by the same characters (25, 27). It is interesting to see the use of archaic phrases such as “lahaul-vilakuvat” by the ancient characters like Aristotle, who is referred to as a big-shot genius, to invoke the feeling of antiquity (27). Using these examples, Maharishi demarcates the world of the scientist from that of a magician.

Mahrishi, the former director of the National School of Drama, produced a stellar example of a science play using bilingualism, metaphors, euphemism and other literary techniques and devices. In doing so, he has established an example for other Indian science dramatists to follow.

Oxygen

The use of language and literary devices in the play *Oxygen* highlights multiple aspects of the relationship between literature and science. The magnum opus of Djerassi and Hoffmann utilises various literary techniques and devices resulting in a seamless integration of form and content in the play.

In the play, the readers come across various old scientific terms which highlight the issue of nomenclature in science. There are a number of archaic scientific terms used in the play like butter of arsenic, sugar of lead and flowers of zinc, among others (4, 66). These terms depict the growth of science and portray the terminology used in that time period. They also represent the legacy of alchemy in the epistemological evolution of chemistry. Alchemy was a pre-scientific branch of natural philosophy that focused on the transformation of materials and the production of elixir. Another interesting term is the phrase "fire air". Fire air refers to oxygen, which was named so by Lavoisier (24). Similarly, the use of "Phlogiston: The essence of fire" in the fourth scene is noteworthy (28). In the play, the readers come across the term "savant" being used for the three men of science in question. As discussed in the section on *The Life of Galileo* by Bertolt Brecht, the term is noteworthy since the word "scientist" was not coined until 1834. Along with the issue of discovery, it problematizes the issue of scientific nomenclature as exemplified by Ulf when he says, "Why not just say, the language of chemistry was a holy mess and the grammar all wrong?" (30). In the eighth scene, Lavoisier tells the audience the logical reason for naming the gas oxygen (72). The name is derived from a Greek root word that fits its description. Thus, the names and the process of naming reveal a lot about the scientific establishment and its activities.

The playwrights also use novel terms and phrases to depict scientific activities and to describe those involved. To describe the preoccupation with priority, Ulf coins the term "Nobel syndrome" (32). This Nobel syndrome forms a pivotal part of the play. Another term to note is "amanuensis", which means a literary assistant. Ulla Zorn, a historian, is introduced by Astrid to the rest of the committee as her amanuensis (33, 64). While explaining the importance of the Nobel prize, Astrid describes it metaphorically as "the biggest pat on the back in science" (35). Also, Ulla refers to the committee as the metaphorical child of Astrid (39). While discussing the history of Scheele with Ulla Zorn, Sune assigns Scheele the epithet of "a chemical monk"

(46). Such an epithet is also reflective of the various kinds of people who professed science. A large number of people who pursued science were not professional scientists. Science as a profession was institutionally formalized in the next century. Something similar comes to the front when Bengt describes Priestley as "a preacher dabbling in chemistry" (55). The readers come across an example of the use of epithet when Ulf Swanholm describes eighteenth-century England as "the hot house of pneumatic chemistry" and when Priestley says that Edmund Burke describes him as "the wild gas" (54, 58). Another example of the use of epithet is when Ulf Swanholm describes eighteenth-century England as "the hot house of pneumatic chemistry" and when Priestley says that Edmund Burke describes him as "the wild gas" (54, 58). These terms and phrases paint an accurate picture of the history of events and aid the readers' imagination.

Joseph Priestley was a Unitarian minister and a natural philosopher. Replying to Mme Lavoisier, Mrs Priestley emphasizes using the salutation "Dr" for her husband (4). This salutation hints at his position as a Unitarian minister and its subsequent results on his occupation. As explained by Mrs Priestley, her husband can neither hold government office nor go to Oxford or Cambridge due to the opposition of Unitarian ideas by the Church of England. The Anglican Church with the monarch as its head opposed Unitarianism and subsequently, its followers were kept out of government positions.

The playwrights highlight the unattributed contribution of women to the scientific work done by their partners. Mme Lavoisier proudly states in the first scene that she aids Lavoisier in the laboratory and has learnt Latin and English to translate works and letters for him (6, 57). She says, "There was Latin to learn, and English too. It is I, Mrs Priestley, who translated Dr Priestley's Experiments on Different Kinds of Airs…and his writings on phlogiston-" (6). Ulf's assertion in the second scene that Astrid prefers to be called "chair" instead of "chairman" throws light on the use of gendered language in science and administration (11). Bengt uses

the metaphor of dirt to talk about the unreported personal details of the lives of the scientists (32). Interestingly, the members of the committee begin with the wives of the scientists to find "dirt". It also points to the issue of the representation of women in the sciences which is discussed in detail in the fourth chapter.

The structure of the play is unconventional as the short and fast-paced scenes are interspersed with intermezzos. An intermezzo is a dramatic portion that lies in between two acts or scenes. It was frequently used in masques and during the Renaissance era. Presently, it is used in long musical pieces and Operas. The play often switches between the two periods in the same scene. This is highly unusual for plays and can be considered unorthodox as it would require special provisions to be made during the production of this play. One such example is in the seventh scene when the time period shifts with Fru Pohl's dialogue right after Ulla Zorn (47). Quickly changing scenes with these intermezzos accentuate the theme of the fast-changing world of science in the play.

The playwrights use mimicry and sarcasm to convey the mood to the readers and viewers. The stage directions at the beginning of the first intermezzo direct the actor playing Mme Lavoisier to mimic Fru Pohl's voice and intonation (9). The first scene showcases the use of sarcasm in the conversation between Mrs Priestley and Mme Lavoisier when Mme Lavoisier says, "Perhaps women mature faster in France…especially those brought up in convent schools" (4). The playwrights often use sarcastic retorts to depict the moods of the characters. One such example is in scene seven, where Ulla Zorn replies to Sune saying that most chemistry students not knowing Scheele is a reflection on the professors rather than the students (50). Also, the committee members' frequent use of banter is noteworthy. The playwrights' choice to use mimicry, sarcasm and banter results in providing comic relief in the play, which is much appreciated by the both readers and audiences.

A problem faced by the retro-Nobel committee is the issue of language. For scientific writing and communication, Scheele, Priestley and Lavoisier used Danish, English and French respectively. They required translators to communicate and also to read one another's works. Astrid, while bantering with Ulf, says, "Who worries about language in dreams?" (17). Here, she refers to the fact that the three scientists in the play spoke three different languages and it points to the issue of a universal scientific language. Mme Lavoisier translated works and letters for Antoine Lavoisier. She also acts as a translator when he meets with other scientists such as JB Priestley. The play highlights the problems of translation and the need for a universal scientific language as it comes to the fore that Mme Lavoisier might not have conveyed everything diligently to Antoine and the message might have been lost in translation. The issue of translation is not just limited to older time period. In the committee proceedings, the members have to translate the materials obtained from the archives. For example, Bengt Hjallmarson translates Scheele's letter to Lavoisier, obtained from the French Academy of Sciences archives. Thus, quite like Brecht's *Life of Galileo*, this play too grapples with the issue of language and translation.

Meta-theatricality manifests itself in the play when Lavoisier informs the others in scene three that he and his wife will perform a masque. The masque is a musical piece on the lines of the traditional masques of the court of King Louis XVI. The masque, masked as an attempt to entertain, is an attempt by the Lavoisiers to sow seeds of suspicion in the minds of others and claim superiority. After the masque, Mme Lavoisier confirms the success of their ruse by using the idiom, "we planted a seed … their doubt will grow" (45). However, this kind of meta-theatricality is different from that discussed in Maharishi's *Einstein* in the previous section. The readers and the audience come across such a meta-theatricality in a play-within-a-play. The verse-dialogues of the masque detail the discovery of oxygen and puncture the claim of priority by Scheele and Priestley. The metaphor of mask also appears in the third scene

pointing out the various aspects of the personality of scientists (23). Mme Lavoisier's statement, "Wearing woman's mask…her husband's face on it", is an allegory to masques and is premonitory of the masque that will be performed (9). Thus, the playwrights utilize meta-theatricality by including a masque within a play.

Djerassi has written widely about the interaction of literature and science. Djerassi and Hoffmann's play provides the field with an engaging example of the use of literary techniques and devices such as sarcasm, mimicry, metaphors, and meta-theatricality among others. The result is a play that stands out for its unique amalgamation of literature and science.

An Experiment with an Air Pump

Stephenson's play is based on Joseph Wright of Derby's *An Experiment on a Bird in the Air Pump* (1768), an oil-on-canvas painting that depicts a scientific demonstration. In the prologue, the use of terms related to painting like "chiaroscuro" help explain with precision the effect that the playwright is looking for. Stephenson achieves a similar effect by using the phrase "bathed in celestial light" (5). The use of language in this particular manner also adheres to the plot's inclusion of the painting.

An important aspect of the plot is the change of time period in the play. The play is set in 1799 and 1999, and the changes are frequent and take place right in the middle of the action in the scenes. In her paper titled "A Moral Dialectic: Shelagh Stephenson's An Experiment with an Air Pump" (2006), Claudia Barnett writes:

> Stephenson's play, set half in the present and half in the past, answers Brecht's call for distance and echoes his delight in dissimilarity while drawing connections between worlds two-hundred years apart. The simultaneous staging of similarity and difference, past and present, results in a drama that grapples with issues of ethics and interpretation and requires its audience to do the same. (206)

This feature of fast-shifting time periods in the play is quite similar to that of *Oxygen*, which has been discussed in the previous section. The two alternating time periods allow the readers to find similarities and contrasts in the various fields of science and their evolving implications.

We see the exquisite use of satire and sarcasm in the play. Replying to Roget, Fenwick says, "When Kant said we are living in an age of enlightenment he reckoned without the existence of Percy Fellowes" (9). Just after this, he sarcastically says, "Tell him to go hang himself. Perhaps he could produce a learned paper on the universal rules of that particular phenomenon" (9). Bantering on, Fenwick says that Reverent Jessop has, "piss where his blood should be" (10). A little later in the play, the maid Isobel, who is a Scot, sarcastically states that the English "have a single word sir, nursery, for the place where both children and plants are raised. Perhaps that is telling" (20). In the second scene, when Tom rhetorically asks Phil if there is anything he does not believe in, he replies with a repartee saying, "Acupuncture. And the Tory party" (55). Sarcasm and satire aid the playwright in putting across their point in a more engaging way which paints an interactive picture of the characters. Such use of sarcasm and satire is highly useful in science plays where some readers might find the content matter less engaging.

Stephenson also employs biblical allusions and religious imagery in the play. Talking about the importance of their time period in the progress of science, Fenwick metaphorically terms the march of science as a "march towards a New Jerusalem with all our banners flying" (10). The biblical allusion to Ezekiel's prophetic vision in the Hebrew Bible is noteworthy. Harriet, Maria and Isobel prepare a short performance described as "a hymn to progress" (14). Similar to Kipphardt, Brecht and Maharishi, Stephenson too makes use of biblical allusions and religious imagery.

The playwright also includes a number of literary references in the play. While talking to Maria about the riot, Fenwick explains that riot "is like a play. Action, reversal, climax,

catharsis and we all go home" (13). Such Aristotelian understanding of a play from a physician is noteworthy. Maria, while talking about her character, says that she is playing an Arcadian Idyll which is an idealistic view of rural country life (14). We also see references to John Milton, William Shakespeare and Robert Southey in the play (14). There are also references to local folklore and folksongs. While talking about the harsh rural life, Roget says that in the cold "Bo Peep" might freeze to death (15). Bo Peep is a character in British folklore that represents a young shepherdess. Similarly, we see a reference to a folksong, the Greensleeves song, which Susannah suggests that Harriet should sing for her performance (51). The kids' performance talks of Britain's past, present and future, thus mirroring the plot of the play. Such mirroring is also known as parallelism. The only character in the play that is based on a real-life person is Peter Mark Roget. Roget was a physician and lexicographer who created Roget's Thesaurus in 1852. Roget being a physician and a lexicographer is a fine example of a practitioner of science and literature. Isobel's conversations with Roget are also an allusion to Roget's creation of a thesaurus in real life. By including literary references in a science play, Stephenson makes a practical case for the two cultures conversing with each other.

Thus, using imagery, allusions, metaphors, satire and sarcasm, Stephenson creates a science play in which it is difficult to tell the science apart from literature. The play, based on Derby's painting, also entices the readers to read more about the time period portrayed in the painting, guiding them to the evolution of sciences in history. In doing so, Stephenson's play actively bridges the gap between the two cultures.

Copenhagen

Michael Frayn's *Copenhagen* portrays the meeting of physicists Neils Bohr and Werner Heisenberg in Copenhagen during the Nazi occupation of Denmark. The play premiered at the Royal National Theatre, London in 1998. Frayn was a journalist and translated the works of

Anton Chekov. In the author's note, he expresses gratitude to Professor Balazs L Gyorffy of the physics department at Bristol University for proofreading the play and providing suggestions. Quite like Maharishi's *Einstein* (1996), this play portrays an example of collaboration between a playwright and a physicist.

The play is unique for its non-linear plot and characters that do not exist in space and time. The play has only three characters – Werner Heisenberg, Neils Bohr and Bohr's wife Margrethe. The non-linear plot of the play begins in medias res and that too with a question. Margrethe asks Bohr, "But why?" (3). The unorthodox beginning of the non-linear plot fits the play. Margrethe asks Bohr a question that encapsulates the central theme of the play. She asks, "Why did he come to Copenhagen?" (3). The interrogations at the beginning outrightly lay out the crux of the play. Frayn also alters the historical chronology of events. When Bohr says that Oppenheimer's regret on the eve of Hiroshima was that they could not produce the bomb in time to use against Germany, the timeline does not follow the chronology of events. The meeting in Copenhagen took place before the bombing of Hiroshima but since the characters are ghosts, they can loop back and forth in the timeline. The repetitiveness establishes itself when Bohr repeatedly calls for "one more draft" (86). The non-linear plot, the repetitiveness, and the altered chronology, highlight the theme of the play, which is, uncertainty.

The playwright uses Heisenberg's uncertainty principle as a metaphor to portray the condition of the characters. Heisenberg ironically states, "Everybody understands uncertainty" (4). Frayn employs the metaphor of Schrodinger's cat in the play when discussing the position of a particle.

HEISENBERG. So the particle's here, the particle's there…

BOHR. The cat's alive, the cat's dead…

MARGRETHE. You've swerved left, you've swerved right…

> HEISENBERG. Until the experiment is over, this is the point, until the sealed chamber is opened, the abyss detoured; and it turns out the particle has met itself again, the cat's dead. (26)

Heisenberg uses the metaphor again while referring to Gamow and Casimir: "Both of them simultaneously alive and dead in our memories" (28). Frayn portrays uncertainty when Bohr states that they have to follow the threads right back to the beginning of the maze (56). Heisenberg points out Bohr's affinity for contradictions and paradoxes. Ironically their situation in the play is itself a paradox as they are ghosts discussing their past actions when the consequences are already known. Another instance of the use of the metaphor of uncertainty principle is when Bohr states, "Unlike this instant his thoughts have been everywhere and nowhere, like unobserved particles, through all the slits in the diffraction grating simultaneously" (86). Margrethe refers to Heisenberg as "The flying particle wanders the darkness, no one knows where. It's here, it's there, it's everywhere and nowhere" (88). Uncertainty also reflects in the dialogue of Heisenberg when he says, "I'm your enemy; I'm also your friend. I'm a danger to mankind; I'm also your guest. I'm a particle; I'm also a wave" (77). Margrethe refers to Heisenberg as her son when she states, "But it's maddening to have this clever son forever dancing about in front of our eyes" (78). She also refers to the atomic bomb metaphorically as an "evil spirit out of a hole in the ground" (79). The play ends with Heisenberg's assertion that the future might have been saved "by some event that will never quite be located or defined. By that final core of uncertainty at the heart of things" (94). Thus, Frayn skillfully depicts the uncertainty of human life, decisions and motives using metaphors.

Apart from uncertainty, Frayn also employs other metaphors to aid the plot. Heisenberg metaphorically refers to Copenhagen as an atom and calls Margrethe its nucleus (68). Frayn also employs the metaphor of chain reaction to refer to the act of telling a truth (75). He also uses the metaphor of skiing to highlight the idea of multiple positions of a particle (75). Another

metaphor that Heisenberg uses is that of staying in the boat when referring to staying as the head of the Nazi nuclear program (76). Towards the end of the play, Bohr metaphorically calls Heisenberg a "lost child" who is wandering the world (93). Frayn's use of metaphors gives the non-linear play an added layer of meaning, that the reader deciphers.

Frayn uses multiple literary and narrative tools to carry the plot forward. At the beginning of the play, all three characters are dead and are contemplating their past actions. Margrethe explains, "Some questions remain, long after their owners have died. Lingering like ghosts. Looking for the answers they never found in life" (3). The playwright uses a simile to depict their condition as they are "lingering like ghosts". Frayn has written the play using non-convoluted language with liberal usage of scientific expressions. In his continuous conversation with Margrethe, Bohr addresses the audience and states, "And the more I look back on it, the more I think Heisenberg was the greatest of them all" (5). The break in narrative style from the to and fro conversation between the characters, to break the fourth wall and address the audience, mirrors the non-linear plot and represents a good example of the merging of form and content. The playwright utilizes foreshadowing when Heisenberg states, "Our tanks are almost at Moscow. What can stop us? Well, one thing, perhaps. One thing" (8). Heisenberg's statement foreshadows the defeat of the German Reich and the death of Hitler. We see a hint of meta-theatricality when the character of Heisenberg states that perhaps they will be murdered one by one, as in a play (45). The non-linear plot of the play features a break in the form of repetition of the utterance "silence" by the three characters. After this break, the plot loops again and it starts with the same question when Bohr asks, "So, Heisenberg, why did you come to Copenhagen in 1941?" (53). Since the non-linear and repetitive plot has only three characters, Frayn skillfully employs literary and narrative tools to keep the readers engaged.

The playwright employs a Biblical allusion when Heisenberg says that Weizsacker has been my John the Baptist (7). John the Baptist was a first-century preacher who used baptism

as a sacrament. The playwright alludes to theocratical structures of power when Bohr refers to himself as "the Pope" and Einstein as "God" (60,64). Such use of allusions is reminiscent of the same in *In the Matter of J Robert Oppenheimer, Life of Galileo, Einstein* and *An Experiment with an Air Pump* as discussed in previous sections.

The playwright brings to the fore questions of language and comprehension in the play. Heisenberg points out the problem of comprehension when he laments that Bohr got all the points of his talk wrong. It hints at the breakdown of communication using language. Due to the repetitive nature of the plot and the characters' arguments, the discussion becomes hard to follow. That is why Heisenberg requests Bohr to put forth his point in "plain language" (38). In the play, Mathematics is called the language of science and Heisenberg asserts that mathematics becomes very odd when applied to people as with people and one plus one adds up to different sums (29). The playwright again alludes to the idea of uncertainty and the problem of comprehension when Bohr states, "So you don't want me to say yes and you don't want me to say no" (40). The question of the language of communication comes up when Heisenberg tries to recall if they conversed in Danish or German. Frayn uses repetition again when the characters repeat the phrases "On Heligoland" and "On my own" (62,63). The problem of comprehension comes up again when Bohr states that in the end, they will have to explain it all to Margrethe (65). The lack of communication and comprehension which Frayn portrays in the play is referred to by CP Snow as "the gulf of mutual incomprehension". In a non-linear play adorned with numerous repetitions, Frayn puts forth the question of comprehension and the use of language.

Using the dialogues of the characters, Frayn exposes the irony and hypocrisy of the scientific nuclear development program. On the accusations of developing the bomb for Hitler, Heisenberg counters by saying, "You weren't dropping it on Hitler, either. You were dropping it on anyone who was in reach. On old men and women in the streets, on mothers and their

children" (43). The assertion that "you" were dropping it, assigns the blame for the death and destruction to the scientists. Similarly, when Margrethe complains to Neils that the Nazis have occupied Denmark and he should not meet Heisenberg, Bohr replies, "He is not they" (7). The irony of the atomic bomb development is such that the physicists who developed the bomb shunned Heisenberg, who never developed it. He laments, "Hands that actually built the bomb wouldn't touch mine" (47). This irony exposes the hypocrisy surrounding the development of the atomic bomb.

Imagery and expressionism feature in the play to enhance the portrayal of uncertainty. Frayn makes good use of imagery in Heisenberg's dialogue when he says, "I start to think about what you'd see, if you could train a telescope on me from the mountains of Norway. You'd see me by the street lamps on Blegdamsvej, then nothing as I vanished into the darkness, then another glimpse of me as I passed the lamp-post in front of the bandstand" (66). Frayn makes use of expressionist ideas and includes recurring motifs and images to depict the uncertainty of intentions and decisions in this historical event as perceived subjectively by the characters.

Along with Brecht's *Life of Galileo* and Djerassi and Hoffmann's *Oxygen*, Frayn's *Copenhagen* is considered a seminal science play. Frayn artistically employs metaphors, allusions, irony and imagery among other devices to create a play on an otherwise complicated scientific topic. The principle of uncertainty finds reflection in the dialogues, action and plot of the play, therefore, resulting in a prolific example of merging form and content.

Inherit the Wind

The foreword of Robert E Lee and Jerome Lawrence's play establishes it as a work of documentary theatre. The plot of the play is taken from the transcripts of the infamous Scopes trial. However, the playwrights assert that the play is not a work of history or a journalistic

piece but a play set in a time "not too long ago". Their statement, "It might have been yesterday. It could be tomorrow", sounds eerily prophetic and foreshadows events of the future.

The title of the play is a biblical allusion and it sets the tone of the play. The cover page of the play features a quote from the Bible, "He that troubleth his own house shall inherit the wind" (Proverbs 11:29). The townspeople sing "Marching to Zion" to welcome Matthew Brady, the prosecution attorney and two-time presidential candidate. Brady, referring to Henry Drummond, the defence attorney, says "If the enemy sends his Goliath into battle, it magnifies our cause" (29). The journalist EK Hornbek, in his verse, alludes to the biblical tale of Sodom and Gomorrah, the tale of Adam and Eve and the Tree of Knowledge (32). A play that features a confrontation between religion and science will indeed feature a number of religious allusions.

The character of Hornbeck provides comic relief in the play using biting sarcasm. When asked if he wanted a place to stay in the town, he replies, "I had a nice clean place to stay, madame, and I left it to come here" (14). The playwrights employ Hornbeck's sarcasm to highlight social issues. Hornbeck refers to the town of Hillsboro as "the buckle on the Bible Belt" (15). Such an assertion paints Hillsboro as a conservative town as the Bible belt refers to regions in the Southern United States characterised by religious fervour and conservatism. When Elijah, a "holy man" from the hills, asks Hornbeck whether he is "an evolutionist? An infidel? A sinner?", he replies, "The worst kind. I write for a newspaper" (15). Upon seeing a monkey, Hornbeck shakes its hand and calls it "Grandpa". When the monkey grabs a penny from a woman's hand, Hornbeck exclaims, "How could you ask for better proof than that? There's the father of human race!" (16). Religion and evolution are contentious topics and the playwrights hit hard at the issues using sarcasm and humour. On seeing Brady, who is a staunch believer in the scriptures, Hornbeck calls out to the monkey and says, "Shield your eyes, monk! You're about to meet the mightiest of your descendants. A man who wears a cathedral for a

cloak, a church for a spire hat, whose tread has the thunder of legions of the Lion-hearted!" (17). Hornbeck's sarcastic portrayal of Brady sets the tone for the events in the plot to come. Hornbeck displays another brilliant use of sarcasm when he states, "When this sovereign state determined to indict the sovereign mind of a less-than-sovereign school teacher, my editors decided there was more than a headline here" (26). Drummond while questioning a feed store worker, asks if he "ever happen to bump into a fella named Charles Darwin?" (45). Drummond uses sarcasm as a defence technique to highlight the absurdity of the trial. Towards the end of the play, when Cates is found guilty by the court, Hornbeck, being his sarcastic self shouts, "Step right up, and get your tickets for the Middle Ages!" (114). The playwrights aptly use sarcasm and humour to deal with the contentious relationship between religion and science.

Using the dialogues of the various characters, Lawrence and Lee portray the clash between dogma and science. Brady refers to the teachings of science as "blasphemies of science" and "heathen dogma" (23, 25). While talking to Rachel, a friend and colleague of Bertram Cates, the accused, he asks "Has Mr Cates ever tried to pollute your mind with his heathen dogma?" (25). Reverend Brown, the town reverend, refers to Henry Drummond, the defence lawyer, as "Henry Drummond, the agnostic" and calls him "a vicious godless man" (27). He even calls him an agent of darkness. The prejudice that the town has against him is evident in these dialogues. Brady refers to the classroom teachings as "evil-ution" and asks a young boy if his teacher Cates ever about creation or the Book of Genesis (69). He further argues, "I say these Bible-haters, these 'evil-utionists', are brewers of poison. And the legislature of this sovereign state has had the wisdom to demand that the peddlers of poison – in bottles or in books – clearly label the products they attempt to sell!" (70). When Drummond questions Brady if he has read the *Origin of Species*, he replies, "I am not in the least interested in the pagan hypotheses of that book" (86). The phrase "pagan hypothesis" is an interesting phrase that encapsulates the dissonance between science and dogma.

The playwrights use imagery to paint Brown's perception of Drummond. He describes Drummond as, "a slouching hulk of a man, whose head juts out like an animal's. you look into his face, and you wonder why God made such a man. And then you know that God didn't make him, that he is a creature of the Devil himself!" (28). The detailed description of the town, the courtroom and the characters aid the audience to visualise the action of the play.

The playwrights employ verse in the dialogues of Hornbeck. The use of verse in the play provides a searing effect to his sarcasm. The following is an apt example of Hornbeck's sarcastic verse:

Cynical? That's my fascination.
I do hateful things, for which people love me,
And do loveable things for which they hate me.
I am afraid of enemies, the enemy of friends;
I am admired for my detestability.
I am both Poles and Equator,
With no Temperate Zones in between. (33)

Another example of the same is the following:

I am inspecting the battlefield
The night before the battle. Before it's cluttered
With the debris of journalistic camp-followers.
[Hiking himself up on a window ledge]
I'm scouting myself an observation post
To watch the fray. (31)

Hornbeck's character and the reference to local newspapers point toward the importance of the publication of news and the resultant dissemination of information. His use of verse adds to his biting sarcasm.

The playwrights highlight the nuanced use of language to depict the conflict. Drummond explains to Rachel, his use of swear words by saying, "You see, I figure language is a poor enough means of communication as it is. So we ought to use all the words we've got" (51). His use of profanity is in contrast with his use of legal language in the courtroom. Hornbeck sarcastically replies to Brady, "How flattering to know I'm being clipped" (60). Reverend Brown gives a sermon in the town meeting in which he states, "And we believe the Word!" (62). The use of "Word" alluding to the Word of God is interesting to note. After this, he proceeds to deliver a highly energetic and frantic sermon. Brady, at the end of the sermon, asks Drummond, "Why is it, my old friend, that you have moved so far away from me?" To this Drummond replies, "All motion is relative" (67). This is a reference to the Newtonian understanding of the motion of bodies. The judge refers to Brady as "Colonel" Brady. Drummond objects to the use of the title colonel as it can influence the people of the town (42). The stage directions for the second scene mention, "The humourless judge sits at his bench" (37). Such directions from the playwright set the stage for a confrontation among the characters.

The use of imagery, sarcasm, metaphors, allusions, verse and humour makes the play unique in its treatment of science and society. Lee and Lawrence effectively utilize the thespian medium and literary devices to portray the contentious relationship between religion and science.

Conclusion

Kipphardt's *In the Matter of J Robert Oppenheimer* and Brecht's *Life of Galileo* employ multiple literary devices to engage the readers and bring their respective stories to life. Kipphardt utilises formal language, literary allusions, wordplay, rhetoric, and irony to effectively portray Oppenheimer's life and struggles. By incorporating these elements, the play

not only delves into the personal ordeals of the renowned physicist but also explores deeper themes of ethics, morality, and the responsibility of a scientist. On the other hand, *Life of Galileo* utilises poetic embellishments, comic relief, and the inclusion of various languages to captivate the audience. Brecht's use of malapropism, sarcasm, and humour brings moments of relief amidst the serious themes of the play. Furthermore, Brecht tackles the issue of language in scientific communication and emphasises the importance of the vernacular language to reach a wider audience. Both plays demonstrate the effectiveness of literary techniques in theatrical works. By incorporating these elements, Kipphardt and Brecht create engaging narratives that not only entertain but also provoke thought and discussion. These plays stand as timeless works of art, showcasing the power of literature to convey complex ideas and emotions while shedding light on the lives and struggles of important historical figures.

Maharishi's *Einstein* showcases the importance of collaboration between scientists and playwrights, reminiscent of CP Snow's vision. The play stands out for its bilingualism, incorporating both English and Hindi in a unique manner. Maharishi skillfully uses literary techniques such as meta-theatricality, euphemism, and references to literary personalities to enhance the play's impact. Additionally, in Djerassi and Hoffmann's *Oxygen* the integration of language and literary devices highlights the complexities of scientific nomenclature, historical context, and the role of women in science. Both plays serve as exemplary works that merge form and content, setting a precedent for future science dramatists in India and beyond. *An Experiment with an Air Pump* and *Copenhagen* exemplify the intersection of science and literature in the realm of drama. Stephenson employs imagery, allusions, metaphors, satire and sarcasm to create a science play that blurs the boundaries between science and literature. The inclusion of biblical allusions, literary references, and the use of language in a precise and engaging manner bridges the gap between the two cultures. Similarly, Frayn's *Copenhagen* explores the uncertainty principle and uses metaphors to depict the condition of the characters.

Frayn also addresses the issues of language and comprehension, exposing the challenges of communication in the context of scientific development. Both plays showcase the collaboration between playwrights and scientists, demonstrating the potential for science and literature to inform and enrich each other. Lee and Lawrence's play, with its documentary-style approach and the use of various literary devices, offers a thought-provoking exploration of the clash between religion and science. Through biblical allusions, sarcastic humour, and vivid imagery, the playwrights skillfully depict the deep-seated prejudices and heated debates surrounding the Scopes trial. The characters' dialogues, filled with dogmatic language and scientific references, exemplify the ideological divide and the struggle between tradition and progress. By incorporating verse, metaphors, and nuanced language, Lee and Lawrence create a unique and impactful theatrical experience that sheds light on the complex relationship between faith and reason.

Chapter 3: The Use of Props and Scenography in Science Plays

Introduction

Theatre as an art is a dynamic form of expression that captivates audiences through its ability to convey themes and messages using a rich tapestry of theatrical elements. Among these elements, stage instructions, props and costumes hold significant sway in enhancing the theatrical experience and effectively communicating complex ideas. Literary critics have often assumed that the written play takes precedence over its performance. They typically view the performance as a realization or interpretation of the written text. The written text influences the performance in various ways, determining what the actors say, structuring the action, and even guiding aspects like movement, settings, and music. Since the play is written before it's performed, it seems reasonable to prioritize the written text.

However, it's also valid to argue that performance shapes the dramatic text as it is articulated. The "incompleteness", where the dialogue refers to contexts not explicitly described, suggests that the dramatic text is deeply influenced by its performability. In essence, the written text is shaped by its necessity for stage adaptation, indicating its reliance on the physical conditions of performance, particularly the actor's body and its ability to bring dialogue to life on stage. This chapter delves into the profound impact of theatrical elements as portrayed in the plays, uncovering their power to transport audiences into immersive worlds and shed light on profound themes. Kipphardt's *In the Matter of J Robert Oppenheimer* serves as a prime example of the potent role that props, costumes, and documentary elements play in recreating the trial and ethical dilemma faced by the eminent American physicist. By utilizing props such as letters, interviews, and government reports, the play constructs a compelling plot that authentically captures the essence of the trial. Symbolism is deftly employed through the

imagery of stars and stripes, military uniforms, and the atomic and hydrogen bombs, reflecting Oppenheimer's inner turmoil. Through its meticulous use of props and documentary elements, the play provides an authentic portrayal of Oppenheimer's trial, inviting reflection on the intricate interplay between science, politics, and personal convictions. Brecht's *Life of Galileo* stands as another remarkable testament to the effective employment of props in conveying scientific concepts, challenging societal norms, and symbolizing broader themes. The play masterfully incorporates a range of props, such as a wooden model of the Ptolemaic system, an iron washstand, an apple, a telescope, a compass, a proving stone, and a manuscript. Each prop carries deep symbolic meaning, representing the clash between traditional beliefs and emerging scientific ideas. In Maharishi's *Einstein* multiple props are strategically employed to enhance communication and engage the audience. Musical pieces, chairs, books, scientific instruments, cyclorama, compass, light, sound, a list of scientists, a fake eye, a whistle, and an apple come together to convey profound meanings and symbolize essential themes. These props serve as powerful tools in storytelling, evoking a range of emotions and highlighting the intricate interplay between science, knowledge, and societal dynamics.

In the play *Oxygen*, the significance of theatrical properties, stage setting, and costumes takes centre stage as the stage setting expertly creates a laboratory-like atmosphere, effectively immersing the audience in the world of scientific discovery. Additionally, period-specific costumes transport viewers to distinct time periods, evoking authenticity and deepening their connection with the characters. The use of props such as books, letters, and documents serves as potent symbols and catalysts for pivotal moments, exploring the intricate relationship between science and ethics. Stephenson's *An Experiment with an Air Pump* showcases the effective utilization of theatre scenography, stage setting, costumes, and lighting to convey its message. The inclusion of Joseph Wright of Derby's painting as a prop establishes a connection between art and science, while the strategic employment of chiaroscuro lighting sets the mood

and signifies the completion of the play. The portrayal of a live bird in a glass dome and other props evoke historical practices of science performances, enhancing the audience's understanding of the play's themes. *Copenhagen* and *Inherit the Wind* demonstrate the power of theatrical elements in conveying thought-provoking themes. Copenhagen's minimalist approach, devoid of explicit scenography and props, engages audiences in an introspective exploration of scientific and personal dynamics. Frayn's skilful use of minimalist theatre elements invites contemplation of scientific inquiry and human relationships. In *Inherit the Wind*, intricate stage instructions and props, such as books and banners, vividly illustrate the conflict between religion and science. In the chapter "Theatre of Cruelty", Antonin Artuad writes:

> Here too intervenes (besides the auditory language of sounds) the visual language of objects, movements, attitudes, and gestures, but on condition that their meanings, their physiognomies, their combinations be carried to the point of becoming signs, making a kind of alphabet out of these signs. Once aware of this language in space, language of sounds, cries, lights, onomatopoeia, the theater must organize it into veritable hieroglyphs, with the help of characters and objects, and make use of their symbolism and interconnections in relation to all organs and on all levels. (90)

These plays exemplify how stage instructions, props, and costumes create immersive worlds, underscore central conflicts, and delve into complex ideas, leaving a profound impact on the audience. Now, the chapter will undertake an in-depth analysis of these props, scenographic elements and stage designs in each play.

In the Matter of J Robert Oppenheimer

The use of props and objects in the play provides us the opportunity to engage with the scenography of the play. Kipphardt's play employs costumes, stage designs, stage settings, lighting and projections to tell the tale of the American nuclear physicist Robert Oppenheimer. The play falls within the realm of documentary theatre, employing evidentiary materials such as notes, letters, interviews, and government reports to recreate the plot. This chapter delves into an analysis of the props and documentary elements that Kipphardt utilises, such as imagery of stars and stripes, military uniforms and Senator McCarthy's interview. Additionally, the atomic bomb and the hydrogen bomb are symbolically represented in the play, reflecting the inner turmoil and dilemma faced by Oppenheimer. The trial of Oppenheimer by the Personnel Security Board serves as a prop to explore the ethical allegiance of a scientist and their responsibility to the nation. Furthermore, reports, files, and documents are used as props to convey essential information and shape the plot, while complementary props such as testimonies and photostats provide a realistic assessment of the hearing. Kipphardt meticulously employs scenographic tools to condense the extensive committee proceedings into a three-part play and immerse the audience in the gravity of Oppenheimer's situation.

The prologue to the play titled "The Play in Relation to the Documentary Data" provides details regarding the historical documents and records used to create this play. The majority of these records were published by the United States Atomic Energy Commission. The play thus falls into the category of documentary theatre. In the first scene, the stage directions specify the documents to be displayed. In documentary theatre, the plot of play is recreated from evidentiary materials like notes, letters, interviews and government reports among many others. The documentary elements while serving as props in the play, also assist in providing a detailed description to the plot of the play. This chapter will analyse all these props and documentary elements employed by Kipphardt in the play.

The setting of the first scene introduces the imagery of stars and stripes and military uniform, thus setting the tone of the play. Imagery is a category of symbolism which evokes a mental picture in the mind the reader. In a play, the literary device of imagism is utilised by the playwright to evoke the senses of the audiences or the readers. In this particular case, the imagery of stars and stripes symbolises the American state and prepares the ground for the conflict between the state and the scientist. The military uniform that is donned by the scientists in the play highlights the interplay of authority between the military and the scientists. A detailed analysis of the same has been undertaken in the first chapter.

Senator McCarthy's interview is used in the scene as a prop to introduce the topic and to give a preliminary introduction to the play. Joseph Raymond McCarthy was a Republican senator from Wisconsin, who gained notoriety during the cold war era because of his unsubstantiated allegations against a large number of public figures for being a communist and an agent of the Soviet Union. His practice of publicly slandering eminent personalities and political opponents was termed as "McCarthyism". During the era of McCarthyism or "Red Scare", multiple men and women were accused of working against the country, thereby diverting nationalistic fervour against them. Oppenheimer was one such person who was accused of plotting against the United States when he refused to head the development of the hydrogen bomb.

The atomic bomb and the hydrogen bomb are themselves used as symbols in the play that convey more than their literal meaning. In literary studies, symbolism is employing a tangible image to portray an abstract concept. While the atomic bomb is portrayed as the necessary evil, the hydrogen bomb is portrayed as inordinate, which was not required but was desired. In the play, Oppenheimer explains that the production of the atomic bomb was necessary to counter the threat of the development of Nazi nuclear weapons program which was being headed by Werner Heisenberg (as we discuss in the play *Copenhagen*). However,

according to the character of Oppenheimer, after the bombing of the Japanese cities of Hiroshima and Nagasaki, the surrender of the Axis forces, and the death of Adolf Hitler, there was no reason to produce another weapon of mass destruction which was many times more lethal than an atomic bomb. Thus, both these bombs in the play symbolise the cause of the inner turmoil and dilemma faced by Oppenheimer.

Personnel Security Board's trial of Oppenheimer can be viewed as a prop used by the playwright to highlight the contrasting issues of ethical allegiance of a scientist and a scientist's responsibility to the nation. Staying true to Kirsten Shepherd-Barr's idea of "Science on Stage", Kipphardt turns the stage into a courtroom, where scientific ideas, principles and subsequent decisions are acted out. Artaud, in "Metaphysics and the Mise en Scène"(1958) states, "the stage is a concrete physical place which asks to be filled, and to be given its own concrete language to speak" (37). Using the thespian medium, the playwright presents a trial on the stage to discuss the conflicting allegiances of a scientist towards science, towards the nation and towards humankind.

During the entire trial, various characters are asked to take the stand. Taking the stand refers to the act of making a deposition before the committee. The stand as a prop in the play symbolises the formal authority of the committee where everyone is supposed to say the truth, having taken the oath. The stand portrays the relative standing of the committee in the play amongst other characters. The committee members will decide the fate of the hydrogen bomb development, and that of Oppenheimer's career and reputation. Various members of the bomb development program and the other relevant experts from different fields depose in front of the committee. The stand is therefore, symbolic of the authority wielded by the committee, as is also discussed in the first chapter of this thesis.

A number of reports, files and documents provide the readers with the necessary information to understand the plot of this documentary play. Kipphardt uses The Franck Report

of 1945 to convey the opposition to testing the bomb. It urged the government of the United States to not use an atomic bomb on Japan and was signed by the leading nuclear physicists of the time. The play also features the letter of the Atomic Energy Commission containing the allegations levelled against Oppenheimer. The letter questions Oppenheimer's allegiance to the United States, and his reluctance and opposition to the development of the hydrogen bomb. The plot brings forth secret FBI files containing information regarding various activities and background of Oppenheimer. These FBI files are used by the committee to assess Oppenheimer's position as a hero or a traitor. A report from the General Advisory Committee is presented which contains the views of Oppenheimer on the development of atomic bomb from when he was the head of the same. All his views are put forth to the committee and to the readers using these props. The playwright mentions a petition to the President which contains the scientists' appeal to halt the development and use of the atomic bomb. Kipphardt use these reports, files and documents presented during the course of investigation as props and scenographic elements to set the stage for the plot to unravel.

There are two props that complement each other and present the readers with a realistic assessment of the condition that was prevalent during the hearing. Paul Crouch is a former communist whose testimony nails Oppenheimer and is crucial for the prosecution. He testifies that Oppenheimer was part of numerous secret communist meetings. Due to the prevalent Red Scare of the time, this would lead the committee to believe that Oppenheimer is guilty of treason. However, Crouch is proved to be an unreliable witness by the bundle of photostats presented in front of the committee by Oppenheimer's defence counsellors. These copies prove that Oppenheimer was not in the locations alleged by Crouch at the time of these meetings. His testimony and the bundle of photostats are complimentary props that ironically, contradict each other and portray the state machinations to get rid of Oppenheimer and the lengths to which Oppenheimer's counsellors had to go to prove otherwise.

In the stage directions for a number of scenes, we see that the text is projected on the hangings. In a documentary play, the sheer number of documents and data can be overwhelming for the audiences. That's why the use of projectors is quite common and adds to the audio-visual experience of the audience. For theatrical communication, projectors work as an efficient scenographic tool.

The Frank Report and Oppenheimer's petition to the president of the United States are props that symbolise agency of the scientists and their utilisation of their right to freedom of speech. When Oppenheimer says that the best people in America put their names to manifestoes, he refers to manifestoes as symbols of democratic dissent when scientists and thinkers could urge the government to reconsider their policies.

In the play, more than being a literal instrument of espionage, the Communist Party becomes a metaphorical, omnipresent and omnipotent villain. Morgan asks Oppenheimer if he knew in 1943 that the Communist Party was an instrument of espionage (33). While the Soviet espionage machinery was quite efficient, the red scare added more fuel to fire in the public imagination. Communists and communism became symbols of everything that was wrong in the American society at the time and anyone who was even alleged to be associated with it was considered anti-national and a menace to the society.

The use of microfilms, tape recorders, newspaper article and photographs in the play provides the audience with a realistic experience of the proceedings of the committee. Kipphardt's documentary courtroom drama is rich in information as the original committee proceeding lasted for four weeks. To condense all the committee proceedings into a three-part play and to show what all cannot be incorporated into text require efficient utilisation of scenographic tools. Similarly, the test explosion projection at the beginning of the second part of the play relays to the audience the gravity of the situation faced by Oppenheimer and other scientists involved in the project.

Through the skillful use of props and documentary elements, Kipphardt's play "In the Matter of Robert J Oppenheimer" brings to life the complex ethical and political landscape surrounding the trial and dilemma faced by Oppenheimer. The play's documentary nature and incorporation of evidentiary materials provide a rich and authentic portrayal of the events, allowing the audience to delve into the inner workings of the committee and Oppenheimer's struggle. The symbolic representations of the atomic bomb, the hydrogen bomb, and the Communist Party add depth and layers of meaning to the narrative, amplifying the tension and moral quandaries faced by the characters. The staging techniques, including the projection of texts and the use of projectors, enhance the visual and auditory experience for the audience, effectively conveying the magnitude of the situation. Overall, *In the Matter of Robert J Oppenheimer* exemplifies the use of scenographic elements, props and documentary theatre in exploring complex historical and ethical themes, inviting the audience to reflect on the interplay between science, politics and personal convictions.

Life of Galileo

A number of props are used to depict scientific concepts and phenomenon in the play. These props have a direct as well as a referential meaning. Broadly speaking, any object used on stage is called a prop, which along with stage movements, body language, dialogue delivery and mise-en-scene create a holistic performance environment. The use of props in a play can greatly enhance the storytelling and convey complex ideas and concepts to the audience. In Brecht's play, various props are employed to depict scientific concepts and phenomena, adding depth and symbolism to the narrative. These props serve not only as visual aids but also carry metaphorical and referential meanings, contributing to the overall communication of the play. From wooden models to telescopes, apples to proving stones, each prop plays a significant role in highlighting the clash of ideas, paradigm shifts, ethical dilemmas, and the evolving

relationship between science, religion, and society. This chapter explores the use of props in Brecht's play and how they contribute to the portrayal of scientific concepts and the broader themes of the work.

In the first scene, we see a big wooden model of the Ptolemaic system. The wooden model depicts the worldview prevalent at that time; however, soon we are introduced to the challenging viewpoint in the form of an iron washstand. Galileo uses the iron washstand and a chair to explain to Andrea the heliocentric model of the universe as put forth by Copernicus. Ptolemy advocated for a geocentric model of the universe, where all other celestial bodies in the solar system revolve around the earth, which is stationary. The Age of Enlightenment in Europe corresponds with a "paradigm shift" in our understanding of planetary movements. The Copernican model advocated for a model where sun was the centre of the solar system and not earth. In philosophy of science, Kuhn's paradigm shift refers to a radical shift in the understanding of a scientific concept or discipline which changes the entire trajectory and basic principles of the field. The paradigm shift from a geocentric model to a heliocentric model was so impactful that it also affected the relative position of humankind with respect to God. Post enlightenment, just as earth was replaced by sun as centre of the solar system God was replaced by humankind as a central tenet to understanding the world. This inward turn in the history of ideas is portrayed by Brecht using a wooden model and a washstand as props.

Additionally, Galileo also uses an apple to demonstrate the motion of the earth around the sun. The round apple becomes a rotating body that revolves around a fixed sun. It becomes a symbol of the forbidden truth in the form a biblical allusion. The apple alludes to the forbidden fruit of knowledge that God decreed Adam and Eve not to eat. Brecht employs visual language of the prop to convey a deep symbolism which informs the readers and the audience at both conscious and sub-conscious level.

Undoubtedly the most important prop of the whole play is the telescope. It is not merely an invention that is displayed on stage but Galileo uses it as a tool to put forth a number of unsettling questions. According to the play's plot, Galileo did not invent it. He built it based on the description provided by Ludovico, his rich pupil, who bought one from the streets of Amsterdam. In the play, Galileo passes off his recreating of a Dutch telescope as his own invention and is rewarded heavily for it by the Doge of Venice. Galileo's telescope is immensely useful for merchants waiting on the shore for their ships, for the sailors at sea and for other military uses. Galileo uses his telescope to solve the questions of the movement of celestial bodies but it also finds commercial use. Brecht highlights the complex issues of ethics of invention, use of a scientific tool for commercial purpose and selling scientific inventions for commercial gain. Furthermore, the telescope is also the most potent prop of the play as Galileo will use it to provide observable proof of the movement of planets around the sun. Galileo believes that this telescope will provide vindication to both Nicolaus Copernicus and Giordano Bruno, who paid for their ideas with their lives. As a prop, the telescope is treated with dignity as it carries a lot of authority in the play. Initially, it is mentioned to be housed in a green leather case and later when Galileo presents into the state dignitaries, it is placed on a velvet cushion in a crimson case. The dignity that the prop receives is not because of its scientific use but its commercial use. Using the telescope as a prop, Brecht also brings into discussion the role of funding and patrons for the advancement of science.

Other inventions of Galileo also feature as props in the play. Repeated reference is made to the compass made by Galileo, which is used by arithmeticians, architects and surveyors. Galileo's geometric compass is different from a magnetic compass. A magnetic compass is used to find directions as it points to magnetic north and a geometric compass is an instrument used to calculate complex geometrical and arithmetic equations. The inventions of geometric

compass and telescope portray the evolution of science and its correlation with the advancements made in various fields during and after the renaissance era in Europe.

To bring about a visual impact to explain a scientific concept, Brecht incorporates the use of a board on which Galileo draws the epicyclical orbit of Venus. Since it will not be possible to show the audience the telescope's observations, the playwright uses the board to draw and depict the same. Such an approach stays true to the notion that theatre is meant to show and not tell. The use of visual aids like a cyclorama, as mentioned in the third scene, aids the audience to have a better understanding of the scientific concepts. This is in line Kirsten Shepherd-Barr's methodology of portraying science on stage.

The chessboard becomes a battleground for the old and new models. As a prop it symbolises the clash between two worldviews of knowledge in the same field, where a new scientific idea is challenging the established normal. Galileo instructs the monks playing chess that they should play according to the new rules wherein the pieces can move more freely on the boards and can have sweeping motions as opposed to limited one straight move as per the old rules. Galileo and the monks are representatives of the two competing models of understanding planetary motion and Brecht uses subliminal symbolism to portray it.

One cannot help but notice the parallelism to the ongoing debate in the play regarding the old rules of the world and new ones that Galileo wishes to prove. The old model is brilliantly depicted by the crystal ball with Earth in the centre and all other planets revolving it (62). This model can be contrasted with the washstand model discussed earlier. Galileo makes an interesting choice regarding the material as it suggests that this model made of crystal is fragile and is about to be shattered, hinting at the oncoming paradigm shift.

In the tenth scene, we see the carnival procession being taken out mocking Galileo and his work. While the setting of the scene and the procession is itself noteworthy, the most exciting part is the use of bible and telescope as props. It is said that Galileo "chucked away

the bible, picked up the telescope" (83). Bible is used here as a prop to depict the old-world order which is being replaced by the new-world order, as symbolised by the telescope. It also depicts the use of the telescope as a symbol for the changing time and values. The observations made by the telescope challenges the authority of the bible here.

The inventions that facilitated trade and warfare, like the brass compass mentioned in Inquisitor's monologue in the twelfth scene, are now probing into the church's domain and are being used by the commoners to question the doctrines. He says "Ever since they began voyaging across the seas – and I've nothing against that – they have placed their faith in a brass ball they call a compass, not in God" (92). The navigational compass facilitated voyages across the oceans and ushered in the era of global exploration. Global explorations lead to international trade across the sea routes, supported and sustained the industrial revolution, and became the starting point for colonisation of the new world. Inventions like the navigational compass, the geometric compass and telescope are signs of a fast-changing world order where the inquisitor might not find a place. Thus, these props are symbolic of the depleting authority of church and an increasing authority of reason.

Just like the apple, Galileo's proving stone is a prop that features repeatedly and has deep symbolic value. Using the stone, Galileo refuted and sarcastically rebuffed Aristotelean teachings about the motion of objects during free fall. He is known to keep the stone on him at all times and it depicts the importance of observable phenomenon and rational inferences. He questioned the hypocrisy in believing an unproven idea even when there is contrarian evidence and his proving stone symbolises his quest against dogmatic hypocrisy.

The thirteenth scene portrays Galileo recant his teachings after twenty-four days in prison. The recantation is symbolised by the sound of Saint Mark's bell. Saint Mark is the author of Mark's Gospel and is usually accompanied by a winged lion. He is symbolised as an authority figure and the bell toll delivers the final verdict on Galileo. The bell sound denotes

Galileo's recantation and epitomises the authority of religion over science. The first chapter elaborately discusses the relationship between religious and scientific authority.

The "dicorsi" or the manuscript of *The Discourses and Mathematical Demonstrations Relating to Two New Sciences* (1638) is in itself one of the most critical props used in the play. After recanting his teachings, much to Andrea's chagrin, Galileo secretly continues to work on the manuscript. When Andrea comes to visit him in the fourteenth scene, Galileo hands him over the manuscript. The manuscript depicts the defiance of Galileo in the face of odds and his dedication to his work. He kept on working in secrecy to ensure that he was able to complete his work and ensure that his work reached the public. He defies the church by continuing his work and goes against the societal norms by writing his work in vernacular Italian rather than the preferred academic language of the day, Latin. He chooses Italian to ensure a wider dissemination of scientific ideas and the invention of the fixed type printing press aided him. The manuscript is therefore the most significant prop with a deep symbolic meaning.

Galileo places the manuscript inside a globe and hands it over to Andrea to smuggle it out of Italy. Brecht's depiction of the globe and the act of placing the manuscript inside is highly symbolic. The work that will change how we look at our planet was placed within our planet's model, depicting that truth lies within. This symbolism resonates with the ideas of renaissance and foreshadows a change in the way humans look at their own world.

The strategic use of props in Brecht's play, *Life of Galileo*, serves as a powerful tool to depict scientific concepts, challenge established norms and symbolize the larger themes explored in the narrative. From the wooden model of the Ptolemaic system to the telescope, compass, proving stone and manuscript, each prop carries deeper meanings that resonate with the evolving understanding of the world and the clash between traditional beliefs and emerging scientific ideas. Brecht's incorporation of visual aids, such as drawing on a board and the carnival procession, further enriches the audience's comprehension of complex scientific

concepts. Through these props, Brecht not only presents the scientific journey of Galileo but also raises questions about ethics, commercialization of knowledge, the authority of religion, and the power dynamics of the time. The props in *Life of Galileo* serve as tangible representations of abstract ideas and enable the audience to engage with the scientific and philosophical discourse taking place on stage.

Einstein

The incorporation of props in theatre holds immense potential for enhancing the communication and impact of a play. In Maharishi's play, various props are employed to convey deeper meanings, symbolize themes and engage the audience on multiple levels. From musical pieces and chairs to books and scientific instruments, these props serve as powerful tools in storytelling, evoking emotions, and highlighting the interplay between science, knowledge, and societal dynamics. In this chapter, we explore the significance and transformative power of the theatrical props used in the play, shedding light on their role in enriching the narrative and immersing the audience in a thought-provoking theatrical experience.

The play features a number of musical pieces. The play begins with a single violinist in the orchestra pit playing Schubert. Later we also see a man in the pit playing Mozart (11, 17). Maharishi makes use the violinist as a prop and the reference to Schubert and Mozart hints at Einstein's affinity for music. As scenographic elements, musical pieces add to the play's communication at an auditory level and appeal to the senses at a sub-conscious level.

The frustration of young Einstein is performed on the stage by showing the actor throw a chair off the stage. Throwing the chair becomes an act of venting out his frustration at the

state of learning prevalent at that time. Young Einstein is miffed as he is being forced to rote learn scientific ideas and is usually shut down when he asks questions. As a prop, the chair becomes a tool to portray his frustration and pent up anger, in a manner akin to that of physical theatre.

Maharishi utilises books as props at various instances. In the first scene, Einstein's uncle Max hands him over a number of books. These books, as props, symbolize the handing over of knowledge from one generation to another. It also signifies a sort of initiation or coming of age of young Einstein where he is made the next recipient or owner of knowledge as symbolised by the books. The playwright employs Euclid's book on geometry to portray the classical view on science and also a traditional approach to mathematics. Einstein laments in the play that the book has a lot of formulae, but no proof and some of the formulations are too direct to require derivation. Euclid's book on geometry hints at a change in guard in the field of physics and mathematics that is about to be brought in by Einstein.

The playwright innovatively uses a cyclorama to depict the sky. A cyclorama provides a 360-degree view of an image to viewer in panoramic orientation. This is a portrayal of the universe at a smaller scale and on the stage, as propounded by Kirsten Shepherd-Barr in her book *Science on Stage*: *From Doctor Faustus to Copenhagen*. The use of cyclorama highlights playwright's employment of scenographic elements to present scientific ideas on stage.

In the play, adult Einstein introduces a child playing the character of young Einstein to a compass. The scene mirrors the passing on of the props of knowledge from uncle Max to young Einstein. In the first case, it was a set of books and in this case, it is a compass. There is an apparent parallelism in Maharishi's use of compass as a prop to symbolise scientific knowledge and Brecht's use of the same in *Life of Galileo*.

In the later part of the play, the audience sees the lights change on stage and hears drums banging in the distance as a dream scene is performed on the stage (24). The playwright uses

light and sound to depict a change in the plotline and characters within the same scene on stage. The use of light and sound to depict a dream scene highlights the playwright's application of scenographic tools to put up a performance of science on stage.

Maharishi portrays scientific progress and the opposition it receives using a single prop. He introduces the readers to a list of major scientists of the world who have made prominent discoveries in the past. The list as a prop depicts the cumulative progress of science that has furthered human knowledge and also the opposition it has received from the likes of the character of the fat lady who says that all these scientists should be put in jail in Siberia. Her approach is quite similar to that of the Roman Inquisition featured in *Life of Galileo*, wherein she too wants to violently do away with those who question authority.

The playwright shows the characters playing with the fake eye of Einstein. The fake eye is used as a prop to portray the issue of round and flattened celestial bodies as discussed by the characters of Einstein 1 and Aristotle. As discussed in the previous section, in *Life of Galileo*, Galileo used a proving stone to debunk Aristotelean ideas of motion of bodies. Maharishi employs Einstein's fake eye to counter the Aristotelean viewpoint on celestial bodies.

In order to perform science on stage, the playwright employs a whistle and candle as props. At the beginning of the second act, Max Talmud uses a whistle and a candle to depict the difference in the transmission of light and sound. The simple experiment proves that light travels in a straight line. The performance of this rudimentary experiment resonates with Kirsten Shepherd–Barr's dictum of performing science on stage.

The use of an apple as a prop is a two-layered allusion. The apple falling into the lap of Einstein is an allusion to the story of the apple that fell on Newton and the subsequent formulation of laws of gravitation. The use of an apple as a prop also has biblical allusions as apple was the forbidden fruit that Adam and Eve were told not to eat in the Garden of Eden.

The utilization of theatrical props in Maharishi's play demonstrates the transformative nature of these elements in theatrical storytelling. Through their symbolic representations, emotional resonance, and ability to convey scientific concepts, the props in the play create a layered and immersive experience for the audience. The musical pieces played by the violinist in the orchestra pit set the auditory tone and hint at Einstein's affinity for music, while the chair thrown off the stage becomes a physical manifestation of frustration and rebellion. Books serve as conduits for knowledge transmission and represent a changing guard in the fields of physics and mathematics. The cyclorama, compass, light, and sound play crucial roles in depicting scientific ideas and shifts in plot and character dynamics. Moreover, the use of props such as the list of scientists, the fake eye, the whistle, and the apple adds depth and intertextuality to the play, drawing connections to historical and literary contexts. Each prop carries layers of meaning, offering opportunities for exploration and reflection on scientific progress, opposition, and the human condition. Through the adept integration of these props, Maharishi showcases the power of theatrical elements to transcend boundaries and stimulate intellectual engagement. The careful selection and utilization of props contribute to a rich and immersive theatrical experience. By transcending the boundaries of the stage, these props become conduits for profound exploration and reflection, leaving a lasting impact on both the audience and the art form itself.

Oxygen

The art of theatre encompasses a myriad of elements that work in harmony to create a captivating and immersive experience for the audience. Among these elements, theatrical properties, stage setting and costumes play pivotal roles in portraying and exploring various themes within a play. They serve as visual cues, symbolic representations, and immersive tools

that enhance the narrative, evoke authenticity, and provide a deeper understanding of the complex layers within the theatrical work. This chapter delves into the utilisation of theatrical properties, stage setting and costumes in the play. From the outset, the technical details presented at the beginning of the play set the stage for a laboratory-like atmosphere. In *The Routledge Companion to Scenography* (2018), Arnold Aronson writes:

> In the theatre, the observer and the thing observed exist in time and space. Thus, a performance must take place somewhere. This immediately necessitates space – a space in which the performance occurs and one in which the spectators reside. These can, of course, be shared spaces or architecturally unified spaces; they can be found or transformed, they can be elaborately constructed and embellished. But, regardless of the specifics of the space, the performance occurs and is seen in some sort of environment. (8)

The incorporation of a laboratory demonstration table, a screen, and a projector creates the illusion of witnessing the inner workings of a scientific laboratory. This careful attention to stage setting allows the audience to be fully immersed in the world of scientific discovery, suspending their disbelief and engaging them in the journey that unfolds. Costumes, another vital element of theatrical storytelling, hold the power to transport the audience to different time periods and evoke a vivid visual experience. Throughout the play, props serve as powerful symbols and catalysts for pivotal moments. Books, letters and documents emerge as key props in driving the narrative and exploring ethical dilemmas surrounding scientific discovery. The chapter will also discuss additional props such as burning lenses, drawings of Lavoisier's equipment, archival slides, and masks which further contribute to the rich tapestry of the play. Through the masterful use of these elements, Djerassi and Hoffmann craft a multi-dimensional

theatrical experience that transcends the boundaries of time and culture, leaving audiences captivated and immersed in the interplay between science, history, and the human experience.

The use of theatrical properties, stage setting and costumes portrays varied themes in the play. The technical details given at the beginning of the play direct the performers to use a laboratory demonstration table, and a screen and projector. The cumulative effect of the same is the portrayal of a laboratory on stage so as to convince the audience that they are viewing the inner workings of a lab. The playwright effectively coverts a lab into a stage and at the same time, a stage into a lab.

The use of costumes allows the director to provide a vivid visual experience. Special instructions are given for costumes relating to the two time periods to evoke authenticity. The two time periods depicted in the play are 1799 and 1999. To provide an immersive experience and to present a realistic performance, Djerassi and Hoffmann instruct the use of costumes that were particular to the two time periods.

As discussed in the previous sections of this chapter, books are regularly used by playwrights as props to symbolise relevant ideas in the play. Published books play an important role in the plot of *Oxygen*, the most important one being Wilhelm Scheele's book *On the Chemistry of Air and Fire*. This book is Carl Wilhelm Scheele's claim to the earliest discovery of Fire Air or Oxygen and symbolises the quest in science to be the first one. Scheele was the first one to conduct the experiments but his work could not be published as the publisher in Sweden took more than a year to publish it by which time Joseph Priestley had published a paper on it. The book as a prop highlights the importance given to publishing in sciences.

Apart from the book, another prop that plays a pivotal role in the plot is the letter written by Scheele to Antoine Lavoisier detailing his experiments with Fire Air. The letter is the single most important document in the play and is referred to repeatedly as the plot hinges on it. The

letter problematizes not just the issue of discovery in the play but also of ethics in relation to scientific discovery. According to Scheele, he intimated Lavoisier of his discovery and the methodology of his experiment. Scheele's claim to the discovery of oxygen lies on this letter and his unpublished book. However, Lavoisier denies having received any such letter and maintains that he discovered oxygen on his own, without any aid from Scheele and using a research method different from that of Scheele. Later in the play, it is revealed that Mademoiselle Lavoisier had indeed received Scheele's letter but hid it from Antoine. The letter, as a prop, highlights the issue of discovery with respect to ethics. Two more letters feature in the play as props. One is the letter that the American chemist DuPont wrote to Mme Lavoisier, and the other is the one from Benjamin Franklin to JB Priestley. The playwrights utilize letters and documents to weave the plot of the play and therefore, the play can also be analysed as an example of documentary theatre.

The playwrights use a fictional retro-Nobel to set the proceeding of play in action in the time frame of 2000. The retro-Nobel committee is a prop that Djerassi and Hoffmann employ to weave the action around the plot. The proceedings of the committee enable the readers to discover the truth about the discovery of oxygen.

The royal invitation from the Royal Court of Sweden is a prop that highlights the authority of the monarch over scientific issues. The monarch, King Gustav III, orders the "savants" to perform their experiments in front of the royal court to assert their claim on the discovery of the new air. The invitation symbolises the authority of a sovereign over matters of science.

The playwrights employ the performance of a play within the plot of *Oxygen* as a prop to communicate the finer details of the discovery of oxygen. We see the use of a play within the play by Antoine Lavoisier and Mme Lavoisier. While the stated purpose of the play is entertainment, the intended purpose put across their version of the discovery of oxygen, thereby

refuting the claims of Scheele and Priestley. The Lavoisiers, in a dramatic fashion, enact the discovery of oxygen, thereby performing science on stage. The Court Theatre at Drottningholm is recreated on the stage for this purpose, thus, depicting a stage on stage. Such an enactment converts a stage into a laboratory and a laboratory into a stage.

Scheele uses burning lenses for his experiments to produce his "eldsluft" or fire-air. He also laments the lack of better lenses of the quality to which Lavoisier has access to. The performance of the experiment on stage adheres to the science on stage strategy of Kirsten Shepherd-Barr. Additionally, Scheele's lament highlights access to infrastructure and funding as limiting factors in scientific research.

Another set of documents that act as a prop in the play are the drawings of Lavoisier's equipment. Mme Lavoisier shares the drawings of the equipment used by Lavoisier with Priestley. These drawings depict the contribution of Mme Lavoisier to record scientific activity undertaken by her chemist husband. Later, in the eighth scene, we see Mme Lavoisier showcase a sketch of the experiments performed by Lavoisier. The drawings point to the unattributed contributions of various women towards scientific advancement.

The slides made by Bengt Hjalmarsson is another documentary evidence used in the play. In the time setting of 2000, Hjalmarsson presents slides made from the material gathered from the archives at the French Academy of Sciences. These slides highlight the role of archives in documenting the history of science. As a scenographic prop, the slides highlight the importance of synergy between the two cultures.

In the eighth scene, when the scientists are performing the experiment on stage, we see the use of a balance, a time piece, a suit of rubber and a mouse. These props showcase the experimental nature and quantitative analysis of the experiments performed, and add to the idea of performing science on stage.

In the tenth scene, we see a book titled *Histoire des Theatre*, which is in fact a travelling chest disguised as a book that belonged to Mme Lavoisier. As a prop, it symbolises the idea of the truth of science being hidden in a book of history, hinting at more cooperation between the two cultures and the relevance of archival history.

The eleventh scene shows the use of two masks by Sune and Ulf. (106) These masks represent the metaphorical masks worn by scientists as mentioned by Ulf and complement the real masks worn by Lavoisier and Mme Lavoisier in the masque, in the previous scene.

Within the realm of theatre, the seamless integration of theatrical properties, stage setting, and costumes holds transformative power. As explored in this chapter, these elements serve as vital tools for portraying themes, creating immersive environments and capturing the essence of characters and their contexts. The utilization of technical details at the onset of the play establishes a laboratory-like atmosphere, allowing the audience to witness the inner workings of scientific discovery. Costumes, with their ability to transport both performers and audience to different time periods, infuse the play with visual richness and historical credibility. By donning period-specific attire, the actors evoke a vivid visual experience, fostering a deeper connection between the audience and the characters they inhabit. Books, letters, and documents play integral roles in *Oxygen*, representing the quest for scientific recognition, ethical dilemmas and historical context. These props contribute to a layered examination of the interplay between scientific pursuit, societal structures and individual morality. In conclusion, *Oxygen* exemplifies the transformative potential of theatrical elements in shaping narratives, exploring themes, and immersing audiences in thought-provoking experiences. The masterful integration of theatrical properties, stage setting, and costumes elevates the play, allowing them to transcend the confines of the stage and ignite conversations about science, ethics and the human condition.

The use of theatre scenography, stage setting, costumes and lighting aids the playwright to effectively convey the message to the audience. The art of theatre encompasses a wide range of elements that work together harmoniously to captivate and engage the audience. Among these elements, theatre scenography, stage setting, costumes, and lighting stand out as powerful tools that aid playwrights in effectively conveying their messages to the audience. Through careful consideration and deliberate choices, these visual and atmospheric elements enhance the theatrical experience, shaping the narrative, setting the mood, and inviting the audience to immerse themselves in the world of the play. This chapter explores the implementation of theatre scenography and its various components in Shelagh Stephenson's *An Experiment with an Air Pump*. Stephenson's play begins with a striking prologue, reminiscent of Joseph Wright of Derby's renowned painting, "An Experiment on a Bird in the Air Pump." The inclusion of this painting as a prop on the stage creates a profound connection between the artwork and the scientific themes explored in the play. Lighting, a fundamental aspect of theatre scenography, establishes the mood and enhances the overall impact of the play. Through skilful lighting design, the audience is guided through the narrative and encouraged to contemplate the interplay between the artistic and scientific cultures. One of the most captivating visual spectacles within the play is the performance of the "bird in an air pump" experiment, which mirrors the historical practices of travelling science performers. The chapter will discuss the inclusion of props such as stuffed birds, hanging animals, and reptiles which further contribute to the historical accuracy, evoking a forgotten era in the development of science. Costumes and makeup, working subtly on the audience's subconscious, bring authenticity to the setting and time period of the play. The house depicted in the play holds significant importance, as it serves as a bridge between two time periods and acts as the setting for the exploration of science and

ethics. Through the careful integration of theatre scenography, stage setting, costumes, and lighting, Stephenson's play presents a visually engaging and thought-provoking experience.

The prologue of the play portrays the entire cast, except Susannah/Ellen on a revolving tableau. Such a depiction mirrors the painting *An Experiment on a Bird in the Air Pump* by Joseph Wright of Derby. Wright's acclaimed artwork forms the basis of the play. The depiction of the painting on the stage as a prop enables the audience to connect the artwork to the science play. The instructions from the playwright for chiaroscuro lighting set the mood of the play. Towards the end of the play, we see a direction from the playwright to change the lighting to give a chiaroscuro effect, as at the beginning of the play. This effect also signals the completion of the play and the action in the plot coming full circle. The painting and its inclusion in the play is an encouraging example of the interplay between the two cultures.

On the stage, we see a live bird fluttering in a glass dome, just like the one portrayed in the painting, mirroring the ethical questions raised by the painting. The performance of the "bird in an air pump" experiment alludes to the performance of such experiments by travelling science performers who would carry the equipment with them and perform such experiments across the country. These travelling performers were precursors to scientists and their experiments were more of a visual spectacle than a controlled and elaborate scientific tests. The same visual spectacle is recreated on the stage by Shelagh Stephenson's play using a live bird and a glass dome as scenographic props. The prologue also establishes the idea that the experiment will be performed on the stage, thereby converting the stage to a laboratory and portraying the lab on a stage. The props on stage like stuffed birds, hanging animals and reptiles, mentioned at the beginning of the first scene, add to the portrayal of the same. These props stay true to the history of science and portray a unique stage in the development of science that is often forgotten.

To provide veracity to the setting of the play in 1799, the playwright incorporates items like a corset, wig and fan in the costumes. Stephenson's instructions regarding the costumes and make up aim at creating a visual aesthetic that is believably from the turn of the eighteenth century. While props are visual cues that establish themselves consciously in the play, costumes and make up are visual cues that work on the audience's subconscious.

The first scene contains a small performance that Harriet, Maria and Isobel prepare. For the performance, Harriet is dressed as Britannia, Maria as a shepherd and Isobel as a sheep. Harriet describes her "play" as a "hymn to progress" (14). This play within a play acts a prop on the stage to guide the audience and the readers to the ongoing discussion in the play, which is, the development of science and the advancement in technology in relation to nature and our surroundings.

The house portrayed in the play is itself an important point of discussion. The play's setting of both the time periods in the same house plays a pivotal role in the plot as it bridges the two time periods. The setting alerts the reader of the playwright's intended connection of the two time periods. The house also acts as the setting where questions of science and ethics are raised in both the time frames.

Shelagh Stephenson's play employs theatre scenography, stage setting, costumes, and lighting to effectively convey its message to the audience. The inclusion of Joseph Wright of Derby's painting, "An Experiment on a Bird in the Air Pump," as a prop on the stage creates a connection between the artwork and the scientific themes explored in the play. The use of chiaroscuro lighting enhances the mood and signifies the completion of the play, while also highlighting the interplay between the artistic and scientific cultures. The portrayal of a live bird fluttering in a glass dome raises ethical questions and pays homage to the historical practice of performing such experiments as visual spectacles. The incorporation of props like stuffed birds and hanging animals further contributes to the historical accuracy and portrayal

of a unique stage in the development of science. The costumes and makeup in the play add authenticity to the setting, visually conveying the period to the audience. The house as a prop bridges the two time periods, raising questions of science and ethics in both contexts. Thus, through the careful integration of scenography, stage setting, costumes, and lighting, Stephenson creates a visually engaging and thought-provoking experience, stimulating discussions on the development of science, ethics, and the relationship between art and science.

Copenhagen

Frayn's *Copenhagen* delves into the extraordinary meeting between two renowned physicists, Niels Bohr and Werner Heisenberg, against the backdrop of Nazi-occupied Denmark. Through its unique storytelling approach and minimalist theatrical elements, the play explores the intricacies of scientific discovery, personal relationships and the profound impact of choices made in tumultuous times. Set during a crucial period in history, *Copenhagen* immerses the audience and readers in a meeting of minds that unfolds without explicit scenographic information or the use of props. Frayn's deliberate departure from traditional stage instructions sets the stage for an intellectually stimulating and emotionally charged exploration of the clash between scientific pursuits and personal loyalties. This chapter examines how Frayn incorporates elements from minimalist theatre, simplifying various aspects of the play while emphasizing the pivotal shifts in conversation and the absence of a fixed narrator. These unique features not only propel the plot forward but also offer a rich canvas for directors to experiment with scenographic interpretations, granting them unparalleled freedom to create visually striking and conceptually profound productions. By navigating the interplay between uncertainty, memory, and moral responsibility, *Copenhagen* raises profound questions about the nature of scientific inquiry, the complexities of human relationships, and the lasting impact of pivotal historical moments. Frayn's masterful crafting

of the narrative invites audiences to contemplate the inherent tension between truth and perception, and the profound implications of our choices in the face of uncertainty.

The play is unique for setting and it begins abruptly without any scenographic information. Throughout the play there is not much to decipher in terms of scenography and there are no props used. The playwright provides the readers with no cues regarding the setting of the scene. Such a beginning unnerves the readers and instils a feeling of estrangement as Frayn incorporates elements from minimalist theatre into this science play. According to the dictums of minimalist theatre, Frayn attempts to simplify various segments of the play and remove all seemingly unnecessary scenographic details.

The readers come across frequent shifts in conversation and abrupt changes in the point of view. As there is no fixed narrator, the plot progresses with these shifts in conversations. At the beginning of the first act we see this conversation between Bohr and Margrethe interjected by Heisenberg's monologue, addressing the audience, and thereby, breaking the fourth wall.

> MARGRETHE. So why did he do it? Now no one can be hurt, now no one can be betrayed.
>
> BOHR. I doubt if he ever really knew himself.
>
> MARGRETHE. And he wasn't a friend. Not after that visit. That was the end of the famous friendship between Niels Bohr and Werner Heisenberg.
>
> HEISENBERG. Now we're all dead and gone, yes, and there are only two things the world remembers about me. One is uncertainty principle, and the other is my mysterious visit to Neils Bohr in Copenhagen in 1941. Everyone understands uncertainty. Or thinks he does. No one understands my trip to Copenhagen. Time and time again I've explained it. To Bohr himself, and Margrethe. To interrogators and intelligence officers, to journalists and historians. The more I've explained, the deeper the uncertainty has

become. Well, I shall be happy to make one more attempt. Now we're are dead and gone. Now no one can be hurt, now no one can be betrayed.

MARGRETHE. I never really liked him, you know. Perhaps I can say that to you now. (4)

These abrupt shifts occur frequently in the play and also convey information related to the plot in a play devoid of stage instruction or a narrator. We see another important example of such an interjection which is addressed to the audience when Margrethe interrupts the dialogue between Bohr and Heisenberg.

HEISENBERG. I've been anxious about you.

BOHR. Kind of you. No call for sleepless nights in Leipzig so far, though.

MARGRETHE. Another silence. He's done his duty. Now he can begin to steer the conversation round to pleasanter subjects.

HEISENBERG. Are you still sailing? (15)

In such a minimalist play, interjections and breaks equip the playwright to control the pace and delivery of the plot. At the same time, it allows a theatre director more scenographic freedom to stage the play in any manner they like. With minimum scenographic instructions from the playwright, the directors have more freedom for scenographic experimentation.

Copenhagen captivates audiences with its unique storytelling approach and minimalist theatrical elements. The play unfolds as a meeting between Bohr, Heisenberg, and Margrethe Bohr, without explicit scenographic information or the use of props. Frayn's deliberate omission of detailed scenography from the play's beginning evokes a sense of estrangement and unnerves readers, setting the stage for a thought-provoking exploration of scientific and personal dynamics. Drawing inspiration from minimalist theatre, the playwright simplifies the play's segments and removes seemingly unnecessary scenographic details, adhering to the dictums of this theatrical style. The frequent shifts in conversation and abrupt changes in point

of view contribute to the play's narrative progression. With no fixed narrator, the plot advances through these shifts, providing insights into the characters' perspectives and relationships. These interjections and breaks not only control the pace and delivery of the plot but also offer theatre directors ample scenographic freedom. *Copenhagen* exemplifies Frayn's skilful use of minimalist theatre elements to create a compelling and introspective drama. The absence of detailed scenography and props, coupled with shifts in conversation and direct audience addresses, heightens the audience's engagement while offering directors an opportunity for imaginative scenographic exploration.

Inherit the Wind

Jerome Lawrence and Robert E Lee's *Inherit the Wind* dramatizes the clash between religion and science. Set primarily in and around the Hillsboro Courthouse, the play unfolds as a fast-paced courtroom drama with intense and dynamic dialogues. Stage instructions play a vital role in setting the tone for the courtroom drama. The detailed descriptions of the characters' costumes serve as a form of visual communication to the audience, enriching the overall performance. Additionally, various books feature as props within the play symbolizing the clash of authorities. The chapter discusses the use of banners by the townspeople as a powerful theatrical device employed by the playwrights. This chapter will look into Lawrence and Lee's skilful utilisation of stage instructions and props to amplify the dramatic conflict between religion and science.

The action in the play takes place in and around the Hillsboro Courthouse. It is a courtroom drama with fast paced to and fro dialogues. The playwrights provide a detailed description of the courtroom setting and insist on inclusion of "the town" in the setting. Part of the instructions reads, "It is important to the concept of the play that the town is visible always,

looming there, as much on trial as the individual defendant" (3). Such stage instructions provide thick description to the text and assist in setting the tone for the courtroom drama.

The readers also come across instructions from the playwrights regarding the characters' costumes. Describing a young boy, the stage instructions read, "Howard, a boy of thirteen, wanders onto the courthouse lawn. He is barefoot, wearing a pair of his pa's cut-down overalls. He carries an impoverished fishing pole and a tin can" (3). As discussed in the previous sections, costumes play an important scenographic role in the performance of the play, as it is employs visual communication to transmit information to the audience.

A number of books feature as props in the play. The accused Bertram Cates mentions Hunter's *Civic Biology* as the book from which he taught in the class. It is his teachings about evolution that land him in in jail because of the litigation with the state. Justifying his actions to his close friend Rachel, Cates asserts,

> You know why I did it. I had the book in my hand, Hunter's *Civic Biology*. I opened it up, and read my sophomore science class Chapter 17, Darwin's *Origin of Species*. (Rachel starts to protest) All it says is that man wasn't stuck here like a geranium in a flower pot; that living comes from a long miracle, it didn't just happen in seven days. (8)

Other than *Civic Biology* and *Origin of Species*, the other book that is mentioned multiple times in the text is *The Bible*, particularly the "Book of Genesis". These two sets of books represent two separate and contradictory authoritative points of view on the topic of evolution. The conflict between the authorities of these books plays out during the trial where both sides base their arguments on these books. The use of books as props is in line with the strategy of other playwrights like Maharishi and Brecht, who have been discussed in the previous sections.

In two instances, we see the use of banners by the townspeople of Hillsboro to voice their opinion on the matter. At the beginning of the first scene, the workmen hoist a banner

above the crowd that reads "Read your Bible" (13). Later, the crowd takes the form of a parade in which many are holding banners. One such banner reads,

> ARE YOU A MAN OR A MONKEY?
>
> AMEND THE CONSTITUTION – PROHIBIT DARWIN
>
> SAVE OUR SCHOOLS FROM SINS
>
> MY ANCESTORS AIN'T APES!
>
> WELCOME MATTHEW HARRISON BRADY
>
> DOWN WITH DARWIN
>
> BE A SWEET ANGEL
>
> DON'T MONKEY WITH OUR SCHOOLS!
>
> DARWIN IS WRONG
>
> DOWN WITH EVOLUTION
>
> SWEETHEART COME UNTO THE LORD (18)

These banners reflect the opinion of the townspeople on the issue of evolution. At the heart of the conflict in the play is the evolution versus creation debate and the playwrights employ banners as props to convey the views of the townspeople on the topic. Such an approach, that is, "to show and not to tell" is highly recommended by the critic Shepherd-Barr.

Contrasting the authority of evidence of religious literature, Henry Drummond, the defence attorney presents in courtroom the fossil remains of a pre-historic creature as evidence. However, the judge disallows the fossil as evidence. Using the fossil as a prop, the playwrights contrast the authority of a scientific evidence with that of a religious text. The judge prefers to rely on the religious text, than take into consideration scientific evidence. This prop embodies the clash between religion and science, which is the central theme of the play.

Inherit the Wind masterfully dramatizes the conflict between religion and science. Through their explicit use of props and stage instructions, the playwrights effectively convey

the clash between these two opposing worldviews on the issue of human evolution. The setting of the play, the Hillsboro Courthouse, serves as the backdrop for the courtroom drama. The detailed description of the courtroom and the insistence on including "the town" as a visible presence emphasize the idea that both the individual defendant and the entire community are on trial. Costumes and props play a significant role in the performance. The instructions regarding characters' costumes, such as the impoverished attire of young Howard, enhance the visual communication to the audience. Regarding the importance of costumes in Scenography, Michelle Liu Carriger, in *The Routledge Companion to Scenography* (2018) opines:

> Costume is the element of the theatre that integrates the performer into the scenography; it constitutes the margin between the performer's body and all the other material factors that make up the performance. As such, costume occupies a complicated position – is a costume part of the actor or the character or the material context of the performance? In the theatre, costumes perform many functions: they establish facts about the character, participate in and communicate the overall production scheme, they must function well no matter what the actors do while wearing them, and they provide visual appeal, calibrated to interest the viewer. (42)

Additionally, the prominent books used as props, including Hunter's *Civic Biology* and *The Bible*, represent conflicting authoritative sources on the topic of evolution. These books become the basis for arguments presented during the trial, illustrating the clash of authorities. Banners held by the townspeople further amplify their opinions on the matter. The banners provide a vivid representation of the public sentiment regarding evolution, demonstrating the use of visual props to convey the viewpoints of the community. Furthermore, the contrast between the authority of religious literature and scientific evidence is exemplified through the presentation of a fossil as evidence in the courtroom. Overall, Lawrence and Lee skilfully

employ stage instructions and props in *Inherit the Wind* to underscore the dramatic clash between religion and science.

Conclusion

The thespian art is a multifaceted form of expression that utilises various elements to convey themes and messages to the audience. Among these elements, stage instructions, props and costumes play significant roles in enhancing the theatrical experience and communicating complex ideas. This chapter portrays the profound impact of these theatrical elements in selected plays. Kipphardt's *In the Matter of J Robert Oppenheimer* utilises props, costumes, and documentary elements to recreate the trial and ethical dilemma faced by the American physicist. The play incorporates evidentiary materials such as letters, interviews, and government reports to construct the plot. Symbolism is employed through the imagery of stars and stripes, military uniforms, and the atomic and hydrogen bombs, reflecting Oppenheimer's inner turmoil. The trial serves as a prop to explore the ethical allegiance of a scientist to their nation. Various reports, files, and documents are used as props to convey information and shape the plot. Projectors and projected texts enhance the theatrical experience, condensing the extensive committee proceedings and emphasizing the gravity of the situation. The play's use of props and documentary elements provides an authentic portrayal of Oppenheimer's trial and invites reflection on the interplay between science, politics, and personal convictions. Brecht's *Life of Galileo* effectively employs props to convey scientific concepts, challenge norms, and symbolize broader themes. These props include a wooden model of the Ptolemaic system, an iron washstand, an apple, a telescope, a compass, a proving stone, and a manuscript. Each prop carries symbolic meaning, representing the clash between traditional beliefs and emerging scientific ideas. The props enhance the audience's understanding of complex scientific

concepts, and visual aids like drawing on a board and the carnival procession further enrich the experience. Maharishi's *Einstein* features multiple props that enhance communication and engage the audience. Musical pieces, chairs, books, scientific instruments, cyclorama, compass, light, sound, a list of scientists, a fake eye, a whistle, and an apple are employed to convey deeper meanings and symbolize themes. These props serve as powerful tools in storytelling, evoking emotions and highlighting the interplay between science, knowledge, and societal dynamics. By skilfully integrating these props, the play immerses the audience in a thought-provoking theatrical experience, showcasing the transformative power of theatrical elements in conveying scientific concepts and stimulating intellectual engagement.

Oxygen showcases the significance of theatrical properties, stage setting, and costumes in conveying themes within a play. The stage setting creates a laboratory-like atmosphere, immersing the audience in the world of scientific discovery. Period-specific costumes transport viewers to distinct time periods, evoking authenticity and deepening their connection with the characters. The use of books, letters, and documents as props serves as powerful symbols and catalysts for pivotal moments, exploring the intertwining relationship between science and ethics. Stephenson's *An Experiment with an Air Pump* highlights the use of theatre scenography, stage setting, costumes, and lighting to effectively convey its message to the audience. The inclusion of Joseph Wright of Derby's painting as a prop creates a connection between art and science. Chiaroscuro lighting sets the mood and signifies the completion of the play. The portrayal of a live bird in a glass dome and other props evoke historical practices of science performances. Costumes and makeup add authenticity, while the house as a prop bridges two time periods and raises ethical questions. Through these elements, Stephenson creates a visually engaging and thought-provoking experience, exploring the development of science and the interplay between art and science. *Copenhagen* captivates audiences through its unique storytelling approach and minimalist theatrical elements. The absence of explicit

scenography and props in the play creates a sense of estrangement and engages viewers in a thought-provoking exploration of scientific and personal dynamics. The frequent shifts in conversation and direct addresses to the audience contribute to the play's immersive nature and offer directors ample freedom for creative staging techniques. Frayn's skilful use of minimalist theatre elements creates a compelling and introspective drama, inviting audiences to contemplate the complexities of scientific inquiry and human relationships. *Inherit the Wind* masterfully dramatizes the conflict between religion and science through its intricate stage instructions and use of props. The setting of the play, the Hillsboro Courthouse, serves as the backdrop for the courtroom drama, emphasizing the larger societal implications of the clash between these opposing forces. Costumes and props, such as books representing conflicting authoritative sources, further illustrate the clash of authorities and highlight the central theme of the play. Banners held by the townspeople provide a vivid representation of public sentiment, effectively conveying the viewpoints of the community. The disallowed use of a fossil as evidence symbolizes the fundamental clash between religion and science, underscoring the play's exploration of intellectual freedom and societal struggle.

Through the examination of these plays, it becomes evident that theatrical elements play a crucial role in conveying themes and messages to the audience. The integration of stage instructions, props, and costumes creates immersive worlds, underscores central conflicts, and explores complex ideas. These theatrical elements heighten the dramatic experience, leaving a lasting impression on the audience and facilitating a deeper understanding of the profound themes within each play.

Chapter 4: Portrayal of Women Scientists in Science Plays by Female Playwrights

Introduction

In the field of science plays, several plays portray the lives of scientists. There are seven plays selected for this thesis, out of which five revolve around the personal and professional lives of scientists. There is a noticeable lack of representation of women scientists' lives in this selection of plays as well as in the field of science theatre. To remedy this, three additional texts were added. In these three texts, the playwrights represent the condition of women scientists and the problems they face in their respective fields. The three plays are Lauren Gunderson's *Silent Sky* (2015) and *Emilie* (2019), and Annie Ziegler's *Photograph 51* (2015). These three contemporary plays by female playwrights provide an opportunity to assess the position of women in the sciences as portrayed by women playwrights. The chapter will explore the working conditions of women in laboratories and scientific establishments. It will look at the treatment of women in science at the hands of their male colleagues, the lack of opportunities for women, the inherent sexism, and blatant misogyny in sciences. This chapter will undertake a textual analysis of the three plays to read into the stories of the struggle of the women scientists who endured male gatekeeping and patriarchal attitudes in different fields of scientific exploration.

Lauren Gunderson's *Emilie* (2019)

Lauren Gunderson's *Emilie* portrays the life, struggles and achievements of Emilie Du Chatelet, who was an advocate of Leibniz's squaring of force and translated Newton's

Principia to French. Gunderson has written over twenty plays, and her work primarily focuses on the representation of women in science and history. Emilie Du Chatelet's amorous relationship with the French Enlightenment philosopher and writer Voltaire often overshadows her life and works. Her work inspired the scientists of the following generations and her conceptualisation of energy as proportional to mv^2 inspired Einstein's E=mc^2. With this play, Gunderson aims to focus on the life, work and contributions of one of the most prominent scientists and philosophers of her time. The play is set in the eighteenth century and begins by introducing Emilie, who is dead and is reliving the crucial moments in her life.

Gunderson begins by portraying the condition of women in the field of science, the paucity of opportunities available to them, and the hurdles they face. In the eighteenth century, there were no opportunities for women to learn and do science formally. They were excluded from all the institutions of scientific learning and scientific practice. In the first act of the play, Emilie asserts, "But I want to go where science is done – which is not in courts or academies, but in the Café Gradot – an all-male, all-night establishment wherein my sex is restricted to various services unbecoming of my class. And my patience" (10). She goes on to state, "Women determine the fate of great nations, of the human race itself, but for us there is no place where we are trained to think, much less to think for ourselves. And if we insist, we are mocked, scorned – The men of letters laugh, the men of town frown" (10). These early dialogues set the tone for the play's portrayal of the treatment that Emilie was at the receiving end by her male contemporaries. Later in the act, Voltaire and Emilie discuss submitting her work to the Paris Academy of Sciences, and he states, "Listen to me. You think The Academy would ever ever give this prize to a woman? If you want to do this work, you've got to do it with me. You're nothing to them. A rich courtier with no reputation except as a card shark and a…tramp. Who are they going to validate, you or me?" (48). This exchange highlights the plight of women who wanted to take up science as a career. There were no avenues for

education, training or research. If someone managed to get through all the hurdles and still be good at science, she would be mocked and denigrated. Gunderson portrays the plight of female practitioners of science aptly.

Despite the hardships and the lack of opportunities, if women do take up science, they are reduced to their sex. A poet, whom Emilie meets at a dinner, compliments her, "If I may say, your work elucidating the great thinkers of our age is a monument to your sex and country" (79). The sexism is evident even in the compliments. When Voltaire and Emilie's work was published, it was a unique achievement as Emilie's work was published under her own name. Voltaire congratulates her and says, "You deserve it. You are a stunning woman. And an impressive man. Better than me…on occasion" (52). To this, Emilie replies, "I take the compliment. Then think, why is manliness the compliment? The mind, the earth, the stars, all of the things I care about are sexless" (52). This reply to Voltaire and the subsequent contemplation capture the thoughts of many women of the time who were reduced to their sex. Gupta et al. in the article "Triple Burden on Women in Science: A Cross Cultural Analysis", published in *Current Science,* say,

> Science professes the self-acclaimed ideal of 'universalism' and an irrelevance of personal or social attributes in judging scientific claims. However, in actual practice, science has been a male domain, and has a social structure dominated and hitherto regulated by men, in which, women find themselves unwelcome. This creates hidden barriers in the practice of science" (Gupta et al, 1383).

Voltaire reduces her accomplishment to being a "stunning woman", and for him, the idea of a compliment to a smart woman is telling her that she is an impressive man.

The few women who took up science as a profession had to follow the diktats of their male colleagues. Emilie's views on force vive and the subsequent altercation with the secretary of the Paris Academy of Science showcases the situation of women who choose to go against

the norms of the day. The second act begins with Voltaire announcing the publication of Emilie's book and he states, "The scene in which a science text, by a woman, captivates the thinking world" (57). The book titled *Foundations of Physics* covers three major problems being faced by eighteenth-century natural physics. After publishing the book, she was invited to be a member of the Academy of Sciences of the Institute of Bologna. The book talks about the principles of Rene Descartes, Isaac Newton and Gottfried Wilhelm Leibniz. Her concepts of space and time are more in line with the modern understanding of these concepts. Voltaire thinks Emilie has insulted the secretary of the Academy by denouncing the position taken by the secretary on force vive. Describing the concept of force vive, Lauren Gunderson writes,

> *Force Vive* (F=mv^2) is a scientific concept that was hotly debated in the 17th and 18th centuries. Proposed by Gottfried Leibniz over the period 1676–1689, the theory was controversial as it seemed to oppose the theory (F=mv) advocated by Sir Isaac Newton. In Leibniz's view, Newton's equation was incorrect because it eventually becomes zero, meaning that the force stops and is "dead." Newton explained that God would come along and add more energy. Leibniz's squaring of velocity meant that energy keeps going and doesn't need outside replenishment of energy; i.e. it was "alive". During the French debates on the subject, Newton's equation became known as "Force Morte," while Leibniz's equation was called "Force Vive". However, Leibniz's theory was not clearly explicated and lacked a detailed experimental finding. By advocating for Leibniz's squaring of Force, Emilie Du Châtelet translated Leibniz's idea in a way that was easily understood and added the decisive evidence of a Dutch researcher. Today, due in part to Du Châtelet's work, we understand that the two equations are describing different things—Newton's equation describes the Conservation of Momentum (F=ma – Force equal Mass times Acceleration), while Leibniz's equation

became what is understood as Kinetic Energy (E=mv2) – Energy equals Mass times Velocity squared)" (3).

Emilie thinks that the secretary is an idiot, but Voltaire reminds her that he is very powerful. The secretary writes to Emilie, saying, "Though you somehow found yourself published on the topic of Force Vive, you rush to judgement like any woman confronted with ideas beyond her skill. My dear you simply did not understand my mathematics disproving Force Vive". He asserts, "Newton is right, Leibniz is wrong, and you, my dear, are out of your element. In the end, all you need to do, Madam, is to read, and reread, and perhaps you could bring us something worth our time" (58-59). To this, Emilie replies, "I am sorry to play the mother to your wandering child, but it is, after all, the instinct of my sex to correct a failure in order to educate". She goes on to say, "On the point of my mathematical skills, I attached complete solutions to all aforementioned problems. I can walk you through the difficult bits" (59). The interaction between Emilie and the secretary showcases the problematic situation of women in academia in Emilie's time and even after that. Even today, acts of misogyny and discrimination against women are not unheard of in academia.

Women in science who achieve success are often denounced or degraded by their peers for fear of ostracization by the male-dominated academia. Voltaire writes a letter to the Academy refuting Emilie's work. Voltaire accuses her of rejecting Newton and she accuses him of backstabbing her. This brings the duo to a breaking point and Emilie states, "Next time, let me know when you trash my work in public. I'd be happy to correct your manuscript before you embarrass yourself. You misspelled 'Leibniz'. Twelve times." (64) Voltaire's betrayal fuels Emilie to get down to translate Newton's work into French.

EMILIE. Force Vive belongs in Newton's universe and I'm gonna put it there.

VOLTAIRE. You can't just do that!

EMILIE. I'll work on the cosmos; you focus on your pants.

VOLTAIRE. Don't throw that around. I don't deserve that.

EMILIE. What do you deserve then, a dirge for your manliness. I deserve better than this insult to everything I was for you. (66)

Emilie finds out that Voltaire is having an illicit relationship with his niece. She is distraught and feels he has betrayed her again. In his defence, Voltaire simply says that he is a man. She kicks him out of her house. The relationship between Voltaire and Emilie started souring after the publication of Emilie's book and her insistence on inclusion into the French Academy of Science. As a woman practitioner of science, her peers repudiated her.

As a daughter, Emilie faced the burdens of the patriarchal society but chose to carve a path for her own despite all hostilities. The playwright portrays Emilie's interactions with her mother. Emilie recalls her mother's words to her, "A girl does not slouch, does not speak in excess, or laugh loudly attracting negative attention. Do not look your betters in the eye. Do not read in public." (74) Emilie retorts against the parochial notions of women's behaviour and says, "Then what's the point? The world is bigger than this!" To this, her mother replies, "Not for you. So follow the damn rules. Everything's easier. And easy makes us happy." (74) Emilie fought against the patriarchal ideas and structures within her family but wished a different kind of life for her daughter.

During her life, Emilie makes multiple courageous decisions but wishes for a comfortable life for her daughter. However, her daughter reminds her of the value of the ability to choose. She ruminates in her loneliness, "Study not only affords women a chance at the glory denied them in so many other pursuits – but you study alone. And who else do you have? Candles and quills and…Newton" (71). Ironically, while thinking of her daughter, Emilie ponders, "She is all woman, and will have a much easier life for it. She is loyal, demure and…entertainable. She is marrying a prince today" (52). The following conversation ensues:

SOUBRETTE. I wanted to be like you. I still do.

EMILIE. No you don't. your life will be much better than mine. Marrying royalty makes you –

SOUBRETTE. Just another wife.

EMILIE. No. It makes you queen. And everyone wants to be queen.

SOUBRETTE. No. Everyone wants to choose to be queen. Why don't I get a choice?

EMILIE. Because you don't need one.

SOUBRETTE. You got one.

EMILIE. I'm an exception. And being exceptional is exhausting. You don't want that. (53)

Here, Gunderson highlights the importance of being able to choose. A choice is a powerful weapon and not just a privilege. Emilie's daughter further asserts, "You chose books over me. I want a choice. Your choice." (54) She goes on to state:

> A chance. You got one. And you could've given me mine. Instead. You gave me what every other kept woman would have given her stupid daughter. Instead of what you know, here's what I know…A girl does not slouch. Does not speak in excess. Does not question or laugh loudly. She marries rich. She obeys. She submits. (55)

Her daughter's words make Emilie introspect, thinking, "And I see what I missed: myself in her. What have I done? What any thoughtless man would do. I assumed…and missed a woman of my own…element. I'm sorry. I am so sorry (55). Emilie chose to fight the patriarchal society and make a place for herself in the scientific community. Her choice resulted in a difficult life for her. However, as a mother, she wanted an easy and comfortable life for her daughter.

Having dedicated her life to an uphill battle against patriarchy and to establish herself in the field of science, she dies a painful death during childbirth. In the later part of the scene, Emilie laments, "There must be a trigger in women that sways us to forget the bruises of certain activities like childbirth, men, and other dangerous sports. It's either madness or martyrdom

or…hope" (84). Towards the end of the play, the poet exclaims, "The work, the woman lives hundreds of years on" (98). Gunderson's play paints the picture of a strong and resilient woman who fought for her righteous place in the field of science and got it. Emilie's grit and dedication outshone the ability of her peers to restrict her, and eventually, she did achieve recognition for her work. Today, her contribution to the field is well-recorded and respected among scholars, and Gunderson's play disseminates the same to broader audiences around the world.

Anna Zeigler's *Photograph 51* (2015)

Anna Zeigler's *Photograph 51* portrays the life of Rosalind Franklin and the discovery of the double helix structure of DNA. Zeigler is an award-winning American playwright who has written plays such as *Actually* (2017), *Boy* (2015) and *The Minotaur* (2018) among others. *Photograph 51* is Zeigler's magnum opus which portrays the travails of the life and career of Rosalind depicting the most important discovery of her life. In the author's note, Zeigler states that though the play is based on the story of the race to the discovery of the double helix, it is still a work of fiction based on Rosalind's life. The play represents the events that took place in England between 1951 and 1953.

Male gatekeeping begins at home and we see an example in the opening dialogues of the play where Rosalind states, "This was the world, a map of rivers and mountain ranges in endless repetition. And when I told my father I wanted to become a scientist, he said, 'Ah. I see.'…Then he said 'No.'" (1) This familial gatekeeping was also observed in Stephenson's *An Experiment with an Air Pump* and discussed in the first chapter. The male gatekeeping at the family level paves the way for academic gatekeeping.

Zeigler portrays the prevalent sexist attitude amongst scientists. Maurice Wilkins assumes Rosalind's subservience when she joins King's College, but she is under the impression that she will be heading her own work. Wilkins informs her that there have been

some changes in circumstances. To this, she replies, "Dr Wilkins, I will not be anyone's assistant" (3). They both agree to work together as partners, but this lays the foundation for the central problem of the plot. Wilkins questions Rosalind's absence from England during the war to which she replies, "Maybe you're aware of the fact that not a single female scientist from Britain was given a research position during wartime?" (5) This highlights the relative position of women scientists during periods of turmoil. During the war, Wilkins was working on the Manhattan project and he takes a jab at Rosalind by saying that even if she were offered to join the project, she would not have taken it as "at any rate, you lot never do seem to approve of it" (5). "You lot" here is a reference to Rosalind being a Jew. At the end of their talk, Wilkins quips, "All right, Rosy." To this she retorts, "My name is Rosalind. But you can call me Miss Franklin. Everyone else does." (6) Inherent sexism and subtle antisemitism are at display here. Talking to Gosling, Wilkins makes a sexist comment when he says "Kindness always works with women, Gosling. I'm a trifle concerned for you if you didn't know that." (22) Zeigler shows how the blatant display of sexist attitudes and male gatekeeping prevents women scientists from achieving their full potential.

Using the plot, Zeigler depicts male gatekeeping at work in academia. Rosalind wants to have lunch, but Wilkins walks off informing her that he eats in the senior common room and it is for men only. Rosalind shares her dismay with her assistant Ray Gosling who tells her she "can't worry about it". She replies, "I can worry over whatever I choose to worry over, Mr Gosling!" (7) To diffuse the situation, Gosling states that scientists don't have great conversations over lunch and they just talk about their work. Rosalind replies, "But those are precisely the conversations I need to have. Scientists make discoveries over lunch." (7) Yousaf and Shmiede, in their article titled "Barriers to women's representation in academic excellence and positions of power," argue,

> Nearly for half a century women's advancement in the workplace has been in a debate. Women's under-represented in higher education institutions and universities across the globe, and especially in the most powerful or influential posts, is well established. Despite gender equality commitments and women's educational attainment, still, they are underrepresented. Regions and countries may vary in term of culture, achievements and development, but barriers for women's representation in academia are surprisingly similar in many regions. It is found that there are several barriers which women might be experiencing in academia ranging from personal, organizational to societal. (1)

Later in the scene, Wilkins asks Rosalind to show him her work. He asserts, "We're partners, aren't we, Miss Franklin?" (21) Rosalind shares her findings with him.

Academic gatekeeping leads to undermining the academic efforts of women colleagues. Without any regard for Rosalind's hard work and research ethics, Wilkins presents Rosalind's work as his own. Rosalind responds calmly but sternly:

> Dr Wilkins, I was told – before I came to King's – that I would be in charge of X-ray diffraction. Given that, and given the credit you seem bent on grabbing all for yourself, when you deserve none of it, I would suggest, and would certainly prefer, if you went back to optics and your microscopes. (25)

Rosalind's finding that DNA exists in two forms is a big discovery. Don Caspar, another scientist states that this discovery will secure "her place in history" (26). Rosalind stands up to Wilkins and informs him that she will not collaborate with him as she does not "appreciate his desire to infringe on my[her] material" and she "will not have my [her] data interpreted for me [her]!" (27) Zeigler's play presents a case of a male scientist not just undermining but usurping a woman scientist's hard work and research.

The readers come across multiple instances of a mix of sexism and antisemitism in the play. The following conversation between the scientists is an apt example:

CRICK. She's really that bad?

WILKINS. Worse.

WATSON. The Jews really can be very ornery.

WILKINS. You're telling me.

WATSON. Is she quite overweight?

WILKINS. Why do you ask? (29)

This behaviour continues as Watson says, "I mean, she could possibly be attractive if she took even the mildest interest in her clothes. But appearances aside, she is not…engaging." He goes on, "When we shook hands, her handshake was far too firm. There's nothing gentle, nothing remotely tender about her. She's a cipher where a woman should be. That said, she's not fat" (31). In a 2021 article published in *Neuron,* Llorens et al posit:

> Though gender stereotypes are already strongly shaped in childhood, college or university study is a further bottleneck to gender equity. Even in their first year beyond high school, women are 1.5 times more likely than men to leave the STEM higher education pipeline. In more advanced university degrees and career stages, the women-to-men ratio progressively decreases, referred to as the ''scissors effect.'' In most countries, the point where the effect begins is at the start of the university years with equal numbers of women and men enrolled. The gap widens (like an open pair of scissors) by the end of the postdoctoral career stage. In the US, the gender gap continues to grow between the postdoctoral and associate professor years, with women transitioning to principal investigator positions at a 20% lower rate than men. (2050)

In a later confrontation, Wilkins states, "You know, you really are unspeakably difficult. I've never encountered a woman with such temerity." To this Rosalind replies, "Well perhaps it's that you haven't encountered very many women." (37) When Watson meets Rosalind, he informs her that Wilkins says that she is anti-helical and she replies that Wilkins has no business

telling who or what she is (40). Watson condescendingly quips, "There's too much to think about. You know there is. It overwhelms you. I can see that. So share your research with me. I mean, you're not going to get it on your own." On hearing this, Rosalind kicks him out of her lab (41). The playwright paints a picture of blatant sexism prevailing amongst some scientists.

The worst of misogyny and sexism is portrayed in the play when Watson resorts to name-calling and says, "She really is a right old hag, isn't she? I mean, the way she lunged at me. I really thought I might get hit" (42). Watson does not stop at this and proclaims, "She must be crazy" (43). Zeigler highlights the problems faced by women academicians when their male colleagues are jealous of their work and intellect, and simply do not consider them as their equals. The denigration, the name calling, sexism and fat shaming portray boys' locker room behaviour. Rida Fathima in a recent article titled "Invisible 'Locker Rooms' in Liberal Academic Institutions" asserts,

> Typical displays of camaraderie, the homo-erotic culture of men vouching for other men, no matter how abusive or wrong, the propensity of 'brotherhood' – all euphemisms for the lesser-known ugly cycles of misogyny that are often not talked about. Yet the harm this does is inversely proportionate in nature to the noise (or lack thereof) they make while engaging in these toxic patterns of masculinity.

When Rosalind and her young assistant Caspar get along well, the boys' locker room gets down to character assassination.

> CRICK. He's in love with her.
>
> WATSON. In love with who? No!!
>
> CRICK. Undeniably.
>
> WATSON. That's quite a theory, Francis. But do you have any proof?
>
> CRICK. That's not the way we work, now. Is it? (55)

Towards the end of the play, Caspar informs Rosalind that women aren't even allowed to enter Harvard's physics building. He implies that Rosalind should be grateful that the men are allowing her to work there.

The last part of the play depicts the last days of Rosalind's life where she laments the lack of time to finish her work. Crick says that had she been a man she might have had the time. Zeigler's play throws light at the inner working of laboratories and the work life of scientists. Both of these are usually neatly hidden away from the public eye. Thus, the problems such as sexism and misogyny that prevail in these circles evade inspection.

Lauren Gunderson's *Silent Sky* (2015)

Lauren Gunderson's *Silent Sky* tells the tale of the astronomer Henrietta Leavitt who worked at the Harvard College Observatory. Her ground-breaking work laid the foundation for future developments in the field. She developed the period-luminosity method to calculate the distance to faraway galaxies. The play showcases her life and work, and the hindrances she faced along the way. In the stage directions, Gunderson describes Henrietta as "a fiercely smart woman, curious, energetic, spilling over her own traditionalism." (9) The prominent part of the action in the play takes place in Harvard Observatory during 1900-1920.

Social order and societal norms limit the opportunities available to women, and they have to struggle hard to carve their own paths. In order to fund her career and education, Henrietta decides to use the dowry her father had saved for her marriage. Regarding her dowry, Margaret says, "This is your future, Henrietta. You know for certain that you'll never marry, you'll never fall in love – people do that. Uncoordinated, unplanned emotion – Just the word 'spinster', Henrietta please" (11). Henrietta replies that she wants to start her own life and wants to put her dowry money to better use. Margaret asks her to stay and take up a teaching job just like every other girl with her "temperament". To this, Henrietta replies, "I like my

temperament and I don't want it stuffed in a schoolhouse. I have questions, I have fundamental problems with the state of human knowledge! Who are we, why are we – where are we?" (11-12) It is this inquisitive nature and dedication that leads her to make her great discovery despite the social pressures.

Gunderson points towards the assistance and contributions of friends and family of scientists that go unrecognised. When Henrietta asks Margaret to come with her, she says that if one daughter leaves, then the other can't, as their father counts on her help. This points to the sacrifices made by not just women in science but also their close ones. It reminds us of the contributions of the wives of the three men of science depicted in the earlier timeline of the play *Oxygen* (2001), and the contributions of the family members of Dr Fenwick in *An Experiment with an Air Pump* (1998). The playwright hints at the unattributed contributions made towards scientific advancement.

Gunderson shows that in academia and scientific research, women and their work are often trivialised. They are not considered equals and are treated as secondary citizens. The second scene, set in the Harvard observatory, explores this central theme of the play. Peter Shaw, the head astronomer's apprentice, shows Henrietta her workplace.

> PETER. I am very aware. Quite a point of pride for us. But. This is the workroom for you girls…to work. In here.
>
> HENRIETTA. A short orientation then.
>
> PETER. We bring the Girls' Department photographic plates from the telescope –latest technology.
>
> HENRIETTA. Yes. Good. Question. Why all women?
>
> PETER. Oh. This is great. Pickering got fed up with the boys he was sent and said – really said this – that his housekeeper could do better. Now it's quite a women's… world… up here. (14)

Peter informs Henrietta that he will evaluate her work. Henrietta takes exception to this.

> HENRIETTA. Mr. Shaw, I also graduated summa cum laude, from Radcliffe, which is basically Harvard in skirts and lucky for us the university doesn't much care what you wear, so my expertise and yours might just complement each other's if we can get past this encroachingly unpleasant first impression. Or I could take this out and you could keep … orienting.
>
> PETER. Well. You'll fit right in the harem.
>
> HENRIETTA. The WHAT?
>
> PETER. Oh – no – nono – it's just a name – a joke – "Pickering's Harem." It's a compliment.
>
> HENRIETTA. If you are a concubine. (15)

The playwright portrays the prevalent attitude towards women and their work in these dialogues. Peter refers to Miss Fleming as "Scottish stock. Swift and angry" and about Miss Canon, says, "…don't get in her way, her name is Dickensian" (16). These examples highlight men's attitudes towards their colleagues in a leading astronomical observatory. In the article titled "Gender inequality in academia: Problems and solutions for women", Casad et al argue,

> Women faculty in STEM experience greater ostracism and incivility compared to male faculty in STEM. Further, women faculty in STEM report feeling more hostility, tension, and discomfort in their work environments compared to male faculty in STEM. Perceptions of chilly climate in academic departments predict lower job satisfaction and greater intentions to quit. (8)

Peter informs Henrietta that she will be paid twenty-five cents an hour which he describes as "good money for women's work" (17). Women do not find a space as equals in the observatory and casual sexism is the prevalent norm.

Women are restricted to particular roles in the observatory and are not allowed to fulfil their potential. They are not considered worthy enough to work as scientists in the observatory and their work is looked down upon. Henrietta wants to put her talent and skills to better use and asks if she will get to use the telescope. Peter says that she will be doing the work that she has been hired to do. Annie Canon refers to their work as "the pinnacle of the astronomical community" but Henrietta sees it as "bookkeeping the stars" (17). Annie devised the method of labelling stars with letters based on temperature and also gave birth to the phrase "Oh be a fine girl, kiss me" to remember the code OBAFGKM. Williamina was the first woman to hold the title of a curator in astronomy. Still, the group of women analysts is referred to as a harem. Williamina states, "We are dirt. From which mighty oaks grow." (19) Henrietta asks her two colleagues about working on their own ideas and they inform her that they don't do that. Williamina's assertion put things in perspective. She says, "I was Pickering's housekeeper before he brought me here. So we're a lot of things, but at present we are cleaning up the universe for the men. And making fun of them behind their backs." (20) Peter also calls them the "ladies of the logbook" (24). The ladies put in hard work but they are not allowed to show their full potential and their work is not appreciated enough.

The work these women do is crucial to the whole operation, yet their contributions are not appreciated enough. Henrietta asks Annie why she doesn't demand a faculty position. According to Annie, she does not need a title to do her work but Henrietta retorts by saying that the boys need their work to keep their titles. Henrietta wants Annie to ask for a faculty position as that would open up avenues for any women like them to join this field.

ANNIE. What do you want them to give you?

HENRIETTA. A chance. To show them what we can do. (26)

Upon her insistence, Annie allows Henrietta to stay back after work to focus on her new ideas. At the beginning of the third scene, Henrietta informs Peter that she has found two hundred

cepheids in the Magellanic Clouds. Her hard work is paying off, although she is barely getting any sleep. She goes over and beyond her duties to sneak into the observatory every night to do the work that she should have been doing during the day.

The women have their own stories of struggle to reach the observatory. Williamina shares with Henrietta that she had a husband who left her as they reached America. She was twenty-one and pregnant at the time. Harriet informs Peter that she used her dowry to get there. Williamina reveals that Annie has been going to Suffragette protests. Annie asserts that women need equal rights as men and they should begin by asking for the right to vote. Despite the hardships in their personal lives, the women in the observatory make it a point to stand for their political rights.

Margaret tells Henrietta that she is working on a symphony. Since it is uncommon for women to write one, Margaret asserts, "upsetting tradition might just run in the family" (41). Such ideas portray the prevalent notions regarding genders and their behaviour.

Despite exceptional talent and perseverance, Henrietta has to face adverse work conditions in the observatory. Henrietta's continual overnight hard work pays off, but she is still snubbed by her male colleagues. Her work finds recognition and she shares the credit with the whole team. Williamina announces the title of Henrietta's published work - 'The Period-Luminosity Relation'. Henrietta asks Peter if she can start a project on cepheids. Peter informs her that the "boys" have already started working and she cannot join the work as she is not an astronomer. Henrietta observes Peter giving a lecture where he says that the universe is not that vast. They have a disagreement on the implication of Henrietta's work and the vastness of the universe. In the fourth scene of the second act, Henrietta laments, "I write all these letters and no one answers. These men, colleagues, all using my work, but they won't let me near it. Useless. Helpless" (53). Gunderson portrays the pathetic work conditions of women in the observatory.

Finally, things turn for the women as Henrietta is offered the post of the Head of Stellar Photometry and Annie is made the Head Curator. A Danish astronomer uses Henrietta's method to measure the distance to Cepheids and proves that there are things beyond our galaxy and that the universe is indeed vast. Henrietta's work stands vindicated. Hudgins Hubble also used Henrietta's methods to calculate the distance of objects thousands and thousands of light years away. Peter explains the implication of new discoveries and says that Henrietta just became the first person to measure the universe. Gunderson's portrayal of the life and work of Henrietta throws light on the oft-forgotten roles played by many women in the sciences and the struggles they went through fighting the patriarchal systems and their male colleagues.

Conclusion

With the help of the three plays, the chapter examines the representation of women scientists in science plays written by female playwrights. The plays portray three different women engaged in different fields of scientific exploration and the problems they faced, such as lack of opportunities, ostracization by colleagues, male gatekeeping, sexism, misogyny, social pressures, character assassination, and lack of recognition, among others. The playwrights expose the myriad predicaments faced by women in sciences and tell the tale of their perennial struggle. The chapter analyses the playwrights' depiction of women scientists who are reduced to their sex, cold-shouldered by their male colleagues, bear the burdens of the patriarchal society, face misogyny and keep working despite adverse working conditions. The plays provide sufficient opportunities to read into the lives of these celebrated women scientists, and therefore, the selection of the science plays featuring non-fictional women scientists appears fruitful. The real-life characters of the scientists in the play have allowed researchers to read effectively the portrayal of women scientists by female playwrights. While there are numerous science plays with women scientists as characters, this selection of science

plays has allowed the researchers to explore the representation of women in science in a nuanced manner.

Conclusion

In the preceding four chapters, this thesis explored the issue of authority, the use of literary devices and scenographic elements, and the portrayal of women scientists using the select science plays. The common thread across the four chapters of this thesis is the selection of these plays, establishing them as science plays (as elaborated in the introduction) and providing four different viewpoints for analysing a science play. The explanatory method of descriptive analysis employed in the chapters first establishes these plays as science plays and then provides novel insights about them as per the four different thematic elements, the conclusions of which are shared below.

Kipphardt's *In the Matter of J Robert Oppenheimer* delves into the complex themes of authority, morality, and responsibility within the context of scientific development and political power. Through the dramatized proceedings against Oppenheimer, Kipphardt explores the various manifestations of authority and how they intersect with scientific expertise. The play raises important questions about the authority of scientists themselves and the role they play in decision-making processes. Oppenheimer, as a leading nuclear physicist, questions the authority of non-scientists to judge his actions and decisions. He emphasizes the need for practitioners of science to be involved in committees and decision-making bodies, highlighting the authority that rigorous scientific training can bring. Furthermore, the play examines the tension between an individual scientist's responsibility and their collective responsibility. Oppenheimer, hailed as the "Father of the Atom Bomb," is both praised and blamed for his involvement in the project. The play explores his agency and the moral responsibility he bears for the consequences of his work, even if he argues that the decision to use the bomb was political and not his own.

Oppenheimer's agency to dissent and the erosion of that agency in an authoritarian environment are also key themes. The play showcases his ethical stand against the hydrogen bomb project and his willingness to resign from committees as a form of protest. However, his dissent comes at a cost of his character and reputation, highlighting the challenges faced by scientists who dare to challenge authority. Additionally, the play touches upon the influence of political ideologies on scientists and the authority that political and military bodies exert over their personal beliefs and actions. The thesis discusses questions about privacy and the boundaries between subjective views and objective work. Through its exploration of authority, morality, and responsibility, Kipphardt's play invites the audience to critically reflect on the power dynamics within scientific and political spheres. It serves as a reminder that authority is multifaceted, dynamic, and subject to both individual agency and external influences. Ultimately, *In the Matter of J Robert Oppenheimer* offers a thought-provoking examination of the complex relationship between science, authority, and the human condition.

In the case of Brecht's *Life of Galileo*, the thesis explores the theme of authority in the context of Galileo's conflict with the religious and political powers of his time. Through the portrayal of different kinds of authorities, including religious, academic, and political, Brecht highlights the challenges faced by individuals who dare to challenge the established order and question traditional beliefs. The play emphasizes the authority of religious institutions, which seek to maintain control over people's thoughts and beliefs. The religious authorities in the play enforce strict adherence to scripture and punish those who deviate from the accepted worldview. Galileo's work is met with opposition from these authorities, who see his scientific discoveries as a threat to their power and control. Brecht also portrays the authority of academic institutions, which align with the religious authorities in perpetuating the status quo. The university officials dictate the type of work that will be performed, always in accordance with religious doctrines. The academic authorities and state-endorsed scholars play a crucial role in

upholding the state's authority and ensuring compliance with the approved worldview. Scientific authority and the scientific method, represented by Galileo, stand in direct confrontation with religious authority. Galileo believes in the power of evidence and objective truth, while the religious authorities fear the impact of rational inquiry on their control over the masses.

The thesis explores the tension between these two forms of authority and the struggle for acceptance of scientific discoveries that challenge traditional beliefs. The play also examines the role of patronage and funding agencies in scientific endeavours. Galileo relies on the support of state officials for financial backing, highlighting the authority that patrons hold over the direction and outcome of scientific research. The chapter elaborates that in the face of oppressive authority, Galileo's recantation is a complex act of dissent. While he publicly renounces his findings under the threat of the Inquisition, he secretly continues his work and instructs others to circulate his manuscript, thus maintaining his agency to dissent by challenging the established authorities. Overall, *Life of Galileo* raises thought-provoking questions about the nature of authority and its impact on scientific progress. Through its exploration of different forms of authority and their interactions, the chapter highlights the struggles faced by individuals who dare to challenge prevailing beliefs and seek to advance knowledge. It serves as a reminder to the importance of critical thinking, evidence-based inquiry, and the continual questioning of authority in the pursuit of truth.

Stephenson's *An Experiment with an Air Pump* explores the theme of authority in the context of science and its impact on society. Through the portrayal of various characters and their interactions, Stephenson delves into the shifting authority from religion to science, the gatekeeping of knowledge by male academics, the unacknowledged contributions of individuals supporting scientists, and the authority of experiments and demonstrations. The

chapter showcases the transition from traditional theological authority to the rise of scientific authority. The shift in the world order is evident as science becomes the centre of inquiry and reason takes precedence over religion. The chapter also addresses the issue of male academic gatekeeping, where men assume the authority to decide who has access to scientific knowledge, while women face exclusion and scepticism. The play recognizes the often-uncredited work of individuals, particularly women, who aided natural philosophers but were rarely acknowledged or attributed for their contributions.

The authority of experiments and demonstrations in science is another key aspect explored in the chapter. Stephenson portrays the public's influence and perception of science, as well as the popularization of scientific knowledge through public demonstrations and performances. Furthermore, the play examines the relative superiority and conflicts between different branches of science, highlighting the authority of peers within the scientific community. The chapter also explores the public imagination of science, demonstrating how the public's understanding and perception of scientific research can shape its authority. Scientific authority is portrayed through the characters' assertions of methodology, evidence, and technological advancements. The play questions the ethical boundaries of scientific research, particularly in the field of genetics, and the authority it grants over individuals' lives and bodies. Ultimately, the chapter draws attention to the complexities of scientific authority and its implications for society. It prompts us to reflect on the ethical and moral dilemmas arising from scientific progress, while also highlighting the need for responsible and inclusive decision-making in the realm of science. Stephenson's play serves as a thought-provoking exploration of the intersection between authority, science, and society.

The section on Maharishi's *Einstein* presents a fascinating exploration of authority within the realms of religion and science. Through the portrayal of various characters, including

Albert Einstein, Aristotle, Nicolaus Copernicus, and Galileo Galilei, the play examines the shifting dynamics of authority and the conflicts that arise between different sources of knowledge. Religious authority is depicted in opposition to academic authority in the play by highlighting the gradual replacement of religious authority with academic authority. The chapter showcases the conflict between the Christian teacher and the Rabbi, representing contradictory religious ideas. As the story unfolds, the authority of religion gives way to the authority of scientific methodology and the scientific community, demanding complete adherence. Scientific authority, on the other hand, emerges from the authority of scientists themselves, as well as the authority of scientific methodology. The play emphasizes the importance of empirical evidence, mathematical proof, and experimentation in establishing scientific authority. Figures such as Einstein, Newton, Galileo, and others are portrayed as authoritative figures in their respective fields, exerting both charismatic and legal-rational authority.

The chapter also explores the tension between theoreticians and experimentalists in the scientific community, highlighting the conflict for authority between these two groups. Additionally, the Gypsy magician character represents charismatic authority derived from dogma and magical beliefs, contrasting with the scientific world of Einstein. Throughout the play, dissent against established authorities is depicted as a means of progress and advancement in both religion and science. The characters challenge dogmatic ideas and established norms, leading to paradigm shifts and scientific breakthroughs. The play emphasizes the importance of questioning and the spirit of inquiry as guiding authorities in the pursuit of knowledge. Overall, the section on *Einstein* offers a thought-provoking examination of authority within the context of religion and science. It demonstrates the complex and dynamic nature of authority, highlighting the interactions and conflicts between different sources of knowledge. Through this exploration, the play encourages collaboration between scientists and artists, as well as the

search for more science plays in regional languages. Maharishi's bilingual play serves as a boon to the field of Indian theatre, presenting a unique and engaging perspective on the life and ideas of Albert Einstein.

The section on Djerassi and Hoffmann's *Oxygen* delves into the concept of discovery and raises thought-provoking questions about the ethics and authority surrounding scientific exploration. Through its exploration of the discovery of oxygen and the historical context surrounding it, the play effectively bridges the gap between the realms of science and humanities, highlighting the importance of interdisciplinary collaboration. The chapter portrays multiple facets of authority, ranging from the authority of award committees and grant-awarding institutions to the authority of scientific theories and experimentalists. It also examines the authority exerted by patrons, monarchs, and publishers in the scientific community. By depicting the struggles for recognition and the desire to be the first in the race for scientific discovery, the section sheds light on the dynamics of authority and competition within the scientific community.

Furthermore, *Oxygen* addresses the issue of gender representation in science, highlighting the lack of female characters and playwrights in the field. The chapter also delves into the authority of publication and experiment reproducibility, emphasizing their role in validating scientific claims. Through its parallel plotting and exploration of historical archives, the play underscores the significance of the history of science and the importance of historical methods in uncovering the truth behind scientific discoveries. It challenges perceived hierarchies of knowledge systems and emphasizes the need for collaboration between scientists and historians to unravel the complexities of scientific advancements. Ultimately, the section on *Oxygen* invites reflection on the complex nature of discovery, the authority attributed to scientific achievements, and the ethical implications surrounding them. By intertwining

scientific progress with personal ambitions and societal influences, the play prompts the audience to question the inherent power dynamics and moral responsibilities that come with scientific exploration.

The section on Frayn's *Copenhagen* delves into the intricate relationship among authority, ethics, and science, specifically focusing on the 1941 meeting between Niels Bohr and Werner Heisenberg. Through its non-linear and repetitive structure, the play explores the complex position of scientists in a world where the development of nuclear weapons and the geopolitical landscape intertwine. Frayn effectively portrays the power of geopolitical events over the lives of scientists, as exemplified by Margrethe's cautiousness towards Heisenberg due to the political ramifications of the time. The chapter highlights the influence of cultural institutes and the authority they hold, especially during times of occupation, as well as the precarious position of Heisenberg as a German-Jew nuclear physicist in Nazi Germany. The section underscores the moral and ethical dilemmas faced by nuclear physicists during and after World War II, as well as their varied responses to the development and use of atomic weapons. The playwright raises thought-provoking questions about the responsibility of scientists and their agency in the face of state authority. Through Heisenberg's character, Frayn explores dissent as a form of agency. Heisenberg employs subversive tactics to slow down the development of nuclear weapons while retaining his position as the head of the German nuclear program. This stands in contrast to Oppenheimer's character in Kipphardt's *In the Matter of J Robert Oppenheimer* where dissent is lamented rather than enacted.

The chapter also highlights the relative authorities within the scientific community, with Bohr seen as the authoritative figure in the "Copenhagen Interpretation" alongside Heisenberg. The play emphasizes the relationship between scientific authority, the scientist's personal authority, and the authority of scientific methodology. Moreover, *Copenhagen*

touches on the imagination and fascination with nuclear physics, as well as the magical element associated with the field. The section also explores the intersection of public imagination and scientific advancement. Overall, the section raises significant questions about the role of scientists, the ethical implications of scientific advancements, and the authority exerted by political, state, religious, and scientific institutions. It prompts reflection on the complex interplay between authority and ethics within the scientific community and the wider society. Through its compelling portrayal of historical events and its exploration of human dilemmas, *Copenhagen* continues to captivate audiences and stimulate discussions on these critical topics.

The section on Lawrence and Lee's *Inherit the Wind* explores a clash of authorities and the complex dynamics between religion, science, and education. Through the courtroom drama based on the Scopes Trial of 1925, the playwrights delve into the struggle for control over public education and the battle between religious and scientific authorities. The chapter highlights the authority of dogmatic ideas, with young minds being influenced by rigid beliefs. It emphasizes the role of textbooks as authorities in shaping children's worldviews, and the power of popular opinion in influencing science and education. The section discusses the coming together of political, religious, and administrative authorities to oppose scientific teachings, perpetuate dogmatic views and stifle intellectual freedom. The clash between the authority of the Bible and established academic authorities becomes a focal point in the chapter. The legal authority, aligned with religious figures, suppresses the testimony of subject experts, favouring religious authority over scientific knowledge. The jury and judge, as the final authorities in the courtroom, demonstrate the influence of public opinion and popular imagination on matters of science and education.

Analysing the character of Bertram Cates, the section highlights the agency of individual dissent against oppressive authorities. Cates stands up against religious, political,

and judicial powers, embodying the struggle for intellectual freedom and the right to teach scientific principles. Ultimately, *Inherit the Wind* serves as a poignant exploration of the conflict between religion and science, delving into issues of authority, dissent, and freedom of thought. The playwrights skilfully navigate the complexities of the Scopes Trial, shedding light on the challenges faced by those who dare to challenge established beliefs and the significance of individual agency in the face of oppressive authority. By masterfully capturing the essence of the Scopes Trial, Lawrence and Lee's play continues to resonate with audiences, inviting reflection on the ongoing tension between religious and scientific authorities and the importance of embracing critical thinking and intellectual curiosity in the pursuit of knowledge.

Kipphardt's *In the Matter of J Robert Oppenheimer* masterfully portrays the ordeals faced by the renowned physicist in the hands of a security board. This section analyses the play's engaging structure and the use of formalized language, literary allusions, wordplays, rhetoric, and irony. The formalized language used in the play, with its announcement of full names and formal oath-taking procedures, effectively conveys the tone and tenor of the courtroom setting. This adds authenticity and immerses the audience in the dramatic proceedings. Furthermore, the use of literary allusions to historical figures, folklore, and religious texts enriches the play, aiding readers in better understanding the situations faced by Oppenheimer and other characters. The characters engage in clever exchanges, such as the discussion of the word "treason" and its connection to tradition, highlighting the nuances of language and ideology. The assignment of colours to political ideology also adds depth to the narrative, reflecting real-world political discourse.

The section explores the use of rhetoric as a powerful tool of persuasion, as seen in Evan's monologue, where he criticizes restrictions on free speech and thought in universities and paints science and scientists with a broad communist brush. This use of rhetoric adds a

layer of complexity to the play, exploring the intersection of politics and scientific inquiry. Irony is prevalent throughout the play, providing readers with contrasting ideas and exposing the contradictions within the characters' beliefs and actions. By incorporating these literary techniques, Kipphardt effectively portrays Oppenheimer's life and thoughts, intertwining science into both the content and form of the play. Overall, *In the Matter of J Robert Oppenheimer* stands as a thought-provoking work that showcases the power of literature to explore complex historical events and their implications. Kipphardt's skilful use of language, allusions, wordplays, rhetoric, and irony makes the play a compelling examination of Oppenheimer's experience and prompts readers to reflect on the intersection of literature and science.

Brecht's *Life of Galileo* is a captivating play that showcases the life and struggles of the renowned Italian mathematician, philosopher, and innovator. This section explores the play's effective utilisation of various poetic embellishments at the beginning of each scene to set the tone and provide vivid imagery for the readers. These poetic devices serve a dual purpose by conveying information about the setting and time period while also creating an emotional atmosphere for the upcoming scenes. Brecht's masterful assimilation of poetry throughout the play, including within the scenes themselves, enhances the desired effect and adds depth to the narrative. Furthermore, the chapter discusses the employment of comic relief to break the tension in the play. The use of malapropism and sarcasm brings a humorous touch to the otherwise sombre storyline. By incorporating these literary devices, Brecht successfully creates moments of levity, providing the audience with a temporary respite from the weighty subject matter.

The chapter also explores the evolution of scientific terminology and the language of communication as depicted in the play. It discusses Galileo's advocacy for writing in the

vernacular Italian rather than Latin, highlighting the importance of accessibility and widespread dissemination of scientific knowledge. This theme resonates with the historical context of the printing press, emphasizing Galileo's deliberate choice to reach a larger audience through the use of the vernacular language. Brecht's discussion of language in science communication adds a layer of depth to the play and raises relevant questions about the form and accessibility of scientific discourse. The play exhibits elements of documentary theatre, incorporating historical evidence and materials related to Galileo's life, which the chapter discusses. This approach lends authenticity and credibility to the play, blurring the line between fiction and reality. Overall, Brecht's *Life of Galileo* is a thought-provoking and multifaceted play that combines poetry, comic relief, and historical context to create a rich and engaging narrative. Its exploration of language, scientific communication, and the humanistic aspects of scientific discovery make it a timeless piece that can be both read and performed with great effect.

The chapter further discusses a fusion of science and drama through the active collaboration between scientists and playwrights, mirroring the vision put forth by CP Snow in Maharishi's *Einstein*. One of the most notable aspects of Maharishi's play is its bilingual nature, with the simultaneous use of English and Hindi. The characters' dialogues are in Hindi, while the stage directions and asides are in English, creating a unique linguistic experience for the audience. The section discusses Maharishi's employment of the transcription of English names into the Devanagari script, such as Max, Einstein, Aristotle, and Galileo. This linguistic approach enhances the play's cultural context and emphasizes the blending of languages. The use of a different language within the text adds depth to the characters and the overall performance. The chapter explores elements of meta-theatricality, with characters exhibiting self-awareness and acknowledging their roles within the drama.

Moreover, Maharishi's play incorporates a poem, a joke, and references to literary personalities, such as Bertolt Brecht, Honoré de Balzac, Charles Dickens, and Fyodor Dostoevsky. These literary allusions contribute to the play's richness and connect it to a broader cultural and intellectual landscape. In terms of form and content, Maharishi masterfully merges scientific metaphors with the dramatic structure. Additionally, the chapter explores the inclusion of scientific formulae in English and the universalization of English as the language of scientific communication, emphasizing the integration of scientific content into the play. Through rhetorical phrases and archaic language, Maharishi establishes a distinction between the scientist and the magician, highlighting their different domains of expertise and performance. Overall, Mohan Maharishi's *Einstein* sets an exemplary standard for Indian science playwrights by showcasing the possibilities of bilingualism, metaphors, euphemism, and other literary techniques. His work paves the way for future collaborations between scientists and playwrights in India, offering a fresh and vibrant approach to the genre of science plays.

The section on *Oxygen* studies the utilisation of language and literary devices to explore the intricate relationship between literature and science. The play skillfully incorporates various literary techniques and devices, resulting in a seamless integration of form and content. One aspect highlighted in the chapter is the issue of scientific nomenclature. The section reveals the evolution of scientific terminology and the legacy of alchemy by analysing the use of archaic scientific terms and the discussion of the process of naming. Additionally, the chapter descibes novel terms and phrases used to depict scientific activities and describe the individuals involved, shedding light on the historical context and diversity within the scientific community. Furthermore, the section addresses the roles of women in science, emphasizing the unattributed contributions of women to scientific work. The portrayal of Mme Lavoisier as a translator and supporter of her husband's scientific endeavours highlights the often overlooked involvement

of women in scientific achievements. The chapter also touches on the use of gendered language in science and administration, raising important questions about the representation of women in the field.

The unconventional structure of the play, with its short and fast-paced scenes interspersed with intermezzos, accentuates the theme of the rapidly changing world of science. This structure, although unorthodox, effectively captures the dynamic nature of scientific progress. The chapter also analyses playwrights' employment of mimicry, sarcasm, and banter to convey the mood and provide comic relief. These devices add depth to the characters and engage the readers and audiences, making the play both entertaining and thought-provoking. Additionally, the section explores the issue of language and translation in scientific communication. The need for a universal scientific language is underscored, as the characters struggle with different languages and the challenges of translation, both in the past and in the committee proceedings depicted in the play. Finally, the section highlights the play's incorporation of meta-theatricality through the inclusion of a masque within the play, creating a play-within-a-play format. This adds a layer of complexity and intrigue to the narrative, enhancing the overall theatrical experience. Overall, *Oxygen* serves as a captivating example of the interaction between literature and science. Through its masterful use of language and literary devices, the play successfully illuminates various aspects of the scientific world, historical context, and the complexities of scientific discovery and communication.

The section on Stephenson's play investigates the use of language and literary devices to create a rich and engaging exploration of the intersection between science and literature. Drawing inspiration from Joseph Wright of Derby's painting, Stephenson effectively uses language to evoke the visual effects and atmosphere depicted in the artwork. The play's structure, featuring alternating time periods, allows for insightful comparisons between

different eras of scientific advancement. This narrative technique, also seen in Djerassi and Hoffmann's *Oxygen*, underscores the ever-changing nature of science and the evolving implications it has on society. The section shows that satire and sarcasm serve as powerful tools in Stephenson's play, adding depth and humour to the characters and their interactions. These devices help to convey the playwright's message in an engaging manner and ensure that even readers who may not be initially drawn to the subject matter can find the content enjoyable.

Biblical allusions and religious imagery further enrich the play's thematic exploration. By referencing the concept of a "New Jerusalem" and incorporating a performance described as "a hymn to progress," Stephenson brings a deeper layer of meaning to the story, highlighting the intertwining of scientific progress and human aspirations. The chapter explores the use of literary references, including mentions of well-known authors and works, showcasing the interconnectedness of science and literature. The inclusion of real-life figure Peter Mark Roget, a physician and lexicographer, emphasizes the practical connection between science and language. Overall, Stephenson's masterful use of imagery, allusions, metaphors, satire, and sarcasm blurs the boundaries between science and literature, demonstrating their interdependence and the value of bridging the gap between the two cultures. The play serves as a testament to the power of language in conveying complex ideas and emotions, and as an invitation for audiences to further explore the historical and intellectual contexts depicted in the artwork that inspired it.

The section on Frayn's *Copenhagen* explores the themes of uncertainty, language, and the moral implications of scientific advancements. Through the use of non-linear plot, repetition, altered chronology, and metaphors, Frayn effectively conveys the complexity and ambiguity inherent in the lives and decisions of the characters, as well as the broader

implications of their work. The play's non-linear structure and repetitive nature serve to highlight the theme of uncertainty. By breaking away from traditional chronology and repeating key moments and phrases, Frayn emphasizes the elusive nature of truth and the limitations of human understanding. The characters' discussions about Heisenberg's uncertainty principle, Schrodinger's cat, and the duality of particles and waves further reinforce the theme of uncertainty and the inherent paradoxes in the field of quantum physics.

The chapter discusses Frayn's use of metaphors which adds depth and layers of meaning to the play. The metaphors of Copenhagen as an atom, Margrethe as its nucleus, and the chain reaction of truth-telling all contribute to the exploration of the characters' motivations, choices, and the consequences of their actions. Furthermore, the section explores allusions to biblical and theocratic structures of power, drawing connections between scientific advancements and the moral responsibilities that come with them. The breakdown of communication and comprehension depicted in the play raises important questions about the limitations of language and the challenges of truly understanding one another.

Through the characters of Bohr, Heisenberg, and Margrethe, the chapter also analyses the irony and hypocrisy surrounding the development of the atomic bomb. It highlights the moral dilemmas faced by the scientists involved in this project and the consequences of their decisions. Overall, *Copenhagen* stands as a seminal science play that effectively merges form and content. Frayn's masterful use of literary and narrative tools, combined with his exploration of uncertainty, language, and the moral implications of scientific advancements, creates a thought-provoking and engaging theatrical experience. The play's enduring impact and critical acclaim are a testament to Frayn's ability to tackle complex scientific topics through the power of drama.

The section on Lee and Lawrence's play *Inherit the Wind* explores the use of various literary devices and theatrical techniques to explore the clash between religion and science. The playwrights establish the play as a work of documentary theatre, drawing inspiration from the real-life Scopes trial, yet they emphasize that it is not merely a historical or journalistic piece. The play's title itself, with its biblical allusion to Proverbs 11:29, sets the tone and foreshadows the events to come. The section analyses incorporation of religious allusions to underscore the central conflict. Hornbeck's biting sarcasm satirizes the absurdity of the trial and the contentious relationship between religion and evolution. The dialogue between characters further illuminates the clash between dogma and science. The prejudiced townspeople, represented by figures like Brady and Reverend Brown, deride scientific teachings as blasphemy and heathen dogma. Drummond, the defence attorney, employs legal language in the courtroom while using profanity outside of it, emphasizing the limitations of language as a means of communication.

The section explores the use of imagery, which enhances the audience's visualization of the play's setting and characters. Additionally, the play incorporates verse in Hornbeck's dialogues, giving his sarcasm a searing effect. His cynical verses and biting wit serve as powerful tools to challenge the status quo and provoke thought. By weaving together metaphors, allusions, sarcasm, humour, and imagery, Lee and Lawrence effectively portray the nuanced conflict between religion and science. They navigate the complex themes with skill, providing a thought-provoking exploration of the clash between dogma and scientific progress. *Inherit the Wind* stands as a testament to the power of theatre to illuminate societal issues, encourage critical thinking and to bridge the chasm between literature and science.

The section on Kipphardt's *In the Matter of Robert J Oppenheimer* demonstrates the power of props and documentary elements in engaging the audience and immersing them in

the scenography of the play. By employing costumes, stage designs, lighting, projections, and various evidentiary materials, the play creates a vivid and authentic portrayal of the events surrounding the trial and moral dilemma faced by Oppenheimer. The chapter analyses the imagery of stars and stripes and military uniforms which symbolizes the conflict between the state and the scientist, setting the tone for the play. Senator McCarthy's interview acts as a prop to introduce the topic and provide a preliminary understanding of the play's context. The atomic bomb and the hydrogen bomb are used symbolically, reflecting the inner turmoil and moral dilemma faced by Oppenheimer. The section studies the trial of Oppenheimer by the Personnel Security Board serves as a prop to explore the ethical allegiance of a scientist and their responsibility to the nation. The use of the stand during the trial symbolizes the formal authority of the committee and its power to decide the fate of Oppenheimer and the hydrogen bomb development.

The section engages with the use of reports, files, and documents as props to convey essential information and to shape the plot as they provide a realistic assessment of the hearing and highlight the contrasting viewpoints and evidence presented. The testimony of Paul Crouch and the bundle of photostats presented by Oppenheimer's defence counsellors complement each other, revealing the lengths to which both sides go to present their case. The chapter explores the use of projectors and projected texts which enhance the audio-visual experience for the audience, effectively condensing and conveying the extensive committee proceedings and the gravity of the situation faced by Oppenheimer and other scientists involved in the project. Overall, the section engages with use of props and documentary elements which create a rich and authentic portrayal of the ethical and political landscape surrounding the trial. The play's exploration of complex historical and ethical themes, combined with its staging techniques, invites the audience to reflect on the interplay between science, politics, and personal convictions. Through these scenographic tools, the play succeeds in engaging the

audience and immersing them in the gravity of Oppenheimer's situation, prompting a deeper understanding of the dilemmas faced by scientists and the impact of their decisions on society.

The next section discusses the use of props in Brecht's *Galileo* which plays a crucial role in depicting scientific concepts and phenomena while adding depth and symbolism to the narrative. These props serve as visual aids, carrying metaphorical and referential meanings that contribute to the overall communication of the play. Each prop, from the wooden model to the telescope, the apple to the proving stone, is carefully selected to highlight the clash of ideas, paradigm shifts, ethical dilemmas, and the evolving relationship between science, religion, and society. The chapter studies the props as they provide a tangible representation of abstract theories and allow the audience to engage with the scientific and philosophical discourse unfolding on stage. By incorporating props like the iron washstand, apple, telescope, compass, drawing board, and manuscript, Brecht effectively portrays the evolution of scientific knowledge and its impact on society. Furthermore, the section explains how the props go beyond their visual representation and carry symbolic value as they represent the changing times, the depleting authority of the church, and the increasing dominance of reason and observation. The props also shed light on ethical dilemmas, such as the use of scientific inventions for commercial gain, the role of funding and patrons in scientific advancements, and the hypocrisy of dogmatic beliefs.

Brecht's strategic use of props aligns with his theatrical approach, to provoke critical thinking and reflection among the audience. The incorporation of visual aids, such as drawing on a board and the carnival procession, aids in better understanding scientific concepts and stimulates intellectual engagement. Overall, the props in *Life of Galileo* contribute to the portrayal of scientific concepts and the broader themes explored in the play. They serve as powerful tools for storytelling, challenging established norms, and prompting discussions

about the nature of knowledge, the authority of religion, and the social implications of scientific advancements. Through the creative and meaningful use of props, Brecht successfully creates a holistic performance environment that captivates and educates the audience.

The chapter then analyses the incorporation of props in Maharishi's play, as a powerful tool for enhancing communication and impact. The props used in the play serve multiple functions, including conveying deeper meanings, symbolizing themes, and engaging the audience on multiple levels. The section studies the use of musical pieces, chairs, books, scientific instruments, and other props in the play creating a thought-provoking theatrical experience that immerses the audience in the narrative. The musical pieces, played by the violinist in the orchestra pit, set the auditory tone of the play and allude to Einstein's affinity for music. The chair thrown off the stage becomes a physical manifestation of frustration and rebellion, representing the protagonist's discontent with the state of learning at the time. Books symbolize the transmission of knowledge from one generation to another, while also highlighting the changing paradigms in physics and mathematics. The chapter focuses on the innovative use of props like the cyclorama, compass, light, and sound which creates a visual and auditory spectacle, presenting scientific ideas on stage in a captivating manner. The props become scenographic elements that transport the audience into the world of the play, allowing them to explore complex scientific concepts and their societal implications.

Furthermore, the props in the play carry intertextual references, drawing connections to historical and literary contexts. The section explores the list of scientists as a representation of the cumulative progress of science and the opposition it has faced throughout history. The fake eye serves as a counterpoint to Aristotelean views on celestial bodies, while the whistle and candle experiment highlight the performance of science on stage. Each prop in the play adds depth and layers of meaning, enriching the narrative and stimulating intellectual engagement.

The incorporation of props in theatre holds immense potential for enhancing communication and impact. Maharishi's play exemplifies the transformative power of props, showcasing their ability to enrich the narrative, evoke emotions, and stimulate intellectual engagement. By utilizing a wide range of props and exploring their symbolic representations, the play creates a layered and immersive experience for the audience. The careful selection and integration of these props contribute to a profound exploration of scientific ideas, societal dynamics, and the human condition. Ultimately, the use of props in the play serves as a testament to the power of theatrical elements in transcending boundaries and creating a lasting impact on both the audience and the art form itself.

The next section explores how the scenographic and theatrical elements are utilized in the play *Oxygen* to portray and explore various themes, bridging the gap between science, history, and the human experience. The technical details presented on stage effectively transport the audience into a laboratory-like atmosphere. The chapter details the meticulous stage setting, which incorporate laboratory demonstration tables, screens, and projectors, creating an immersive illusion that allows the audience to witness the inner workings of scientific discovery. This attention to detail and authenticity captivates the audience, suspending their disbelief and drawing them into the world of the play. The section further analyses costumes, which play a vital role in transporting the audience to different time periods and enhancing the visual experience. The use of period-specific attire adds richness and historical credibility to the performance which not only evokes a sense of time and place but also explores the social and cultural contexts in which the characters exist. The chapter explores props such as books, letters, and documents as powerful symbols and catalysts for pivotal moments in the play. They represent the quest for scientific recognition, ethical dilemmas surrounding discovery, and historical context. By weaving these props into the narrative, the playwrights delve into the complex layers of scientific pursuit, societal structures, and

individual morality, providing a multi-dimensional exploration of the interplay between these ideas.

The section discusses the seamless integration of theatrical properties, stage setting, and costumes which elevates the play, transcending the boundaries of the stage and immersing the audience in thought-provoking experiences. It demonstrates the transformative potential of theatre to shape narratives, evoke emotions, and engage audiences in profound ways. In conclusion, through the masterful utilization of props, stage setting, and costumes, the play effectively explores themes, sparks dialogue, and leaves the audience with a deeper understanding of the complexities within the realms of literature and science.

In Stephenson's play *An Experiment with an Air Pump*, the implementation of theatre scenography and its various components is evident. The striking prologue, reminiscent of Joseph Wright of Derby's renowned painting, *An Experiment on a Bird in the Air Pump*, creates a profound connection between the artwork and the scientific themes explored in the play. By including the painting as a prop on the stage, the audience is able to connect the artwork to the science play, setting the stage for a immersing experience. The section discusses lighting as a fundamental aspect of theatre scenography which plays a crucial role in establishing the mood and enhancing the overall impact of the play. Skilful lighting design guides the audience through the narrative, encouraging contemplation of the interplay between artistic and scientific cultures. The use of chiaroscuro lighting not only sets the mood but also signifies the completion of the play, bringing the plot full circle and leaving a lasting impression on the audience. The chapter focuses on the performance of the "bird in an air pump" experiment, which mirrors the historical practices of travelling science performers and becomes a captivating visual spectacle on stage. The inclusion of props such as stuffed birds, hanging

animals, and reptiles further contributes to the historical accuracy and evokes a forgotten era in the development of science.

The chapter analyses costumes and makeup which, working subtly on the audience's subconscious, bring authenticity to the setting and time period of the play. These visual cues, along with the props and lighting, work together to enhance the overall experience and immerse the audience in the world of the play. The section explores the house portrayed in the play as a bridge between two time periods which acts as the setting for the exploration of science and ethics. The incorporation of the house as a prop is a connection between the two time periods and raises questions of ethics in science in both contexts. In conclusion, Stephenson's play effectively employs theatre scenography, stage setting, costumes, and lighting to convey its message to the audience. The careful integration of these elements creates a visually engaging and thought-provoking experience, stimulating discussions on the development of science, ethics, and the relationship between humanities and science. By utilizing the power of theatre scenography, Stephenson invites the audience to explore complex themes and engage with the play at multiple levels, leaving a lasting impact long after the final curtain falls.

Frayn's *Copenhagen* challenges traditional theatrical conventions by incorporating minimalist elements and stripping away explicit scenographic information. The play's unique storytelling approach, devoid of props and detailed stage instructions, invites audiences to engage intellectually and emotionally with the meeting between Niels Bohr and Werner Heisenberg. Frayn's departure from traditional scenography grants directors unparalleled freedom to experiment and create visually striking and conceptually profound productions. The section examines the absence of explicit scenographic cues at the beginning of the play which creates a sense of estrangement and draws readers and viewers into the narrative. Frayn's adherence to the principles of minimalist theatre simplifies various aspects of the play,

emphasizing the shifts in conversation and the absence of a fixed narrator. These abrupt changes propel the plot forward, providing insights into the characters' perspectives and relationships. The chapter explores the deliberate interjections and breaks in the dialogue which offer the playwright control over the pace and delivery of the narrative. These breaks also provide opportunities for directors to explore creative scenographic interpretations, enhancing the visual impact of the play.

The section examines the play's minimalist approach as a canvas for contemplation, inviting audiences to reflect on the complexities of scientific discovery and the intricate dynamics between individuals facing moral dilemmas. Frayn's masterful crafting of the narrative sparks intellectual discourse and emotional resonance, leaving a lasting impact on those who experience the play. In summary, Copenhagen's minimalist theatrical elements, including the absence of explicit scenographic information, the shifts in conversation, and the opportunity for creative interpretation, contribute to its compelling and introspective nature. Frayn's exploration of scientific inquiry, personal relationships, and historical context prompts audiences to contemplate the profound implications of choices made in the face of uncertainty. As a science play, *Copenhagen* stands as a testament to the power of minimalist theatre and its ability to engage, challenge, and provoke thought.

Lawrence and Lee's *Inherit the Wind* effectively brings to life the contentious clash between religion and science. Through their meticulous use of stage instructions and props, the playwrights create a compelling courtroom drama that explores the conflicting perspectives on human evolution. The section explores the setting of the Hillsboro Courthouse which serves as the backdrop for the intense legal battle. With the inclusion of "the town" in the stage instructions, the playwrights emphasize the idea that the entire community is also on trial. The chapter examines the role played by costumes in visually communicating the characters' roles

and backgrounds to the audience. The section analyses the use of books as props, notably Hunter's *Civic Biology* and *The Bible*, which symbolizes the clash of authorities in the debate between religion and science. These books become the foundation for arguments presented during the trial, showcasing the divergent viewpoints on evolution.

The chapter reads the banners held by the townspeople act as powerful theatrical devices, displaying opinions on the matter of evolution. These visually striking banners provide a direct and vivid representation of the public sentiment, demonstrating the effectiveness of visual props in conveying the viewpoints of the community. Furthermore, the section studies the contrast between the authority of religious literature and scientific evidence through the presentation of a fossil as evidence in the courtroom. The judge's rejection of the fossil highlights the preference for religious text over scientific evidence, encapsulating the central theme of the clash between religion and science. Overall, Lawrence and Lee skilfully utilise stage instructions and props in the play to amplify the dramatic conflict between religion and science. The detailed courtroom setting, costumes, books, and banners all contribute to the immersive experience of the play and effectively convey the opposing perspectives on the issue of human evolution. Through their masterful use of these theatrical elements, the playwrights provoke thought and encourage the audience to reflect on the complex relationship between faith and scientific inquiry. The employment of scenographic elements allows the playwrights to effectively portray science on stage.

In Gunderson's *Emilie*, the life, struggles, and accomplishments of Emilie Du Chatelet are portrayed, shedding light on the challenges faced by women in the field of science and their often overlooked contributions. Through Emilie's story, the section highlights the life, work, and achievements of one of the most prominent scientists and philosophers of her time. The chapter discusses the condition of women in science during the eighteenth century, where they

faced limited opportunities, exclusion from institutions of learning and practice, and mockery and scorn from their male contemporaries. It elicits reflection on hurdles faced by women who desired a career in science, showcasing the lack of avenues for education, training, and research. Moreover, the chapter delves into the issue of reducing women in science to their gender, as exemplified by compliments that emphasize femininity rather than intellectual achievements. This mirrors the continued struggle faced by women in academia today, where their accomplishments are often undermined or belittled. The section also highlights the limitations imposed on women who pursued science by discussing Emilie's altercation with the secretary of the Paris Academy of Sciences. This interaction exemplifies the challenges faced by women who dared to challenge the norms of their time.

The chapter further explores the complex relationship between Emilie and Voltaire, ultimately leading to Emilie's decision to translate Newton's work into French after feeling betrayed by Voltaire's actions. Emilie's determination and resilience in the face of societal obstacles exemplify the courage exhibited by women in science who often face denunciation and degradation from their peers. The section establishes Emilie as a powerful testament to the resilience, determination, and contributions of women in science. Through Emilie Du Chatelet's story, the chapter discusses the struggles faced by women in a male-dominated field and emphasises the importance of recognising and celebrating their achievements. Gunderson's work brings Emilie's life and work to a broader audience, ensuring that her contributions are acknowledged and respected among scholars and inspiring future generations to challenge societal norms and pursue their passions regardless of gender.

The section on Zeigler's play *Photograph 51* offers a powerful portrayal of the challenges faced by women in the scientific community, particularly focusing on the life and work of Rosalind Franklin during the discovery of the double helix structure of DNA. The

chapter exposes the pervasive presence of male gatekeeping and sexism in both personal and academic spheres. It analyses the familial gatekeeping experienced by Rosalind, with her father dismissing her aspiration to become a scientist and it explores sexist attitudes that she faces from her male colleagues, particularly Maurice Wilkins, who initially assumes her subservience and attempts to take credit for her work. Rosalind's desire to engage in scientific discussions during lunch is met with exclusion, as the senior common room is designated for men only. This exclusion not only limits her opportunities for collaboration but also underscores the broader issue of women's underrepresentation in influential positions within academia.

Moreover, the section discusses instances of sexism and antisemitism, as Rosalind faces derogatory comments about her appearance, personality, and Jewish heritage. These biases and stereotypes further hinder her professional growth and contribute to the marginalization of women in the scientific field. Furthermore, the chapter explores the consequences of undermining and appropriation of Rosalind's work by her male colleagues. Wilkins attempts to present her findings as his own, disregarding her contributions and research ethics. This betrayal not only highlights the exploitation faced by women scientists but also serves as a poignant critique of the gender inequities within scientific institutions. Ultimately, the section sheds light on the hidden realities of scientific laboratories and the challenges faced by women scientists. By bringing these issues to the forefront, the play encourages dialogue and reflection on the persistence of sexism, misogyny, and gender inequality within the scientific community. Zeigler's work serves as a reminder of the importance of fostering an inclusive and supportive environment that allows all individuals, regardless of gender, to pursue their scientific career.

Gunderson's *Silent Sky* shines a light on the life and work of astronomer Henrietta Leavitt, highlighting the challenges she faced and the significant contributions she made to the

field of astronomy. The section explores themes of gender inequality, societal norms, and the undervaluing of women's work in academia and scientific research. It emphasizes the limitations placed on women and the struggles they face in carving their own paths while highlighting the often unattributed contributions made by friends and family of scientists. The chapter discusses the prevalent attitudes towards women in the scientific community, with casual sexism and trivialization of their work being the norm. Henrietta's interactions with Peter Shaw, the head astronomer's apprentice, exemplify the unequal treatment and belittlement she faces.

The section highlights the gender inequality and hostile work environment experienced by women in STEM fields. Furthermore, it reveals the restricted roles assigned to women in the observatory and the lack of recognition for their contributions. Despite their crucial work, they are considered secondary to their male counterparts, and their potential remains untapped. The perseverance of Henrietta and her colleagues is evident as they strive to make their voices heard and demand equal opportunities. In *Silent Sky*, Gunderson successfully highlights the struggles, perseverance, and achievements of women in science, particularly Henrietta Leavitt. The play serves as a reminder of the ongoing fight against gender inequality and the importance of recognizing and valuing the contributions of women in scientific research and academia. Henrietta's story inspires and encourages future generations of women to pursue their passions and break through societal barriers, ultimately reshaping the scientific landscape.

To Sum Up

Concludingly, the thesis in its chapters explores authority, morality, and responsibility in the context of scientific development and political power. Chapter one examines the scientists' agency to dissent and the erosion of that agency in an authoritarian environment. It

also touches upon the influence of political ideologies on scientists and the authority that political and military bodies exert over their actions. It examines the conflict between religious and academic authorities and the struggle for scientific acceptance. Additionally, it delves into the shifting authority from religion to science and the unacknowledged contributions of individuals, mainly women, supporting scientists. It raises questions about the ethics and authority surrounding scientific exploration and the dynamics of authority within the scientific community focusing on the moral dilemmas faced by scientists during times of conflict. The thesis portrays the clash between religious and scientific authorities and the struggle for intellectual freedom in education.

In the second chapter, the use of formalized language, literary allusions, and wordplays effectively portrays the ordeals faced by scientists. The thesis studies the plays' structure, setting, sarcasm, poetic embellishments, comic relief, historical context, and humour which add depth to the narrative and aid in understanding the characters' situations. The chapter explores the intersection of politics and scientific inquiry through rhetoric and irony, while also intertwining science into the play's content and form. The chapter explores the possibilities of bilingualism and literary techniques merging science and drama, and highlights scientific nomenclature, gender roles, and language barriers. The thesis also delves into uncertainty, language, and moral implications through non-linear plots and metaphors. These plays showcase the power of literature to explore complex historical events and the implications of scientific progress.

The third chapter examines the use of props, costumes, stage designs, lighting, projections, and documentary elements to create an engaging and immersive scenography. Symbolic imagery such as stars and stripes, and military uniforms represents the conflict between the state and the scientist. Props like Senator McCarthy's interview, reports, files,

documents, atomic bombs, and the trial stand contribute to the understanding of the plays' context and themes. The chapter explores the use of projectors, projected texts, cyclorama, banners and musical pieces as theatrical elements to enhance storytelling and explore scientific and ethical themes. The chapter examines the utilization of props, stage settings, costumes, and lighting to immerse the audience in thought-provoking experiences and leave a lasting impact.

Furthermore, the thesis portrays the life and accomplishments of women scientists, shedding light on the challenges faced by women in science and their overlooked contributions. The second chapter discusses the limited opportunities, exclusion, and ridicule faced by women in science. It also explores the reduction of women in science to their gender and the limitations imposed on women who pursued science. The section on *Photograph 51* focuses on Rosalind Franklin's challenges, including gatekeeping, sexism, and antisemitism, as well as the appropriation of her work. *Silent Sky* highlights the gender inequality, undervaluing of women's work, and hostile environment experienced by women in STEM fields, emphasizing the perseverance and achievements of Henrietta Leavitt. The chapter serves as a reminder of the ongoing fight against gender inequality and the importance of recognizing and valuing women's contributions in science.

With the aid of the four chapters, this research strives to address the knowledge gap in the field of literature and science. By adopting a comprehensive outlook towards science plays, this work attempts to bring together the different voices in the field. This thesis has thus attempted to demonstrate novel viewpoints that scholars can take for a literary analysis of science plays.

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