

**Staging the Scientist: The Representation of Science and its Processes
in American and British Drama**

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“Putting on a play is a sort of a scientific experiment. You go into a rehearsal room which is sort of an atom and a lot of these rather busy particles, the actors, do their work and circle around the nucleus of a good text. And then, when you think you’re ready to be seen you sell tickets to a lot of photons, that is an audience, who will shine a light of their attention on what you’ve been up to.”

Michael Blakemore, Director of Copenhagen

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ABSTRACT

KEYWORDS: performance, science, drama, theatre, science play

The aim of this dissertation is to demonstrate that drama, performance and science are naturally interconnected. Various plays introduce science into their dramatic content, structure and performance by means of different dramaturgical strategies, and the objective of this dissertation is to present this diversification of science plays. In this dissertation I discuss three different representational strategies of science in recent American and English plays. My corpus includes: *Copenhagen* (1998) by Michael Frayn, *Photograph 51* (2008) by Ana Ziegler, and *Mnemonic* (1999) devised by Complicite company, and conceived and directed by Simon McBurney. *Copenhagen* is a metatheatrical play that demonstrates complicated science in an attractive and accessible way for the audience/readers. It tells a story about Heisenberg, Bohr and his wife Margrethe who meet after their death in the vague, spirit world to talk about what happened in Copenhagen in 1941. *Photograph 51* stages the competition between four prominent scientists to discover the double helix of DNA structure, and it captures the psychological portrait of Rosalind Franklin, who contributed greatly to the DNA structure discovery. *Mnemonic* is the “alternative” or “postdramatic” science play that stages two parallel stories: The journey of Welsh-Lithuanian Alice, a contemporary woman, who mysteriously left her boyfriend Virgil to look for her never seen father in Eastern Europe; and the 1991 discovery of the Iceman, a frozen body found in the Northern Italian Alps that thought to be more than five thousand years old. These two stories function within a third, bigger narrative, which is about private and cultural recollections.

The analyses of these science plays are based on the common research questions: How are science, scientific process or scientist presented in the plays? What is the role of this representation? How do the plays rework conventional paradigms of perception of science and how do they reveal the nature of the scientific process? How are real facts transformed in the plays? What is the role of this transformation? What is the nature of performance in each play and how it is related to the dramatic content? Is the scientist the tragic hero and if so, what is the tragic conflict? And finally what is the structure of the play, what literary conventions does each play rework and what dramaturgical strategies and choices they operate?

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Introduction

Art in its mimetic impulse has been following contemporary constant changes in science and technology, and their impact on human relations. This is visible in all forms of literary genres including drama. “Science plays” were, and still are, reflections on the role of science in contemporary life and society. Naturally, this interest in science has brought to the center of attention the figure of scientist himself or herself and the process of making science and of scientific discovery. Dramatists tried to scrutinize the scientist’s motivations and ideas, and wanted to reveal the less known aspects of the scientific process.

The origin of science plays can be traced back to the 17th century, when Christopher Marlowe wrote *Doctor Faustus*, a play about the great scientist who sold his soul to possess the knowledge about black magic and alchemy. Since that time, the science play genre has evolved and nowadays there are various types of science plays, for instance, science plays written by playwrights who dramatize some scientific concept, figure or event from the history of science; science plays which are vehicles of advocating and teaching science; or science plays which are a product of collaboration between scientist and theatre directors. The purpose of this dissertation will be to discuss three different representational strategies of science in the recent American and English plays. My corpus will include: *Copenhagen* (1998) by Michael Frayn, *Photograph 51* (2008) by Ana Ziegler, and *Mnemonic* (1999) devised by Complicite company, and conceived and directed by Simon McBurney.

I have chosen *Copenhagen* because it successfully deals with hard science by means of an intentional interdependence of dramatic form and content. *Copenhagen* is an example of the metatheatrical play as the actors, who are moving and speculating on the stage, are performing at the same time the ideas introduced into the dramatic content. The play’s ability to demonstrate complicated science in an attractive and accessible way for the audience with the usage of powerful metaphors woven from the scientific material, makes *Copenhagen* a canonical science play.

The next chosen play is *Photograph 51* which deals with the process of one of the most groundbreaking scientific discoveries of the 20th century, precisely the discovery of the double helix of DNA structure. *Photograph 51* stages the competition between four prominent scientists to discover what some call “the secret of life”, and it captures the psychological portrait of Rosalind Franklin, who contributed greatly to the DNA structure discovery.

The last play to be discussed is *Mnemonic*. My selection of *Mnemonic* is motivated by the play’s achievement of conveying science mainly through the performance. *Mnemonic* represents the recent wave of science plays, which are not based on one fixed text, but various scripts that may be used in the performance. Such plays depend more on the active participation of the audience, and the physicality and visuality of acting.

This dissertation comprehends four chapters: In the first chapter, I will mainly problematize the object of science play and its main traits by a brief analysis of the two plays: *Life of Galileo* (1945) by Bertolt Brecht and *The Tragical History of the Life and Death of Doctor Faustus* (1592) by Christopher Marlowe, which I treat as prototypes of science plays. Apart from that, I will present possible classifications of science plays in terms of their thematic content, dramatic structure and theatricality; and I will explain why science has become an area of interest of playwrights.

In the second chapter, I will analyze *Copenhagen*. The structure of the play, its content and the performance are organized in terms of the uncertainty principle, discovered by Werner Heisenberg, and the complementary principle, discovered by Niels Bohr. These two great physicists were pioneering science during the Second World War, but when they met in Copenhagen in 1941 their friendship and possibility of continuing a common work had been interrupted by the realities of the war. Frayn, in his complex play imagines a reunion of Heisenberg, Bohr and his wife Margrethe after their death to talk about what happened during the mysterious meeting in Copenhagen in 1941. The characters explain themselves and their motivations, but the readers and audiences, according to the uncertainty principle, are not allowed to be sure that they have reconstituted what Heisenberg and Bohr exactly said to each other in 1941.

In the third chapter, I will analyze *Photograph 51*, which reveals the competitive nature of the scientist and portrays the personality of Rosalind Franklin. *Photograph 51* dramatizes the circumstances of the 1953 discovery of the DNA double helix and revisits the role of four scientists in the process of this discovery, namely the geneticist James Watson, and biophysicists Francis Crick, Maurice Wilkins and Rosalind Franklin. The controversy that revolves around that historical event is that the three men were awarded the Nobel Prize, while Rosalind Franklin, who contributed substantially to the discovery, remained largely unnoticed. However, the dialogues in the play are not only limited to the issues of what constitutes grounded discovery and who deserves to be considered the creator of a theory but also rework ethical and philosophical questions, for instance, whether one scientist has the moral right to use the findings of another scientist without his/her knowledge or permission, or whether the human's actions are irreparable.

In the last chapter, I will discuss *Mnemonic*, which explores the mysteries of the memory by storytelling that relies on corporal expression and mime acting combined with visual imaginary, sound and lighting effect, and the use of video projections. The play stages two parallel stories: The journey of Welsh-Lithuanian Alice, a contemporary woman, who mysteriously left her boyfriend Virgil to look for her never seen father in Eastern Europe, and the 1991 discovery of the Iceman, a frozen body found in the Northern Italian Alps that thought to be more than five thousand years old. These two stories function within a third, bigger narrative, which is about private and cultural recollections.

The analyses of the plays will be connected by the common research questions: How are science, scientific process or scientist presented in the plays? What is the role of this representation? How do the plays rework conventional paradigms of perception of science and how do they reveal the nature of the scientific process? How are real facts transformed in the plays? What is the role of this transformation? What is the nature of performance in each play and how it is related to the dramatic content? Is the scientist the tragic hero and if so, what is the tragic conflict? And finally what is the structure of the play, what literary conventions does each play rework and what dramaturgical strategies and choices they operate?

Chapter I

Science on stage: Background

I. 1. Introduction

The gap between science and humanities that can be encountered in the contemporary art, system of education and everyday life is distressing. The medium that has been trying to bridge this gap for centuries was literature; and science plays in particular. The advantage of drama as a piece of art is that it not only functions as a text but also in the theatre, on the stage where it is transformed into a vivid performance. Probably this double function of drama makes it a powerful device of putting together the world of science and humanities. In this chapter I will discuss a variety of plays which successfully involve science in their dramatic content. By a brief analysis of the two plays: *Life of Galileo* (1945) by Bertolt Brecht and *The Tragical History of the Life and Death of Doctor Faustus* (1592)¹ by Christopher Marlowe, which I treat the prototypes of science plays, I am going to render the object of the science play and its main traits. I will also present possible classifications of science plays in terms of their thematic content, dramatic structure and theatricality. Apart from that, I will explain why science has become an area of interest of playwrights, which is crucial for understating what a science play actually is. I will also recall periods in the history of literature when similar attempts were taken to merge science with art.

I. 2. Between two cultures

In his lecture *The Two Cultures and the Scientific Revolution* (1959) C.P. Snow gives an acute and perspicacious commentary on the condition of the modern society in terms of education, communication and socio-technological changes. By analyzing British and Western societies he distinguishes two autonomous cultures: the first one makes literary intellectuals and the second produces scientific intellectuals. Each of the groups has its own way of life, point of view, attitude, even language, but what makes

¹ Here referred to as simply *Doctor Faustus*.

them two distinct cultures is there a mutual incomprehension, a contempt for each other and a complete lack of communication. For this situation C.P. Snow blames the flawed British educational system, pointing out that English students are educated to be specialized in a narrow discipline, while they lack a general background. For instance, electrical engineers are experts in their field, but the majority of them does not know the masterpieces of English literature.

C.P. Snow believes that the system of education needs “re-thinking”, so that scientists and non-scientists would be able to work together and take part in a creative intellectual experience. C.P. Snow was by himself a scientist and a novelist, thereby he personally had had a chance to understand how much scientists and non-scientists lose by not cooperating with each other. In his opinion, the confrontation of those two different cultures, two different paradigms would bring creative results and new powerful possibilities.

The clashing point of two subjects, two disciplines, two cultures – of two galaxies, so far as that goes – ought to produce creative chances. In the history of mental activity that has been where some breakthroughs come. The chances are there now. But they are there, as it were, in a vacuum, because those in the two cultures can't talk to each other. (*The Two Cultures* 17)

The scale of the problem sketched by C.P. Snow is proportional to the numerous responses to his lecture. He was wildly read in Europe and America, and in 2008 *The Times Literary Supplement* included the edition of his lecture in the list of 100 books that most influenced Western public discourse since the Second World War. His work found many followers and critics. For instance, the writer who intended to follow the discussion launched by C.P. Snow and find the bridge between the “two cultures” is Glynne Wickham. In the lecture he gave in 1961 at the University of Bristol entitled *Drama in a World of Science*, he paid attention to the same fact that C.P. Snow did, namely that the 20th century educational system was not constructed to unify knowledge, but to fragment it. In other words, the subjects were artificially divorced and narrowed down to specializations, which consequently led to the division of society. The students, instead of gaining a wider knowledge, narrowed their horizons and mental capacities; instead of learning how to understand their society, its tradition and prospects, they were consistently separated from it.

In Wickham's opinion, the area of knowledge that had the capability to encompass other fields of studies, for example science, is drama. He recalled the words of Eugene O'Neill, who observed that "dramatists were psychologists – and good ones at that – before psychology was thought of" (qtd. in Wickham 46), indicating that drama was exploring various fields of studies well ahead they were invented. Thus, drama was an art of living that could lead and unify other disciplines. Wickham expresses this notion by saying:

I ask you to think of drama as a discipline centered upon the comparison of moral values – technological, social, and individual – and equipped at its frontiers with launching sites for a great variety of journeys into other disciplines. Drama, I submit, far from being 'no subject', is in fact a subject with remarkable integrating power, a subject that can relate the ancient world to the present day, which can bring critical appraisal into direct contact with creative experiment, which can provide the arts man with lively introduction to scientific thinking and the scientist with as lively a reflection of his own human condition. (56)

Wickham thinks of drama as a piece of art that can provide a discerning insight into the world of science and other interrelated areas of knowledge. The discussion about the idea of the unification of knowledge, launched by C.P. Snow and later continued by Wickham, is reflected in various contemporary works, for instance in the book *Consilience: The Unity of Knowledge* (1998)² by Edward O. Wilson.

C.P. Snow, after critical responses to his lecture, published his own reflections in the follow-up *The Two Cultures: And a Second Look: An Expanded Version of The Two Cultures and the Scientific Revolution* (1963). In the second essay he meditates more optimistically on the potential of intellectual dialogue and considers a possible third culture which would be a mediator between the scientific and humanistic worlds. In Snow's third culture, the literary intellectuals would be on speaking terms with the scientists. However, C.P. Snow does not discuss the nature of the mediator between the two cultures as he believes that "It is probably too early to speak of a third culture already in existence. But I am now convinced that this is coming." (*A Second look* 70-

² Wilson in his book discusses forms of unification of human knowledge, in particular the unification of the biological sciences and the humanities. He uses the term "Consilience" to name such a unification. Wilson is also a founder of sociobiology.

71) In his opinion, concepts such as “organic community” or the nature of the pre-industrial society are the manifestation of the impending third culture.

It has been exactly fifty years since *A Second Look* was published and one may wonder if the third culture was only C.P. Snow’s dream or a credible prediction which finds its reflection in the contemporary reality. Is there nowadays any material evidence of putting together two different realities? There are probably many forms of conversation between science and humanities, starting with interactive exhibitions, educative festivals and ending with new interdisciplinary studies. However, in my dissertation I will focus on literature, precisely on the creative clash between theatre and science and its “offspring”: the science play, which is one of the most interesting and developing forms of union between humanities and science. The origin of the science play can be probably traced back to the 17th century, when Christopher Marlowe wrote the drama *Doctor Faustus* about the great scientist who had devoted his soul to black magic and alchemy. Other science plays which feature the scientist in their center are Ben Jonson’s *Alchemist* (1610), George Bernard Shaw’s *The Doctor’s Dilemma* (1906), Bertolt Brecht’s *Life of Galileo* (1945), Howard Brenton’s *The Genius* (1983), Friedrich Dürrenmatt’s *Physicists* (1962), Timberlake Wertenbaker’s *After Darwin* (1998), Michael Frayn’s *Copenhagen* (1998), and many more. After the Second World War, science plays emerged one after another describing both the danger of advanced technology and revealing the personality of scientists as the initiators of technological revolution and the originators of mortal weapons like atomic bombs. The figure of the scientist and the scientific processes were and still are an infinite source for science playwriting, which will last as long as science is dynamically developing.

Science plays

(...) have made the stage a major forum for the exploration of the scientific ideas and given the theater pride of place as the site of substantive interaction between the hard sciences and humanities. No other gender or art form has seen such a powerful merging of the two cultures of science and humanities. (*Science on Stage* 1)

Recent plays such as Carl Djerassi’s *The Newton’s Darkness: Two Dramatic Views* (2004), Crispin Whittell’s *Darwin in Malibu* (2003), Caryl Churchill’s *A Number* (2002) and Peter Pranell’s *Trumpery* (2009) are the best evidence that science playwriting has reached a high point of maturation.

There are of course other literary forms that engaged science successfully. An especially fruitful era was positivism – a trend in Polish literature³ that based its ideology on the indisputable, verifiable laws of science. The role of the positivist writer resembles the attitude of the scientist – he is obliged to make a research about the processes which shape the condition of society and subsequently note his results in the literary form, preferably a novel. Thus, a positivist writer, like a scientist, to describe and explain the world, must reject subjectivity, the interest in the metaphysical phenomenon, and the emotional attitude; instead he ought to promote rational reasoning, objectivity and documentary truth which should be verified easily by empirical experience. Moreover, the writer-scientist has to study the sociological processes by finding the origins and results of each process. The writer can specify the future acts of the society only by such a rational reasoning.

The positivist literature had a didactic tendency and one of its aims was to educate the society. The greatest positivist works were written by Bolesław Prus, Stanisław Sienkiewicz, Eliza Orzeszkowa, Gabriela Zapolska, Maria Konopnicka and Aleksander Świętochowski. They are a priceless documentation of the condition of societies in the times of industrial revolution, the women's liberation movement and the increasing significance of national minorities. In their novels there is a visible

³ Positivism in the Western countries is recognized as a trend in philosophy, while in Poland the same trend was also prevailing in literature. Its beginning can be traced to 1863, a year of January Uprising against the occupying army of Imperial Russia. Another important date associated with the origins of Polish positivism is 1871 when the article "My I Wy" (transl. "We and You") written by Aleksander Świętochowski was published in *Przegląd Tygodniowy*. The article is a manifestation of positivism in Polish literature and Świętochowski blames the old generations of writers, representatives of romanticism, for being narrow-minded and precluding the new generation of positivist writers from the literary and ideological debate. After this manifestation, the positivist literature gained on its strength and positivist writers published their masterpieces, for example Bolesław Prus' *The Doll* (1887-1889), *The New Women* (1890-93), *Pharaoh* (1895-1896) or Eliza Orzeszkowa's *On the Niemen* (1888), *The Boor* (1888).

Positivism was one of the most fruitful eras in Polish literature. The novels and stories written at that time were related to the political and sociological situation in Poland. It is said that Polish positivism was not only a trend in literature, but also a socio-cultural movement which as its main aim had the fight for freedom by educating society. The program of Polish positivism was based on four principles: "organic work" which assumed that society works like a human organism: each organ of the country has to work well, so the whole society can be healthy; "praca u podstaw" (transl. work on basis) which states that rich part of society has to give an intellectual and economical support to people situated at the bottom of the social ladder; the assimilation of Jewish and national minorities; the emancipation of women. More about positivism in Polish literature in *The History of Polish Literature* (1983) by Czesław Miłosz (pp. 281-322).

influence of philosophical ideologies inspired by science: Herbert Spencer's organicism, August Comte's scientism, John Stuart Mill's evolutionism and utilitarianism.

Another interesting literary and philosophical movement, which derived from scientific laws was naturalism – a follow-up of realism. The most important theorist and disseminator of naturalism was Emile Zola. In his treatise *Experimental novel* (1880), he explained the program of naturalism including the writing techniques and the mission of the writer. According to Zola, the writer should be also a kind of scientist, but his interest would revolve around the lowest social classes like peasants, thieves, villains and poor townspeople. His novels are the documental record of social injustice, abnormalities and pathologies. Zola was also paying attention to the human physiological needs; for example, in his cycle of novels *Les Rougon-Macquart* (1871-1893) Zola describes in detail what happens with man's mind and body when he/she is starving, dying or having sex. Naturalists, including Zola, believed that man was behaving according to his physiological needs and his life was driven by the instinct of survival. The naturalist philosophy was inspired by Darwinism and in Zola's novels the motives of death and the topic of the fight to survive prevail. In *Les Rougon-Macquart* there is a visible influence of turpism and direct comparison between a man and animal.

Although Zola, in *Experimental novel*, was advocating the objectivism of the narrator, his novels were not a complete study of the society but rather the selected description of social abnormalities. The crucial point of Zola's theoretical book is when he claims that the novel has to be a record of the scientific experiment: the naturalist, in the beginning of writing a novel, has to assume a hypothesis and the fate of the characters must demonstrate or prove this hypothesis. Moreover, the writer can state that hypothesis only if he previously made an exhaustive research about the condition of society and if he is an expert in the field he has chosen.

I. 3. Brief typology of science plays

The idea of art as a scientific experiment is reflected in some science plays like *Copenhagen*, *After Darwin* or *Molly Sweeney* (1994) by Brian Friel and *Arcadia* (1993) by Tom Stoppard. The writer of such science plays derives the topics, motives and

archetypes from the world of science and makes them figure as a metaphor on a textual and theatrical level. The actors perform the scientific ideas by talking with each other and moving on the stage. The science plays that enact ideas that have been introduced into the content of the drama are metatheatrical: the text is literary performed by the actors. The theatrical device which enables enacting scientific ideas is the defamiliarization of the stage: There are few actors and their costumes are these of every man; sometimes they double the role and they perform on the empty stage with no props, just with chairs and, if necessary, a table.

Although the stage is completely non-realistic, the actors are real-looking and they present a real dramatic conflict. Shepherd-Barr explains that in such plays “The realism is not abandoned, but it is thrown into sharp relief and questioned” (*Science on Stage* 42). In that sense “metatheatrical science plays” are experimental. They are written and staged in a manner that deviates from realism⁴. Plays like *Copenhagen* or *Arcadia* do not have a linear action and traditional stage directions, and act and scene divisions. Paradoxically, the dramatic structure is not “well made”, but it enables to employ metaphors that spin the form and content.

Kristen Shepherd-Barr distinguishes a group of science plays which are metatheatrical. In the introduction to her book *Science on Stage* she stresses that:

The most striking contribution is that the best ones [science plays] successfully employ a particular scientific idea or concept as an extended theatrical metaphor. They literally enact the idea that they engage, a performativity that is creative and innovative and that has occurred so consistently in science plays that it is more than just a trend or coincidence. (...) The extraordinarily through integration of real science into the texture of these plays is one of the defining characteristics of good science plays – successfully harnessing a theatrical language to a scientific one. (6)

The uniqueness of these kind of plays depends on “conscious theatricality”, which means the intentional performance of the ideas involved in the drama. Such science plays became highly successful and they attracted the attention of the theatre-goers, critics and scientists. The most compelling feature in science plays, like

⁴ Not every metatheatrical science play is characterized by a staging that deviates from realism, but the simplification of the setting of the stage is the device that facilitates the performance of such science plays.

Copenhagen, seems to be the liveness of the performance and the real science incorporated into theatre.

Nevertheless, the plays that successfully merge the content with the form and the performance are just one group of science plays. There are also plays that are more traditional in the sense of having a linear plot and organized structure like *Trumpery*, or *Inherit The Wind* (1955) by Jerome Lawrence and Robert Edwin Lee, and *Experiment with an Air Pump* (1998) by Shelagh Stephenson. “Traditional science plays” do not employ complicated science in their plot, but rather make a use of an event from the history of science⁵. For instance, *Trumpery* is about Charles Darwin’s struggles to publish *The Origin of Species* and his competition with the researcher Alfred Russel Wallace to establish priority. Another play, *Inherit the Wind* fictionalizes the famous The Scopes Trail⁶ and raises the debate about creationism versus the theory of evolution. However, these plays are traditional, especially in terms of their form, not content, as there are many metatheatrical science plays which also fictionalize authentic events from the history of science, for instance *Copenhagen*. Science plays like *Trumpery* might be classified as traditional, most of all because they respect conventional staging methods and the traditional structure of the play like act and scene divisions.

Science plays that can be also regarded as traditional science plays are those, whose main purpose is didactic. For instance, Carl Djerassi, the author of *The Newton’s Darkness: Two Dramatic Views*, is not a professional writer but a scientist who treats the theatre as a vehicle of teaching and promoting science. Interestingly, the content of didactic dramas is undeniable, while their theatricality is very weak. They employ

⁵ The fact that this type of drama do not engage any real scientific issues, but tell a particular story connected with science may undermine their status of science plays. If one claims that the main feature of science plays is a scientific concept introduced into the play and consequently enacted on the stage as a metaphor, dramas such as *Trumpery* or *Inherit the Wind* probably should not be classified as science plays but rather plays about science.

⁶ The Scopes Trail, commonly referred to as the Scopes Monkey Trial, was an American legal case in 1925. John Scopes, a high school teacher from the small town of Dayton, Tennessee was accused of teaching the theory of evolution, which was violating Tennessee's Butler Act. Scopes was found guilty and had to pay fine 100 \$. The purpose of the trial was to attract intense national publicity as big-name lawyers William Jennings Bryan (the prosecutor) and Clarence Darrow (the defender) had agreed to represent each side.

some scientific ideas or concepts, but they are unable to stage science in an aesthetically consistent way.

Judy Kupferman in the article *Science and Theatre* presents another classification of science plays, which is based mainly on the topics they undertake. The first category is made of dramas whose main area of interest is how science affects society, for example *The Physicists*; the second type of science plays include dramas that depict scientists as people - it has the purpose of making the figure of the scientist, abstract in the public imagination, more authentic, for example *The Newton's Darkness*; the last group of science plays are those that introduce scientific ideas into the theatrical performance, for example *Arcadia*.

Sheppard-Barr notices that as far as such classification enables to distinguish science plays in terms of their thematic content, it does not take into account theatricality. In *Science on Stage* she proposes an alternative classification that involves both science and theatre. She distinguishes plays that are written by playwrights who dramatize a scientific concept, figure or event from the history of science, for example *Photograph 51* (2008) by Anna Ziegler. The second type of plays are works written by scientists who are interested in conveying the scientific ideas by the medium of the theatre, for example *The Newton's Darkness*. The last type includes science plays which are a product of collaboration between scientist and theatre directors (who sometimes are playwrights as well), for example *Mnemonic* (1999) by Complicite. It is easy to understand that Sheppard- Barr, while classifying science plays, pays a special attention to who writes them. In this case the profession of the writer indicates in what way science could function in the play and how it could figure on the stage.

In the next section I will discuss why science became an area of interest of dramatists and why theatre came across as the most suitable medium for performing science. Theatre as a medium of choice is in this case not accidental and understanding the relation between science and theatre is crucial for understanding what the science play is.

I. 4. Science and theatre

In the end of the 20th century new media like magazines, television and internet made science accessible for ordinary people. By dint of these inventions they could learn about the new achievements of science such as the technological devices which are part of contemporary life, for example the television or the cell phone. Nevertheless, in television or magazines the process of scientific discoveries is barely explained and it is reduced to the presentation of its moments. In other words, mass media is used to inform people about the new scientific revelations, but it fails to educate them by explaining the scientific process in an attractive and accessible way.

One of the roles of theatre is to turn the mysterious and complicated scientific material into a vivid performance. The attractiveness of the theatre performance is mainly based on the possibility of dialogue between the actors and the audience. People are able to respond to what they see on the stage which makes each theatrical performance highly individual. The mysteries of science and its processes can be finally revealed. Who is the scientist? What is the context of the scientific invention? The audience is keen on understanding the individual scientific process which accompanies every invention. Michael Frayn stresses the interactive role of the audience in the theatre in one of the seminars on his play *Copenhagen*:

(...) I do think that idea of the human confrontation is absolutely of the essence, the whole of art, the whole of literature, the whole of storytelling, the whole possibility of language and communication. One can't communicate with oneself unless one communicates with others⁷ (qtd. in *Science on Stage* 45)

The possibility of communication with the audience and concentration on the liveness of the performance are the attributes of the theatre which the other media lack. Film in particular fails to engage complicated science in the way that theatre does. It usually makes use of the public imagination about science and tends to turn science into fantasy. The best examples are popular science fiction films like *Metropolis* (1927) and *Inception* (2010). The reason of the difficulty to introduce real scientific issues into the action of the film can be found in the nature of the film spectatorship. First of all, a film is directed to a large audience, so there is no intimacy

⁷ Frayn at Copenhagen seminar, Niels Bohr Institute, Copenhagen, Denmark (19 November 1999).

in the performative act. Moreover, the audience cannot respond to the film performance or contribute anything to the film's production. Due to this non-dialogic nature of the film, it is more difficult to keep the attention of the audience. The story that is told in the film must be compelling enough to make the audience stay in front of the screen for about one hundred twenty minutes.

Thus, the film makers are used to abandon the difficult scientific material and if they decide to deal with science, they usually choose to fictionalize a particular story derived from the history of science or they adapt a book which concerns a scientific issue. For instance, *Proof* (2005) directed by John Madden is based on the Pulitzer Prize-winning science play of the same title⁸. It tells the story of Robert, a professor of the University of Chicago, a mathematical genius who struggles with a mental illness; and his daughter Catharine who is also a passionate of mathematics but gives up college to take care of her ill father. After the death of Robert, his student Hal finds proof for the prime number theory in Robert's office. The core issue of the film is the question who is the author of the theory, Robert or his daughter, and how the authorship can be proved.

Another recent film which revolves around the figure of the scientist is *Creation*, (2009) directed by Jon Amiel. It shows the life of Charles Darwin in the moment when he struggles with publishing *The Origin of Species*. Darwin's masterwork causes moral qualms as his revolutionary theory of evolution contradicts the beliefs of his religious wife.

Both *Proof* and *Creation* are the representation of films that are successful in telling a complete story which concerns science or the figure of the scientist. In that sense film probably has even more possibilities than theatre. The action of the film can be set in many places and it can involve any number of actors including movie stars. For instance, *Proof* starred very famous actors like Gwyneth Paltrow and Anthony Hopkins. Another example is film *A beautiful mind* (2001)⁹ directed by Ron Howard

⁸ *Proof* is a drama written by the American playwright David Auburn and premiered in Off-Broadway theatre in 2000. The play won the 2001 Pulitzer Prize for Drama and Tony Award for Best Play.

⁹ *A Beautiful Mind* was a commercial success and won four Academy Awards for Best Picture, Best Director, Best Adapted Screen Play and Best Supporting Actress.

where the main role is played by Russell Crowe, nominated for the Academy Award for Best Actor. One also cannot ignore the financial and visual predominance that film has over the theatre. For instance, in the film special visual effects can be used, which make the action of the film more attractive for the audience.

On the other hand, the financial and stage limitation imposed on the actors probably gives the theatre its appeal. Interestingly, the directors of the science plays sometimes do not even use the possibilities of stage as they could. Especially in metatheatrical science plays like *Copenhagen* or *A number* only a few actors are performing with almost no props, sometimes just chairs and a table on the empty stage. The bareness of the stage forces the audience to concentrate on the dialogue. Shepherd-Barr notices that the “theatrical experience is doubly dialogic; characters converses on stage, while in a larger sense the actors maintain an unspoken dialogue with the audience.” (*Science on Stage* 45) Textual or dialogical abundance and minimalism of the stage is characteristic for the science plays. The audience, focused on the dialogue, is more involved in the performance and feels like a part of the scientific experiment which happens on the stage. The fourth wall is broken and the audience interact with the vivid performance.

However, not only the nature of the theatre is suitable for science, but, similarly, the nature of science is suitable for the theatre. At the core of every play is the tragic conflict and the world of science provides endless material of possible conflicts that can be introduced to the drama. In science plays the tragic conflict is built on the network of ethical dilemmas and fundamental questions that impact our lives; for instance, they may ask the question if the scientist is responsible for the changes in the life of society provoked by his invention. The conflict in some science plays is also centered in the figure of the scientist, whose historical authenticity and frequently unconventional behavior makes him a perfect tragic hero. The scientist is driven by the desire to gain more and more knowledge, he questions the reality familiar to society and he does not accept the prevailing knowledge. Such a powerful personality is a great inspiration for playwrights.

Moreover, dramatists are interested in science because it has become so crucial for our lives that it calls for illumination. Science and everyday activities are

nowadays entwined and one cannot imagine life without technological inventions. Art in its mimetic impulse has been following constant contemporary changes in science and technology and their impact on human relations. This is visible in all the literary forms, including drama. Science plays have always been reflecting the role of science in the contemporary life of society. Science playwriting has even created its own mythology based on science and its inventions. Science plays have their own literary form, specific language and heroes. They have also their own illustrative metaphors generated from scientific ideas or experiments. Interestingly, recent science plays make use of very complicated scientific principles, like the second or the third theory of thermodynamics. The theories are turned into metaphors and they are used to illustrate some ideas or notions that are important for our lives. For instance, in *Copenhagen* the uncertainty principle is turned into a metaphor of the uncertainty of human motivation. Frayn shows that the conflict between characters has its origin in the fact that one human being will never know another human being entirely, that A will never understand what B exactly wanted to say and moreover A will never understand entirely himself.

The playwrights create the metaphors to destabilize the familiar notions of truth and reality. The world of science has its own rules and the author of science plays makes the readers confront that world. The result of this confrontation gives most of the time creative results and forces readers and audience to look at their lives from a different perspective. The common sense of understanding reality is reestablished and new qualities are revealed due to the engagement of scientific principles to the dramatic world.

There are probably many more reasons why drama willingly adopted scientific material. However, my aim was to show that the association of science with drama is not a bizarre hybrid, but rather a creative cooperation. The popularity of some science plays proves that science may be successfully involved in the dramatic act and that the audience, scientists and critics observe this engagement of science and drama with curiosity and enthusiasm. For many, the figure of the scientist and the process of the scientific discovery still remains a mystery that is awaited to be revealed as the audience is drawn to the pursuit of truth and knowledge.

I. 5. The tradition of science plays

Science and drama have experienced a fruitful intersection for centuries and recently science is becoming the most compelling topic in the theatre. Science plays encompass many periods, scientific fields and ideas: physics, biochemistry, biology, genetics and astronomy are just examples. The decisive year for the clash of science and theatre was 1998 when Michael Frayn's *Copenhagen* was staged. Its unprecedented success led to a wave of science playwriting: plays like *Darwin in Malibu* or *A Number* made the stage a place to debate important scientific ideas and to discuss the influence of powerful scientific figures.

Science plays have a combination of some common critical features such as the representation of the scientist as a hero or a villain, the engagement with real scientific ideas, the integration of form and content, and a complex ethical discussion. However, one has to bear in mind that each science play is individual and it is never written according to one pattern. Science playwriting is still developing and the latest plays are very different from those written in the 20th century. As it is impossible to discuss all of the science plays and their variety I will briefly analyze the plays which I treat as the prototypes of science plays, namely *Doctor Faustus* by Christopher Marlowe and *Life of Galileo* by Bertolt Brecht. I chose these plays because of two reasons: first of all, they successfully engage science and manifest the features of the modern science plays; secondly they introduce the archetypical figure of the scientist and its two representations – the scientist as an overreacher and an underreacher. By analyzing the prototypes of science plays I would like to render the object of the science play and reveal its main traits.

I. 5.1. *Doctor Faustus*

There are many dramatizations of the Faustus myth but there is a particular one that lies on the basis of the tradition of theatre dealing with science. Marlowe's *Doctor Faustus* was one of the first plays that has established literary roots and a theatrical model for science plays. The play shares the common features with the modern science plays, although there are some divergences that have to be noted as well.

At first glance, *Doctor Faustus* does not seem a science play as it hardly deals with “real science”. There are few passages about astronomy and apart from that science is mostly presented in terms of black magic and alchemy. It is because in Marlowe’s time, in the 16th century, science was understood in more general terms; it was encompassing humanities and disciplines of knowledge which today are excluded from what we call “real science”, for example alchemy. The shift that occurred in the notion of science is interestingly presented by Carla Mazzio who defamiliarizes the contemporary understanding of science and stresses that in the age of Shakespeare¹⁰, science was equivalent with knowledge, “including but also exceeding what was called, in the medieval period, the quadrivium (arithmetic, geometry, astronomy and music) and the trivium (rhetoric, grammar, and logic)” (2). According to Mazzio, in the 16th century the process of making knowledge of any kind was called science and it could be playing lute or observing the stars - all those practices of gaining knowledge were science.

However, what matters in science plays is not the quantity of science, but how it figures both textually and theatrically. There are many science plays which are very successful and at the same time they have barely introduced any specific scientific issue into the dramatic content. For instance, in the play *Experiment with an Air Pump* there is no trace of hard science, but the drama involves two major topics which are characteristic for science plays: it is the unscrupulousness of the scientist and the danger that science would serve big business’ purposes rather than helping the society.

In *Doctor Faustus*, science or the usage of science is centered in the figure of the scientist. Here we encounter one of the first representations of the scientist in the play and *topos* of the failure of man who has ventured to pursuit the banned knowledge: The curiosity of Icarus led him to the unfortunate downfall, while the curiosity of the biblical Adam made him lose privileges given by God. Marlowe repeats this *topos* and Faustus has to sell his soul to the devil in exchange for possessing the supernatural knowledge. The Faustian bargain is the embodiment of the enormous

¹⁰ By referring to the age of Shakespeare I am referring to the age of Marlowe as well. Both writers are from England and they were born in the same year, 1564.

price that one has to pay if she/he wants to gain complete wisdom. In the modern science plays this topic is transformed into “the idea of science having gone too far and created a hell on Earth” (*Science on Stage* 18). Especially the post-war plays identify science with something which led to man’s destruction. The ethical aspect of such plays is more complex than in *Faustus*: the scientist is not responsible for the individual destruction but rather for his inventions which influence society in a negative way. For example, in *Physicists*, three scientists have to struggle with their crimes which have allegorical meaning in the play. The murder of the nurses is linked with the murderous potential of physics. The characters of the play represent two different approaches to the perilous power of science: The patient Newton believes that the moral concerns about consequences of using scientific knowledge should be abandoned for the sake of pioneering science, while Einstein claims that the scientist cannot escape the responsibility of providing the society with a huge source of power.

In *Physicists*, the division between good and evil, love and murder, sanity and madness, tragedy and absurdity is blurred. Many post-war science plays like *Physicists* do not have a didactic purpose. They propose topics and raise questions to discuss, and they ask the audience to confront them. In opposition, *Doctor Faustus* remains the inheritor of the medieval morality plays. The demarcation between good and bad, divine and infernal, is very clear and the audience suspects Faustus’ self-destruction after he has decided to sell his soul. Angels, like in morality plays, are personifications of the good forces and they fight to rescue Faustus’ soul, but Faustus refuses good advises and he immerses himself in the black magic even more profoundly. The fate of Faustus is not the result of *fatum*, like in the antique tragedies. Faustus, in opposition to Oedipus, is consciously choosing his fate by negotiating with the devil.

However, the huge knowledge that Faustus possesses with the help of the devil does not give him any power. He uses his abilities to make cheap tricks and play pranks on the Pope. Marlowe explicitly links Faustus’s illicit practices with the theatrical illusion. Faustus is the personification of the idea of theater as a place of illusionist, theatrical practices. His figure is the core of many metatheatrical moments in the play, for example when he presents himself as the performer: “Then in this show let me an actor be, That this proud Pope may Faustus’ cunning see.” (30). Faustus is wasting his

supernatural powers to play tricks instead of gaining worthy knowledge which could be used for good.

This conscious theatricality is an inherent component of the modern science plays like Hallie Flanagan's *E=mc²* (1948) and Ewan MacColl's *Uranium 235* (1952). These dramas use an abstract idea which is consciously performed on the stage. For example, *E=mc²* is one of the first modern plays which successfully has merged form and content. The character of Atom is allegoric: it is unpredictable and unstable like human behavior. The use of the allegorical figures and archetypes in *E=mc²* is the echo of the metatheatrical moments of *Doctor Faustus*. "By putting the archetypal scientist on the stage, Marlowe helped to establish a link between theatricality, science and subversion that we find again and again in the science plays" (*Science on Stage* 19). Since *Doctor Faustus* was written, the stage had become a place of subversive energy, where the ideas generated from the scientific qualities were cumulated.

I. 5.2. *Life of Galileo*

Another very interesting model of the scientist is presented in *Life of Galileo* by Bertolt Brecht. The drama plays a central role in the development of science plays by its representation of the scientist. Brecht wrote many versions of *Galileo* and in the first ones the scientist is presented distinctly as a hero who fights for the enlightenment of society. However the final version of the play (1947) had dramatically changed after two very important events in human history: the Second World War and the use of atomic bombs on Hiroshima and Nagasaki. Brecht was very criticized for changing facts of real history and multiplying the draft versions of *Galileo* according to political purposes. In the final version of the play, there is a strong tension of the individual desires of the scientist and his responsibility for society. Here, the scientist has to identify with his destination and understand what the consequences are of providing the society with dangerous knowledge. In the play, there are many scenes when the negative role of science is underscored. For example, Galileo is accused by the authority of the church that his discoveries do not contribute anything positive to the life of society and that they make mob puzzled and confused. It is well illustrated in the scene with the Little Monk, who explains to Galileo why he gives up astronomy:

What would my people say if I were to tell them they were living on a small chunk of stone that moves around another star, turning incessantly in empty space, one among many and more or less significant? What would be the good or necessity of their patience, of their acquiescence in their misery? (39)

The discoveries of Galileo have resulted in a new vision of the world which conflicts with the biblical theory that man is in the center of the universe and everything else is subordinated to him. The theme science versus religion or individuality versus community appears in many modern science plays¹¹ as well as in *Doctor Faustus*. In both plays the individuality has to fight with the public opinion and church to promote his ideas and retain controversial attitude. Faustus gives up his life of a respected scholar and start to deal with magic for individual purposes, while Galileo tries to convince the church authorities to the validity of his conceptions. The difference between Faustus and Galileo is that the former is fighting for selfish purposes while the latter is working for the common good.

Galileo in the beginning believes that the enlightenment of the society would bring only positive results, but with the passage of time he realizes that his ideas only cause anxiety and confusion among the people. Galileo, due to his convictions, is condemned to isolation and surveillances of the church till the end of his life. The motif of the isolation of the scientist because of the incomprehension of others is common in the modern science plays. For instance, the variation of this motif is presented in *The Genius*; the main character Leo Lehrer has to isolate himself in the Midlands to stand up against the powerful forces of the Pentagon and MIT.

A similar situation we encounter in *Life of Galileo*, when the scientist, at some point of his life, also doubts in his mission and wonders what the purpose of his discoveries is. He represents the model of the scientist as an underreacher rather than the Faustian overreacher. Faust wanted to gain knowledge at any cost, while Galileo wished he could have taken back the knowledge that once he attained. The notion of the underreacher is prevailing in the science plays written after the Second World War,

¹¹ The best example of the play that represents the conflict science versus religion is *Trumpery*. The plot focuses on Darwin' struggles with the publication of *The Origin of Species* and the threat of being trumped by the discoveries of another scientist, Alfred Russel Wallace. Along with writing his controversial masterwork, Darwin has to face the philosophical questions whether life is an accident or if it is possible to successfully merge new scientific discoveries and faith in God.

especially those which present the scientists who are responsible for the invention of mortal weapons or who are decisive figures in the resolution of the war. In the play *The Genius*, one of the characters, Gilly, feels helpless in the face of the dangerous knowledge she has acquired. She understands that what she knows affected her usual life in the way that nothing is the same any more, even such domestic activities like eating breakfast or calling her mother. In another science play, *Arcadia*, the motif of impossibility of reversing the human thought is introduced by the metaphor of the second law of thermodynamics:

When you stir your rise pudding, Septimus, the spoonful of jam spreads itself round making red trails like the picture of a meteor in my astronomical atlas. But if you stir backward, the jam will not come together again. Indeed, the pudding does not notice and continues to turn pink just as before. (...) You cannot stir things apart. (6)

The phrase “You cannot stir things apart” is an explicit reference to the idea of impossibility to unthink something that you already know. The representation of the scientist as the underreacher plays a central role in other very well-known dramas like *Inherit the Wind*, *Physicists* or *Copenhagen*.

There is another aspect of *Life of Galileo* which had a strong influence on the modern science plays. This is conscious theatricality that has already been mentioned while analyzing *Doctor Faustus*, although it was on a textbook level. In *Life of Galileo* the only metatheatrical impulse resembling the cheap tricks performed by Faustus is when Galileo is presenting his new invention, a telescope, to the admired publicity. On the theatre level Brecht has much more to offer. He established his own model of theatre (called Brechtian Epic Theatre) which as the main trait takes *Verfremdungseffekt* – the alienation effect, “by which audiences are prevented from identifying too closely with a character and are kept at an emotional distance.” (*Science on Stage* 30) The alienation effect is made by using devices during the performance which remind the audience that they are in a theater watching a show, for example speeches directed to the audience or constant interruptions and comments. The echo of the Brechtian epic theatre can be found in the midcentury science plays, for example *The Skin of Our Teeth* (1942) by Thornton Wilder. Here the metatheatrical device is the character of Sabrina who is reporting to the audience about how the performance is going and she constantly reminds that she is only an

actress. The audience who is aware of being part of the performance does not identify with the characters and have distance to them. Other science plays which derive from the Brechtian theatre is $E=mc^2$ and *Uranium 235*. Both plays follow the Brechtian approach in their format and the way they are performed, namely in episodic structure, using archetypes, direct address to the audience and overt didacticism.

I. 6. Conclusion

The tradition of science plays that has been shown in this chapter is definitely far richer and a brief analysis of barely two archetypical plays and a selection of the modern science plays is probably a considerable limitation. However, *Doctor Faustus* and *Life of Galileo* remain distinct features which are being repeated over and over in other science plays. First of all, both plays show that dramatists treat science as a mine of illustrative archetypes, topics and ideas which create insights of human's behavior. In *Doctor Faustus* we encounter the archetype of a scientist who fails due to his aspiration to gain a supernatural knowledge. In the post-war dramas like *The Genius* this motif is even more powerful – it is not the scientist who pays for his dangerous inventions, which are products of possessing a huge knowledge, but the guiltless society. In various science plays like *Life of Galileo* and *Inherit the Wind* the scientist is aware of the danger which is implied in the status of being a genius, so he tries to reverse the knowledge, that once he acquired, by isolating himself. Nevertheless, the scientist soon realizes that the knowledge cannot be taken back and what he knows will have a major impact on the condition of society. The impossibility of unthinking what we already know is accurately illustrated by the metaphor of the second theory of thermodynamics introduced into the play *Arcadia*: You cannot stir things backward, the pudding will continue to turn pink just as before.

The possession of powerful and dangerous knowledge is also associated with a complex ethical and moral discussion. In the drama *Physicists* the patients Newton and Einstein argue about the responsibility that a scientist has to take for his invention; the former claims that the scientist should give up the moral qualms about consequences of using knowledge for the sake of pioneering science. In the play *Trumpery*, Darwin presents quite a different attitude of a scientist – he struggles to finish *The Origin of*

Species because he is aware that the theory of evolution contradicts the faith of his wife and daughter.

Doctor Faustus and *Life of Galileo* are source of thematic lines that modern plays undertake. However, there is another very important aspect of both plays that ought to be taken into consideration while discussing their influence on the modern science playwriting. *Doctor Faustus* and *Life of Galileo* are innovative in their theatricality, namely in breaking the fourth wall. In *Doctor Faustus* it is the archetypical figure of the scientist who acknowledges himself as the performer and illusionist. The repetition of this metatheatrical device can be found in *The Skin of Our Teeth* when the character Sabina is reminding the audience that she is only an actress.

Techniques that make the audience aware of the theatrical illusion were involved and developed in the Brechtian Epic Theatre. It were non-realistic stage setting, comedy convention of the play, direct speeches to the audience, episodic structure of the drama and actors doubling the roles. Similar alienation devices are inherent in the post-war science play like *Uranium 235* and modern science plays like *Arcadia* or *After Darwin*. The Epic Theater also had an influence on metatheatrical dramas which used a scientific concept or theory to be enacted on the stage as metaphor.

In the next chapter I am going to analyze the British science play *Copenhagen* which uses various scientific theories that figure as metaphors about human life. I chose *Copenhagen* because it is a rare example of a play which deals effectively with complicated science. While analyzing *Copenhagen* I will reveal why it attracted huge attention both of theatre-goers and intellectuals. Since *Copenhagen* has been written, scholars started to be interested in the science play genre.

Chapter II

Meditating on the mysteries of human motivation:

Copenhagen by Michael Frayn

II. 1. Introduction

The drama *Copenhagen* (1998) was written by Michael Frayn¹² and it was first staged in the National Theatre in London in 1998. The performance of the play was directed by Michael Blakemore and it received enormous attention and many respectable reviews both from theatre critics and dramatists as well as scientists. The premiere in London was followed by an equally successful performance in Broadway at the Royal Theatre in 2000 and went on to win a Tony Award for Best Play. Michael Frayn was astonished by the public debate triggered off by the play as he had never thought it would attract that much attention. Being aware of heavy scientific dialogues introduced to the drama, Frayn was prepared to offer *Copenhagen* as a radio play if no one would stage it. "I was amazed. I really don't know why people have come to see it. I suppose there is an element of mystery in it -- that's always something that intrigues people." (qtd. in Nestruck 1)

The mystery of the play lies in its topic which has a historical significance. *Copenhagen* is based on a real event. It is about the meeting between probably the two greatest physicists in the 20th century during The Second World War in nazi-occupied Denmark: Werner Heisenberg – the German physicist who invented the uncertainty principle, and Niels Bohr – the Danish physicist who invented the complementary principle. These two scientists had been close friends and colleagues

¹² Michael Frayn was studying Moral Sciences (Philosophy) at Emmanuel College in Cambridge and for many years he considered himself more a journalist than a playwright or a novelist. After graduation he was writing columns for the respected newspapers like *Guardian* and *The Observer*, and only as an experienced journalist he gave up this kind of work to devote his time entirely for writing books. *Copenhagen* is one of his latest plays which was a commercial and critical success. Earlier it gave him fame a play *Noises off* (1982) and the novel *Towards the End of the Morning* (1967). His recent dramas are *Democracy* (2003) and *Afterlife* (2008). *Democracy* won the Evening Standard and Critics' Circle awards for Best Play.

for over fifteen years, starting from 1922, when Heisenberg and Bohr met for the first time in Göttingen on the festival held in Bohr's honor. A few years later, in 1927, Heisenberg came to Copenhagen to be Bohr's assistant in his Institute for three years. They had pioneered in the field of atomic physics and their work could eventually have led to the invention of the first atomic bomb. The problem was that when they met again in Copenhagen in 1941, they were on opposite sides of the war. Heisenberg was German and a representative of the occupier country while Bohr was half-Jewish, living in occupied Denmark. Thus, the meeting since the beginning was very difficult. According to Heisenberg, they had a short conversation, during which Bohr got very upset and eventually the meeting was broken off. Ever since historians and intellectuals had argued about what these two scientists said to each other, and what Heisenberg wanted to say.

The conversation between Heisenberg and Bohr in Copenhagen in 1941 was very important because of the political reason. When the two scientists met, it was the middle of the Second World War and the countries were seeking for a weapon that would give them a predominance over their enemies. In 1941 the authorities of both countries had already known that the possibility lies in atomic physics and some of the most prominent scientists has been working on utilizing nuclear fission as a weapon, but no one was quite sure how it could be done. The political forces were convinced the resolution of the war depended on the advancement of nuclear physics studies, therefore the race for inventing the first atomic bomb has started, mainly in the United States, Great Britain and Germany. In the latter the nuclear project was headed by Werner Heisenberg, one of the best theoretical physicists at that time. Before the Second World War he was a good friend of another great physicist, Niels Bohr, but since 1939 these two scientists became the members of the hostile to each other countries. When in 1941 Heisenberg came to Copenhagen to visit Bohr, the lives of thousands of people were at stake and everyone knew that the meeting must have had a political dimension. Some people claimed that Heisenberg had a moral qualms about participating in the nuclear project, so he asked Bohr if a scientist had the moral right to work on atomic weapons; others believed that Heisenberg wanted to convince Bohr that they both could stop the authorities from using atomic weapons in the

future. The discussion about the reencounter between those two great scientists continues till today, but no one could put beyond the doubt what they have really said to each other and why Bohr got so upset during the meeting.

Frayn makes this particular event the core of the play, precisely the uncertainty about why Heisenberg insisted on meeting with Bohr and what they were talking about. However, *Copenhagen* does not lift the curtain on the mysterious meeting, but makes use of the historical event to raise a universal, philosophical problem. The drama expresses the notion that once it is impossible to know other people's intentions, we should not easily judge them. It naturally refers to Heisenberg who during his life as well as after death was accused by some historians, scientists, and third persons of being a member of the Nazis party, working for Hitler to provide him with an atomic bomb or being a bad scientist who did not manage to complete the nuclear project. The aim of *Copenhagen* is not to defend Heisenberg, but to present to the reader the various intentions that the scientist could have had when he went to visit Bohr in 1941. Frayn sets his play in the vague spirit world, where Heisenberg, Bohr and his wife Margrethe meet after their death to talk about what happened in Copenhagen in 1941. The story is held in the reconstitution of the retrospect: each character gives his/her own account of what happened and each of them tries to explain themselves and their motivations. Michael Frayn presents several draft versions of the meeting: he gives the voice to each character and lets them speak for themselves.

The play is compelling and original also for another reason. It deals with science in an attractive and accessible way for the reader. The scientific laws that Heisenberg and Bohr invented, namely uncertainty and complementary principles are turned in *Copenhagen* into metaphors about the nature of the human's life. The metaphors figure on the text level as well as in the performance. The actors enact the ideas involved into the play by moving and speculating on the stage. This classifies *Copenhagen* a metatheatrical play – the actors are performing what the play is about. Due to the theatricality of *Copenhagen*, the play is more interesting and practicable in the sense that the audience is able to confront hard science that is presented in an attractive manner. Since *Copenhagen* has been staged, writers started to be interested

in the world of science and its history as an inexhaustible source of ideas, metaphors, supernatural figures and mysterious stories.

In this chapter I am going to discuss the theatricality of the play and dramaturgical devices that this play operates. I will also analyze the function of science introduced into *Copenhagen* and the representation of the characters, for instance I will reveal if the character of Heisenberg is rather a tragic hero or a villain. In addition, I will discuss the structure and the convention of the play.

II. 2. Draft versions of the meeting

The plot of the play is non-linear and is divided into small scenes which are “draft versions” of the reencounter between Heisenberg and Bohr in 1941. This one situation is reiterated many times in the play and told from the point of view of each character. What makes the play difficult to analyze is that Heisenberg, Bohr and Margrethe usually do not make clear statements, but rather express their reflections, doubts, ask questions or they are trying to explain their motivations. It is even more difficult to guess the characters’ intentions as they are talking over each other and sometimes the reader can fail to notice that a character has just joined the conversation. Characters cannot even agree where the famous meeting between Heisenberg and Bohr has in fact taken place. Heisenberg claims that it was in October in Faelled Park, under the street lamps next to the bandstand, while Margrethe and Bohr say that it is impossible, because Faelled Park is four kilometers from their house. There were also no street lamps, as it was 1941 and no leaves as the meeting was in September, not October.

The misunderstandings between the characters are the result of the inaptitude of their memory. In the play memory is presented as an elusive device which can easily deceive a human’s mind. Although characters are trying to establish facts over and over again, their memories let them down: “And once again I crunch over the familiar doorbell gravel to the Bohr’s front door, and tag at the familiar bell-pull. Why have I come? I know perfectly well. Know so well that I’ve no need to ask myself. Until once

again the heavy door opens.”¹³ (89) The reader is the witness of Heisenberg’s conscious process of recalling the moment when he was going to meet Bohr in his house. The monologue is held in the illusion of realism – it seems like Heisenberg is watching himself and commenting what he is experiencing. In the play, metalanguage is used to make the illusory distance between the character and the past; an impression that Heisenberg is fully aware of his actions of the past, while in reality he cannot establish simple facts like why he wanted to meet with Bohr in Copenhagen in 1941.

In *Copenhagen* the role of memory is central. The play calls into question the reliability of memory and the notion of absolute truth, and suggests that memory undergoes constant process of revision and editing. The multiply draft versions of the meeting in Copenhagen reinforce the idea of illusiveness of facts. While Heisenberg, Bohr and Margrethe are trying to verbally reconstruct what happened during the meeting in 1941, it appears that not only each of them cannot possess the total knowledge about other people’s experience, but they are also not able to entirely understand their own motivations.

In reality, Bohr wrote seven letters which were multiple draft versions of the meeting in Copenhagen. They were written in the late 1950s and early 1960s and addressed to Heisenberg, but none of them has been sent. Bohr’s family released the letters to the public in 2002¹⁴ due to the attention that play has brought to the relationship between Heisenberg and Bohr. In each letter Bohr is speculating over what Heisenberg thought that Bohr was thinking during their conversation in Copenhagen: “I am greatly amazed how your memory has deceived you.” (qtd. in Frayn 106) In draft after draft Bohr is trying to reconstruct the meeting and claims that his memory is quite define, although he admits the difficulty of recalling where and even when the meeting took place. The letters are the best example of the deceitfulness of the memory. The reader cannot figure on a real Bohr as much as on a fictional one because both of them fail to establish basic facts from their past. Although Bohr obsessively rewrites each letter, he does not resolve the important

¹³ The cited words of Heisenberg is a intradialogic speech act – a character describes what he is doing.

¹⁴ The epistolary cache is available on the website on the Niels Bohr Institute: www.nbi.ku.dk

matters such as what he and Heisenberg exactly said to each other and where the meeting took place - in the office, in Bohr's house or on the walk. This is consistent with Frayn's play, in which characters cannot rest after death as they are revising one incident over and over again. *Copenhagen* is the example of a piece of art that accurately imitates life. Bohr's letters, in which he persistently comes back to the same situation, reaffirms Frayn's concept that we cannot rely on our memory, especially if we try to recall our motivations. According to the author of the play, our thoughts are elusive and our perception of reality is partial. In the Postscript of the play Frayn stresses that "The epistemology of intention is what the play is about!" (136).

II. 3. Illustrating the ideas

Dialogues in the play are everything. We know about the characters as much as they say about themselves. There are no stage directions: costumes, props and scenography are left to the director, which makes the structure of the play nonrealistic or even antitheatrical¹⁵. On the other hand, dialogues are held in the realistic convention as characters, who are dead, behave and talk like real people. Margrethe says about Heisenberg and Bohr that the "First thing they ever did was go for a walk together... Walk, and talk. Long, long before walls had ears" (31).

The conversations between Heisenberg, Bohr and Margrethe have a special function in *Copenhagen*: they are a source of anecdotes, which illustrate the ideas conveyed in the play. The first conversation segment is about skiing and it appears in Act I.

Heisenberg: Your skiing was like your science. What you were waiting for? Me and Weizacker to come back and suggest some slight change of emphasis?

Bohr: Probably.

Heisenberg: You were doing seventeen drafts of each slalom?

Margrethe: And without me to type them out.

Bohr: At least I knew where I was. At the speed you were going you were up against the uncertainty relationship. If you knew where you were when you were down you didn't know how fast you have got there. If you know how fast you'd been going you didn't know you were down.

¹⁵ The concept of *Copenhagen* as antitheatrical play is explained in the end of this chapter, in *Conclusion*.

Heisenberg: I certainly did not stop to think about it.

Bohr: Not to criticize, but that's what might be criticized with some of your science. (...) You never cared what got destroyed on the way, thought. As long as mathematics worked out you were satisfied.

Heisenberg: If something works it works.

Bohr: But the question is always, What does the mathematic mean, in plain language? What are the philosophical implications? (24-25)

Skiing is the symbol of the competition between Heisenberg and Bohr. The characters very often use the metaphor of skiing to describe the personality of the opponent: Heisenberg's recklessness, naivety and speed in taking decisions and Bohr's caution and reasonable attitude. Bohr and Heisenberg's conversation also introduces the uncertainty principle to the reader and illustrates the characters' different attitudes to science, which are adequate to their personalities. Bohr always rereads his mathematics and takes into account hidden implications while for Heisenberg science and the final result of his calculations are the most important.

In the play, apart from skiing, other games that Heisenberg and Bohr were used to play are mentioned, like chess, poker, table tennis, which have a similar metaphorical meaning. However, the most interesting conversations are those that demonstrate or explain science. For instance, in the beginning of Act II characters recall the times, when Heisenberg arrived to the Institute and meet Kramers, one of Bohr's closest assistant. While they are describing the relation between Bohr, Kramers and Heisenberg at the same time they are explaining the structure of the atom to the audience. Another example appears a few pages later, when the characters tell "a papal progress tale" which is about Bohr's train journey to Leiden and the attempts of other scientists to know Bohr's opinion about the new discovery of spin. This story is particularly interesting because it has many functions. First of all, it demonstrates the role of Bohr among other very prominent scientists like Wolfgang Pauli, Samuel Goudsmit, George Uhlenbeck or Albert Einstein. Scientists treat Bohr evidently as the "pope of physics" and they want to know his opinion about every new scientific discovery. The attitude of other scientists to Bohr is relevant for understanding the relation between Heisenberg and Bohr: Although Heisenberg was a great scientist and sometimes questioned mathematics of Bohr, he treats him like a close colleague, best friend, even a patron and a father who always takes care of him. Secondly, the

movement of Bohr in the train and other scientists who try to pin him down during the journey illustrates the uncertainty principle. Bohr is the symbol of atom and the scientists are trying to track his trajectory, but they never know where the atom is as the position of Bohr is always changing.

Copenhagen is the best example of a play which talks about science without lecturing the audience. In the play, the dialogues are composed into illustrative metaphors and anecdotes about scientific ideas. In the Postscript of the play Frayn writes that he wanted “to demonstrate that science is rooted in the conversations.” (96) The friendship between Heisenberg and Bohr, their common work and passion for physics was a perfect basis to introduce powerful scientific metaphors to the play. What is interesting in the conversations between two friends-scientists is that they contribute to their discussions the physics theories that they have invented. Uncertainty and the complementary principle are turned into powerful metaphors which define the point of the whole play. In the following monologue Heisenberg explains the uncertainty principle:

And that's when I did uncertainty. Walking round Faelled Park on my own one horrible raw February night. It's very late, and as soon as I've turned off into the park I'm completely alone in the darkness. 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 the 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. And that's what we see in the cloud chamber. Not a continuous track but a series of glimpses - a series of collisions between the passing electron and various atoms of water vapour.... (66)

Heisenberg expresses here the notion that one can never have the total knowledge about physical things, that everything that can be possibly thought and said about the world and abstracts is based on human observations, which cannot be complete due to the limitation of the human mind. This uncertainty of human thinking is fundamental to the nature of the world. Frayn's philosophical interpretation of the uncertainty is based on the correspondence between the uncertainty relations in our measurements of atomic particles and electrons with the uncertainty in the relation between human beings – in this case in the relation between Bohr, Heisenberg and Margrethe. Frayn shows that the conflict between the characters has its origin in the simple fact that one human being will never know another human being entirely, that

A will never understand what B exactly wanted to say and, moreover, A will never understand entirely himself. This is why Heisenberg cannot explain why he came to Copenhagen, because he is in the center of the universe - he can see everything around him except himself. In the play Margrethe directly expresses this idea: "If it's Heisenberg at the center of the universe, then the one bit of the universe that he can't see is Heisenberg. (...) So it's no good asking him why he came to Copenhagen in 1941. He doesn't know!" (72)

Everything what the characters are doing and saying in the play has its metaphorical implication. Another interesting theory for which Frayn found a philosophical reference is the complementarity principle. In the play Bohr is trying to explain to Heisenberg the complementarity by saying that "to understand how people see you we have to treat you not just as a particle, but as a wave. I have to use not only your particle mechanics, I have to use the Schrödinger wave function." (69) It means that we always perceive something from one point of view that is incompatible with the others; as soon as we choose one way of seeing we are not able to perceive reality from the point of view that we have not chosen. Heisenberg illustrates complementarity by explaining why Bohr had not killed him during their walk in 1941. He says that Bohr regarded him as an enemy but also as a friend, he considered him a danger to mankind, but also a guest – he was a particle as well as a wave. It means that we always have a various set of obligations – to the wife, to the country, to the neighbor – that cannot be reconciled. We always have to choose just one way of looking at some matter and see what will happen. This is the tragic conflict of human beings that Frayn wanted to stress. First of all, we can never understand other people's intentions and, secondly, our actions are motivated by perceiving something from one chosen standpoint. If Bohr had considered Heisenberg first of all as an enemy, he would have killed him in Copenhagen in September in 1941.

II. 3.1. Staging mathematics

Frayn does not only introduce the complementarity and uncertainty principle into the play, but also other scientific ideas, such as fission, Schrödinger's wave function, uranium 235, cadmium and calculation for critical mass. In *Copenhagen* all of this scientific material is "translated" to the powerful metaphors about the human's

condition of life. Frayn, in an interview with Anthony Gardner, admits that dealing with science in the drama was extremely challenging: “Many, many times I sat in total despair trying to think how on earth to get this mass of material into workable shape.” His effort paid off, as *Copenhagen* is one of the few plays which involves heavy science and makes it understandable for the audience. Frayn, instead of explaining what uncertainty or complementary principle is, illustrates these scientific laws by introducing anecdotes into the dramatic content. It is a brilliant way of merging the form with the content of the play as the dialogues brim with a vivid demonstration of the scientific principles.

The metaphorical meaning of the conversation between Bohr, Heisenberg and Margrethe is reinforced by the staging. In the play there are no stage directions which gives the director an opportunity to liberate his imagination. When *Copenhagen* was performed in Broadway in the Royal Theatre in 2000, the actors were playing on a bare stage with three chairs and no props or scenery. The stage was itself atom-like so characters could orbit within it like they “(...) move to their several re-enactments of the 1941 meeting, like variations on a theme.” (Young 218) Some of the audience was also involved in the performance by being placed in the elevated tribunal in the back of the stage. It seemed like they were watching and judging the action of the characters and in turn they were watched by other part of the audience. Yet, Frayn does not give the final draft of what actually happened in Copenhagen, therefore the audience is let alone to make their own conclusions about the characters and their history.

When *Copenhagen* was first performed in 1998 in the National Theatre in London the stage was also turned into a metaphor. It was a “theatre in round” – the actors were walking in the circle and the way they argued, symbolized interactions of atomic particles. The staging of the play was experiment itself, it remained scientific concept. This is why *Copenhagen* is metheathrical play – the audience is the witness of the experiment which happened on the stage and is observing how the actors are enacting the scientific ideas involved in the play. “Two properties [the content of the play and the performance] are no longer divorced but are interdependent; the ‘what’ of the play is directly related to ‘how’ it is told” (*Science on Stage* 194). The conscious theatricality makes the audience being aware of the fact that they are in theatre. They

do not eavesdrop on the actors who pretend that they do not know about the presence of the audience.

While analyzing the structure and staging of the play, it is relevant to define the role of Margrethe in this triangle relation between the characters. One may say that she is unnecessary in the performance, because only Heisenberg and Bohr are involved in the historical and intellectual battle. Margrethe, however, is very important, as she has the function of the director of the dialogues. Many times she interrupts Heisenberg and Bohr's conversation with questions and remarks, which make the discussion more clear for the audience. Her role is to translate the heavy scientific dialogues into "plain", understandable language. If she lacked on the stage, the audience would be probably left with the complicated physics equations. Moreover, Margrethe is also observing and commenting the behavior of the characters. She has the status of the narrator who introduces the characters to the audience, but who also contributes her own opinion to the play. Her questions and direct remarks move the action forward.

Interestingly, many critics do not notice that Margrethe does not only accelerate the pace of the action, but also slows it down. It is particularly visible in the television movie *Copenhagen* from 2002 produced by BBC and directed by Howard Davis. While Heisenberg and Bohr are discussing physics and the pace of the discussion is accelerating, it launches a chain reaction, and the characters behave like they are going to explode. Margrethe's role is to interrupt them in the critical moment, so the (atomic) bomb cannot set off.

II. 4. When fiction meets reality: Heisenberg and the atomic bomb

The discussion about the atomic bomb and why Heisenberg did not manage to build any nuclear weapon is particularly interesting in the play. It starts in the middle of Act I when characters are arguing about what Hinesburg said to Bohr during their walk in 1941 that immediately made Bohr very upset. Heisenberg narrative claims that he simply asked "if as a physicist one had the moral right to work on the practical exploitation of atomic energy." (36) Bohr, according to Heisenberg, got horrified

hearing that, because he understood that his friend was probably participating in the nuclear program.

In the play Heisenberg tries to convince Bohr that he did not intend to build a bomb, but a reactor to produce power and electricity and that in fact he came to Copenhagen to work with Bohr on the common enterprise which was not providing authorities with nuclear power. At the same time Heisenberg expresses his patriotism and the conviction that if the enemy participates in the nuclear project, he will be forced to defend his country and continue to be in control of the nuclear program which would lead eventually to the invention of atomic bombs.

Bohr, I have to know! I'm the one who has to decide! If the Allies are building a bomb, what am I choosing for my country? (...) 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 picked me up when I fell, all the voices that encouraged me and set me on my 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'm deciding for them! (42)

Heisenberg certainly presents himself as a tragic hero in the play. On one hand, he insists that he does not want to work on the invention of atomic bombs, on the other hand, he knows that if the Allies drop bombs on Germany, he will be responsible for the death of his nationals. The tragic conflict of Heisenberg has a personal and a political dimension. He has to choose between moral rights and the safety of his country. Heisenberg hoped that Bohr had some contacts with the Allies and that they both could suggest to the political forces that the bomb is not practicable during the course of the war. Heisenberg's moral struggles are revealed to the audience to contradict the general opinion that Heisenberg was a member of the Nazi party or that he had sympathized with the Nazis.

When the war started, Heisenberg was already a Nobel Prize winner and he was free to immigrate to another country. He received many invitations to work for prestigious American Universities, but he refuses to accept them and he remains in Germany. This decision provoked many attacks on him, because people thought that he stayed in his country to work with the Nazi party. The play presents Heisenberg in a brighter light and advocates the conviction that Heisenberg was a patriot, maybe even a nationalist, but he has never been a follower of Nazis' politics. Bohr also defends his

friend by reminding Margrethe that Heisenberg has gotten into troubles with the Nazis in the 1930s due to his assistance to some of his Jewish colleagues. Heisenberg was called a White Jew by the Nazis, because he “thought Jewish physics (...) and stuck with Einstein and relativity, in spite of the most terrible attacks.” (Frayn 8)

II. 4.1. Miscalculations

Heisenberg is a complicated figure, but he presents himself more as a tragic hero rather than a villain. Margrethe, however, has quite a different opinion about the German scientist than her lenient and polite husband. She accuses Heisenberg of a lack of empathy regarding the Danish people’s situation under the German occupation or of being willing to work on a German nuclear reactor that could be employed for the construction of a bomb. Margrethe is also convinced that Heisenberg eventually failed to build the atomic bomb, because he simply did not know physics well enough and how to do the right calculations. Heisenberg obviously understood that a bomb would require fast U-235 rather than slow U-238. He got the clue, but he eventually opted out of doing calculations as he assumed that more ton of fossil material would be required to build a bomb.

Bohr: So Heisenberg, tell us this one simple thing: why didn’t you do the calculation? (...)

Heisenberg: I don’t know! I don’t know why I didn’t do it! Because I never thought of it! Because it didn’t occurred to me! Because I assumed it wasn’t worth doing!

Bohr: Assumed? Assumed? You never assumed things! That’s how you got uncertainty, because you rejected our assumptions! You calculated Heisenberg! You calculated everything! The first thing you did was the mathematics! (...)

Heisenberg: Though in fact you made exactly the same assumption! You thought there was no danger for exactly the same reason I did! Why didn’t you calculate?

Bohr: Why didn’t I calculate?

Heisenberg: Tell us why you didn’t calculate it and we’ll know why I didn’t!

Bohr: It’s obvious why I didn’t

Heisenberg: Go on.

Margrethe: Because he wasn’t trying to build a bomb!

Heisenberg: Yes. Thank you. Because he wasn't trying to build a bomb. I imagine it was the same with me. Because I wasn't trying to build a bomb. Thank you. (86-87)

In the play Heisenberg explicitly suggests that he did not do any calculations, because he apparently did not want to supply Hitler with an atomic weapon. Many critics and scientists did not agree with this positive interpretation of Heisenberg's attitude. For instance, *Copenhagen* had drawn the attention of Paul Lawrence Rose, Professor of Jewish Studies and European History, who found the play anti-Semitic, a travesty of real history and a "white wash" of Heisenberg's inability of build a bomb. He criticized *Copenhagen* for its revisionism and in the article *Frayn's Copenhagen Plays Well, at History's Expense* Rose presents Heisenberg "(...) as a Nazi collaborator who did his level best to build a bomb for Germany." (qtd. in Dasenbrock 220) Another scientist, Samuel Goudsmit, an occasional friend of Heisenberg and the head of the war mission "Alsos", claimed that German physicists including Heisenberg, wanted to build a nuclear weapon, but they simply did not know how to do it.

All these remarks and historical implications are enclosed by author in the quite long Postscript attached to the play. However, as far as the comments given by intellectuals create the relevant context to the play, they cannot undermine the value of *Copenhagen* as a fictional construct. One should bear in mind that play was written by a playwright and is not a reconstruction researched and elaborated by a historian. The intention of Frayn, as an author of the play, was not to judge whether Heisenberg wanted to build a bomb or reveal why he insisted to meet with Bohr in Copenhagen. Frayn, first of all, wanted to present various possible motivations of Heisenberg's visit in Copenhagen. The point of the play was that as far as we cannot know other people's intentions we should not make definite conclusions. In the introduction to the television film *Copenhagen* Frayn stresses that:

A lot of people think that a play is about moral question, about whether scientist should work on weapons. And of course moral question do come into it. Before we can make any moral judgments of anyone, we have to understand why they are doing what they do. You can't make a moral judgment about anyone, unless you have some knowledge of their intentions.

However, the scholar Reed Dasenbrock warns the reader from oversimplifying the metaphor contributed to the play. "Nothing in the play (...) suggests that in ethical

situations we must be left in a fog of uncertainty. The uncertainty principle is in the first place a description of the interaction of a particle and an observer"¹⁶ (226). In other words, uncertainty does not mean that one cannot have an opinion about other people's behavior, but that "thoughts and intentions even one's own (...) remain shifting and elusive" (Frayn 99), therefore we should not be eager to make easy conclusions about other peoples' actions.

The final scenes of *Copenhagen* are probably the most accurate definition of uncertainty. After the characters' death there is only silence and the feeling that nothing matters any more, that nothing can be added and that no words cannot be erased now. This is not frustrating though. In the play, Heisenberg and Bohr have a chance to meet and discuss what really happened in Copenhagen, the chance that they hadn't had in reality. This discussion, however, does not change anything – Heisenberg and Bohr still do not know what they exactly said to each other during their walk in Copenhagen and what their intentions were. The play advocates the idea that the recognition of human beings will always remain somehow mysterious and that this mystery is not sad, but charming and beautiful.

II. 5. Conclusion

Copenhagen is certainly an innovative drama regarding its structure, its representation of the scientist and its engagement with science. Traditional plays have specified use of structure like the division into act and scenes, and extra dialogic intermissions. Such an organization of the structure separates the audience spatially and temporally from the performance and from the actors. For instance, the play *A Rising in the Sun* by Lorraine Hansberry is in three acts "with each opening and closing of the curtain between acts distinguishing audience-time from play-time. Act breaks used as intermissions calls attention to this distinction even more strongly." (qtd. in

¹⁶ In the Postscript of the play Frayn presents essentially the same idea: "It's true that the concept of uncertainty is one of those scientific notions that has become common coinage, and generalised to the point of losing much of its original meaning. The idea as introduced by Heisenberg into quantum mechanics was precise and technical. It didn't suggest that everything about the behavior of particles was unknowable, or hazy. What it limited was the simultaneous measurement of 'canonically conjugate variables,' such as position and momentum, or energy and time. The more precisely you measure one variable, it said, the less precise your measurement of the related variable can be; and this ratio, the uncertainty relationship, is itself precisely formulable." (98)

Science on Stage 133) In the contemporary science plays such as *Copenhagen* the plot is non-linear and there are no logical connections in the structure of the play. *Copenhagen* is only a two-act play without any scene divisions and stage directions, therefore the audience is forced to make their own associations which would compose the play in an integral and logical text. Each performance of *Copenhagen* is individual because it relies on the active role the audience and their personal interpretations.

The representation of the characters is also far from traditional. First of all, they do not have any ontological status – Heisenberg, Bohr and Margrethe meet after their death in the indeterminate, spirit world. In *Copenhagen* the realism is questioned as characters behave and talk like real people, although they are already revenants. On the other hand, realism is not completely abandoned in the play. The driving power for every play is usually a tragic conflict and *Copenhagen* is classic in this sense. Its “action hinges on unfolding of the conflict and their suspense lies in how it will be resolved.” (*Science on Stage* 2) In *Copenhagen* the conflict between the characters is based on the impossibility of establishing the facts from their past lives. In the play there is also conveyed a personal and ethical dilemma if a physicist has the moral right to work on the invention of an atomic bomb in order to defend his country.

Secondly, Bohr and Margrethe are psychologically complicated characters rather than typical figures which are easy to categorize. Of course, each of the characters has a special function in the play, for example Margrethe is the director of the dialogues. However, as it was said before, Heisenberg, Margrethe and Bohr do not contribute any clear statements to the play, but express their doubts, reflections or they are trying to explain their motivations. *Copenhagen* does not assess who is more right in the play as in Frayn’s opinion each character should be “(...) allowed the freedom and eloquence to make the most convincing case (...)” (Frayn 137) for themselves. In the beginning of the drama Bohr and Margrethe accuse Heisenberg of trying to build the bomb, while in the end of the play the demonized Heisenberg comes across as a person that “never managed to contribute to the death of one single solitary person (...)” (Frayn 91) It is the beloved Bohr, who eventually has played “a small but helpful part in the death of a hundred thousand people.” (Frayn 91) Thus, along the action unfolds, the criticism towards Heisenberg as the member of the

German nuclear program turns into sympathy, making him almost a tragic hero who has been trying to avoid the use of atomic bombs. Nevertheless, Frayn does not provide the final draft that would make absolutely clear if Heisenberg really wanted to build an atomic bomb and what he wanted to achieve by meeting with Bohr in Copenhagen. The audience have to shape their own opinion about the characters and the issues presented in the play.

Copenhagen is also innovative in its theatricality, although some critics call it into question due to the textual abundance of the play and heavy scientific dialogues. They claim that *Copenhagen*, which is overflowed with dialogues and at the same time does not have any extra dialogic intermissions, resembles a “psychodrama drama” (Adams) that can function better as a radio play than a performance: “This format of just reading the play is I think very good. One can concentrate on what it says without being distracted by theatrical business.” (qtd. in *Science on Stage* 94)

However, the overtextuality of the play and the bareness of the stage does not mean that the play cannot be well performed. In fact, the lack of the extra dialogic intermissions gives the director an opportunity to manipulate with the actors on stage in the way that they would literally enact the scientific ideas conveyed in the drama. “Far from merely telling the audience what the science is, the dialogue performs it because the textual definitions are reinforced visually by the way the actors circle the stage and interact with each other.” (*Science on Stage* 99) In this sense, *Copenhagen* is innovative, as the theatricality of the play is strictly integrated with its content and is essential for understating the meaning of the play.

Chapter III

The dark secrets of a genius' personality: *Photograph 51* by Anna Ziegler

III. 1. Introduction

Photograph 51 (2008) by Anna Ziegler¹⁷ was staged in two theaters: On 27th November 2010 it premiered at the Ensemble Studio Theatre in New York City where it was directed by Lindsay Fireman; and the play was subsequently produced by Theatre J in Washington and directed by Daniella Topol. In 2008 Anna Ziegler won the STAGE International Competition for the best script about science and technology for her play. *Photograph 51* holds some resemblance with *Copenhagen*, because it is also based on a real event derived from the history of science. The play traces the circumstances of the 1953 discovery of the DNA double helix, called "the secret of life". It was certainly one of the most important scientific discoveries of the 20th century and the play highlights the role of four scientists in the process of this discovery, namely the geneticist James Watson, and biophysicists Francis Crick, Maurice Wilkins and Rosalind Franklin. The controversy that revolves around that historical event is that only three men were awarded the Nobel Prize, while Rosalind Franklin, who contributed substantially to the discovery, remained largely unnoticed. The contribution of the female scientist attracted the public attention only after several years, when in 1968 James Watson, already a Nobel Prize Winner, published *The Double Helix*, an autobiographical account of the discovery of the double helix structure of DNA. In his book, Watson admits that without "photograph 51," an image of DNA that Franklin had captured using a technique called x-ray diffraction, the discovery of the double helix would practically have been impossible.

¹⁷ Anna Ziegler was born in 1979 and she graduated from Yale University and holds a Master of Fine Arts from NYU's Tisch School of the Arts. She has just begun her playwright career, but being a quite productive writer, she is already recognized in the literary circle. Her plays include *BFF* (2007), *Novel* (2007), *Dov and Ali* (2008), *Life Science* (2009), *Variations on a Theme* (2008), *The Minotaur* (2010), *An Incident* (2010) and *Evening All Afternoon* (2011). Anna Ziegler also writes poetry that has been published in *The Best American Poetry* 2003, *The Michigan Quarterly Review*, *Arts and Letters*, *Mid-American Review*, and other journals. However, the critical and commercial success brought her *Photograph 51*, the play that will be discussed in this chapter.

However, some of the scientists and bystanders claimed that Franklin's contribution to the discovery of DNA was not recognized, because she was simply not interested in getting along or collaborating with scientists who were working on DNA. The author of *Photograph 51*, Anna Ziegler, admits that the uneasy personality of Franklin was an inspiration for making her a key figure of the play: "My take on Rosalind Franklin's character, and what I find so juicy, fascinating and sad about her has to do with her own tragic flaws--her inability or refusal to form useful working relationships with certain people." (qtd. in Ballantyne)

Photograph 51 dramatizes the events that have taken place at the eve of the discovery of the double helix structure of DNA. In this chapter I will analyze the complexity of the psychology of the scientist and the process of making groundbreaking discovery. I will discuss the role of the scientist in such a process and the place that women occupy in the world of science in England in the 1950s. Moreover, I will reveal the use of science in the play and ethical and philosophical questions that the play raises. Finally, I will analyze the convention, structure and theatricality of the play.

III. 2. Portrayal of the scientist: Between competition and self-interest

Photograph 51 is a play without any act and scene divisions. The story presented in *Photograph 51* begins in 1951 when Franklin first arrives at King's College in London from the Laboratoire Central des Services Chimiques de l'Etat in Paris to work on x-ray diffraction studies of proteins in solution¹⁸. However, the research priorities changed when John Randall¹⁹, the director of the Biophysics Research Unit and the head of the laboratory in King's College, obtained a unusually pure sample of DNA from Rudolf Signer. Randall showed the samples to Maurice Wilkins, the assistant and biophysicist, who was fascinated by the new materials and immediately decided to

¹⁸ Franklin was hired by Randall, the director of the Biophysics Research Unit at King's College, to work in the new biophysics laboratory on protein structure as she was a specialist on the structure of coal.

¹⁹ John Randall (1905–1984) was a British physicist and biophysicist, who is known for its radical improvement of the cavity magnetron, an component of centimetric wavelength radar that was decisive to the Allied victory in the Second World War. In 1946 Randall was appointed the Head of Physics Department at King's College in London. Later he was promoted a director of Biophysics Research Unit and he led a team which worked on structure of DNA. His staff included Maurice Wilkins, Rosalind Franklin, Raymond Gosling, Alex Stokes, Herbert Wilson and a few more.

conduct further research. Wilkins also suggested to Randall that Franklin's expertise might be better applied to the promising DNA research, as she was specialized in crystallography. Randall approved the idea and in November 1951 he wrote to Franklin a letter in which he explained the change of the object of her future research. In the letter he also stated that Franklin would be the head of the project and apart from her, the only person involved in the project would be a graduate student, Raymond Gosling. However, Randall did not mention that Wilkins was also very interested in making research in the same field, nor did he tell Wilkins the content of the letter sent to Franklin. These serious omissions generated a misunderstanding between Franklin and Wilkins because both of them had different perceptions of managing the project: Wilkins naturally assumed that he would be in charge of the project and that Franklin would be just a part of the loosely defined research team, while Franklin thought that she would be leading individually x-ray diffraction studies of DNA with just a minor assistance of the doctoral student, Gosling.

In *Photograph 51* it is Wilkins who informs Franklin about her role in the process of doing research and the object of her studies.

MAURICE. Yes, instead of proteins you will be working on deciphering the structure of nucleic acids.

ROSALIND. Is that right? (...)

MAURICE. You will be assisting me in my study of the Signer DNA from Switzerland. (...)

ROSALIND. I don't think I heard you right.

MAURICE. You did! We have the Signer stock. Quite a coup, really. (...)

ROSALIND. But did you say *I'd* be assisting *you*?

MAURICE. Yes!... And my doctoral student, Ray Gosling, will assist you.

RAY. Hello! (*He puts out his hand and Rosalind ignores it.*)

ROSALIND. But... Randall told me I'll be heading up the study. That I'll be in charge of my own work. Surely, there's been some misunderstanding.

MAURICE. No, no misunderstanding. Circumstances changed. We recently took x-ray photos of DNA that convinced me and Randall that we must move forward with nucleic acid as opposed to protein to get to the bottom of what some are calling the secret of life, to the way genetic information is replicated and encoded. In other words, if we discover *this* structure – this structure – we could discover the way world works, Miss Franklin. Can you imagine that?

ROSALIND. Dr. Wilkins I will not be anyone's assistant. (...) I don't like others to analyze *my data, my work*. I work best when I work alone. If, for whatever reason, I am forced into different situation, I should feel that I came here under false pretenses. (12-13)

The misunderstanding launched by Randall caused a poisonous atmosphere between Franklin and Wilkins. Both scientists had different points of view about their role in the study of the structure of DNA. Wilkins naturally expected to be in charge of the project, as he had already been working on DNA before Franklin arrived to King's College and he had already managed to obtain x-ray photos of DNA structure. On the other hand, Franklin was at that time an independent researcher of established reputation and she was convinced that research on DNA should have been her exclusive problem. She refused to be an assistant of Wilkins or even a collaborator, as in her opinion it was offensive. She did not want anyone to analyze her own data, neither had she any interest in other scientists' work. In this situation Wilkins was obliged to share the DNA research program with Franklin. He offered her the assistance of a doctoral student, Raymond Gosling, some of the laboratory equipment, and a good sample of DNA obtained by Rudolf Signer of Berne.

The conflict between Franklin and Wilkins has a central role in the play. Since the moment that scientists had started to work separately and had limited their contact to some necessary formalities, the discovery of DNA structure became much more difficult and challenging. One should remember that while Franklin and Wilkins were in disagreement, other scientists interested in the field of genetics, were working together on the common enterprise of discovering the DNA structure. The race had already begun and help and support given by others was indispensable to win it. In the play it is explicitly suggested that Franklin did not eventually discover DNA structure because she refused to collaborate with Wilkins due to the misunderstanding they had. This conviction is expressed in the play by a comment the character of James Watson made: "See? She was meant to be Wilkins' *assistant*, and therein lay the problem. She misunderstood the terms. And after that the rest was inevitable. The race lost right there. In a single moment." (14)

The dysfunctional relationship between Franklin and Wilkins is the major preoccupation in the play. The conflict was exacerbated by differences in personality:

Franklin was of a direct, honest, strong character, who “doesn’t suffer fools” (Ziegler 9), while Wilkins was a gentleman: formal, unobtrusive and willing to compromise. As long as Franklin was at King’s College he was trying to rebuild the relationship with her but he has never succeed. It is particularly visible in the scene when Wilkins offers a box of chocolate to Franklin – a simple and kind gesture of saying sorry to someone. Franklin did not only ignores it, but she also insulted Wilkins.

RODALIND. We’ve already started again once, haven’t we? How often will we have to do this?

MAURICE. It’s just that... I mean, I’d like to... have an easier relationship with you. (...)

ROSALIND. Was your wife cold?

MAURICE. I beg your pardon? (...)

MAURICE. She could be.

ROSALIND. And I’m not her. We’re not married. You don’t have to try to win me over. Because you won’t succeed. I’m not that kind of person.

MAURICE. I’m just trying to...

ROSALIND. What?

MAURICE. Be your friend.

ROSALIND. I don’t want to be your friend, Dr. Wilkins.

MAURICE. You don’t?

ROSALIND. No. (*Beat.*)

MAURICE. Well then. Enjoy the chocolates. (*He exits; the lights shift.*) (27)

The presented dialogue may give the impression that Wilkins was secretly in love with Franklin. Other characters conjecture on Wilkin’s affection, when once he loses his temper while talking about Franklin. The love hypothesis makes the story very compelling because the reader witnesses the clash of two very different personalities. Throughout the play the characters almost come together, but in the end it never happens due to misunderstandings and conflicts they share. Wilkins takes every chance to improve the relationship with Franklin, while she contributes very little to make it at least workable on a professional level.

The representation of the scientists in *Photograph 51* was commented by James Watson and his coworkers in a casual interview given for *Scientific American*. Everyone agreed that the play “bears little resemblance to actual events”, but at the

same the scientists “were pleased that the play had not softened her [Franklin] personality.” (Kuchment) James Watson also referred to Franklin’s personality in his famous book *The Double Helix*, where he describes her as a person unafraid of argument, territorial and belligerent. On the other hand, Maddox, the biographer of Franklin, claims that she was not a misanthrope like most of the people thought, but cordial, kind and generous person in relation to her family and friends. According to Maddox, Franklin just had a very strong personality and was direct in expressing her own opinion which some people could find intimidating at times.

Some claims that Franklin’s self-preserved attitude was motivated by discrimination of women which still had been common in mid-20th century England. In the play there are several situations when Franklin is named by other scientists “Rosy” or just Rosalind – instead of being respectfully addressed Dr. Franklin.

ROSALIND. Maybe you’re aware of the fact that not a single female scientist from Britain was given a research position during a war time? (...)

MAURICE. All right, Rosy.

ROSALIND. My name is Rosalind. But you can call me Miss Franklin. Everyone else does.

MAURICE. Fine.

ROSALIND. Of course I’d prefer Dr. Franklin but this doesn’t seem to be done here, does it, Mr. Wilkins?

MAURICE. Dr. Wilkins.

ROSALIND. Dr. Wilkins, I don’t joke. I take my work seriously as I trust you do too. (14-15)

In the play, Franklin is not keen to make friendship with other scientists, because they are isolating her from the group of the respected scholars by means of various acts of discrimination. Fiction does not fall far from the reality, as in *The Double Helix* Watson is used to describe Franklin in a condescending manner, addressing her “Rosy” – a quiet inappropriate name for a highly esteemed scientist. Moreover, in *Photograph 51* as well as in reality, King’s College maintains a separate senior common room, although Randall’s staff includes a number of women.

In the play Franklin's character criticizes every act of discrimination. Franklin's strong personality and pride came from the status²⁰ that she held at that time. She was a descendant of a wealthy British family; she received excellent education and she occupied a highly respected position among scholars. Nicholas Wade claims that Franklin's origins made her not only a very confident person, but even reserved and arrogant. In his article for *The Scientist*, Wade calls her "a snob, both socially and intellectually." Wade supports his opinion by quoting a letter, in which Franklin assesses her new colleagues from King's College:

The other middle and senior people are positively repulsive, and it's they who set the general tone. I've got myself organized so that I hardly ever see any of them. The other serious trouble is that there isn't a first-class or even a good brain among them - in fact no one with whom I particularly want to discuss anything, scientific or otherwise....

One would never know if various opinions about Franklin have a pinch of truth, but the constant literary debate over her personality indicates how complicated and at the same an attractive nature she had. Levy, the director of *Photograph 51* concludes that Franklin was "a brilliant scientist but sort of socially inept [who] has difficulty dealing with her strength and her spirit." (qtd. in Ballantyne) In fact, one cannot get rid of the impression that Franklin's uneasy personality led to the situation that she and Wilkins did not manage to build the correct model of DNA.

²⁰ Franklin was born in Notting Hill, London, in an influential British Jewish family. Her father was Ellis Arthur Franklin, a politically liberal London merchant banker who taught at the city's Working Men's College, and her mother was Muriel Frances Waley. Both of them were active in charities and other community services, and they expected her daughter to follow that tradition as well. Rosalind attended St. Paul's School for Girls, which was preparing its graduates for careers, not just for marriage. During her education Franklin had demonstrated an aptness for math and science, and a flair for languages (she spoke excellent French, good Italian, and satisfactory German). In 1938 she went up to Newnham College, Cambridge, where she majored in physical chemistry. In 1942, after receiving her BA, she became a researcher of the British Coal Utilisation Research Association (BCURA), where she had been working for four years to elucidate the micro-structures of various coals and carbons. Her researches at BCURA led to a doctoral thesis; she received her PhD from Cambridge in 1945. After the war Franklin got a position in Jacques Mering's lab at the Laboratoire Central des Services Chimique de l'Etat in Paris. She learned there how to analyze carbons using x-ray crystallography (also called x-ray diffraction analysis), and later she became very proficient with the technique. Franklin's work at the French laboratory brought her an international reputation among coal chemists and lifelong friendships. Finally, in 1950 she was awarded a three-year Turner and Newall Fellowship to work in John Randall's Biophysics Unit at King's College London, where she met the future Nobel Prize winners Maurice Wilkins, James Watson and Francis Crick.

III. 3. In the race against time no holds barred

Photograph 51 conveys the notion that Franklin was the one to be partly blamed for the failure of the research team at King's College. On the other hand, the play emphasizes the fact that Franklin's self-assertive, determined and a work-ethic attitude enables her to obtain the x-ray *Photograph 51* which suggested that DNA was helical, and to make various analyses and calculations which were crucial data for the discovery of DNA structure. Franklin is presented as a very hard working person who does all the necessary calculation before stating any definite conclusion. Cricks' character pejoratively describes Franklin's working mode: "And so Rosalind did her work. Or tried to. Painstakingly. Paying attention to every detail. Every discrepancy." (30) James Watson and Francis Crick, in contrast to Franklin, prefer to take a shortcut in doing research by building a draft model of DNA structure based only on a hypothesis. Due to this impatience Watson and Crick make several omissions which result in the wrong model. The difference between Franklin and the two scientists is undermined in the scene in which Franklin is giving an important speech on the nucleic acid structure while Watson and Crick instead of listening, are commenting on Franklin's appearance.

JAMES. She could possibly be attractive if she took even the mildest interest in her clothes. But appearances aside, she is not... engaging.

FRANCIS. No. Not at least.

ROSALIND. If you examine it, you can transition from A form to B form / in this hydrated sample.

JAMES. When we shook hands, her handshake was far too firm. There's nothing gentle, nothing remotely tender about her. She's a cipher when a woman should be. That said, she's not fat.

RAY. (*To the audience.*) So busy analyzing the speaker, they didn't hear what she was saying. That she stated quite clear that:

ROSALIND. Based on these calculations, it's clear that phosphates exists on the outside of the molecule. There is no question that this is the case. (33)

This dialogue has many functions regarding the structure and the content of the play. First of all, it gives the reader an idea of how Franklin looks like and it reveals how other scientists perceive her. The characters' opinion is very important as stage directions include only a curt description about the characters' age, nationality and

personality. More information about the characters are introduced only by the dialogues. According to Watson and Crick, Franklin comes across as a tomboy: she does not pay attention to her clothes and hair she wears. Franklin's appearance reflects her personality: She lacks the delicacy and charm that British man expected a woman to have - instead she is straightforward and stiff-necked in relations with people. Secondly, the presented dialogue may also suggests that Watson and Crick sometimes pay more attention to foolishness rather than being interested in the real scientific debate. They do not hear the key result of Franklin's analysis which will later partly lead to the construction of the wrong model of DNA.

The scene is also noteworthy because it gives an insight into the structure of the play. *Photograph 51* consists of different kinds of narratives. In the author's notes attached to the play, the reader learns that there is a choral-like narrative in which characters "narrate historical events from the future perspective" (5); there is a contested narration in which characters discuss how some events really happened; there is a present narration which is the current action of the play commented by other characters; and finally an imaginary narration called by the author "what ifs". All of these narratives are integrated and overlapping, so the play does not lose on its pace and vigor. It is visible in the presented scene: Watson and Crick's conversation runs almost simultaneously with Franklin's speech. Intradialogic stage directions indicate in which moments Franklin should be interrupted by Watson and Crick: "*In this scene, James and Francis watch her, (...). Their lines should run over some of hers; They are talking over her. The '/' indicates the next line could interrupt the current line.*" (33) Apart from these two overlapping narrations there is also another, a very important one, concentrated in Ray's character. Ray, who is a doctoral student and Franklin's assistant, has the function of the narrator and the commentator of the present action. He addresses the audience directly and highlights the most important moment of Franklin's speech in that way the audience is well informed where Watson and Crick make the mistake. When in a few lines later the two scientists present their model of the structure of DNA and Franklin criticizes it, because the molecule could not hold together, the audience is not surprised. They have already assumed that Crick and Watson would build a wrong model with phosphates inside of the molecule

instead of locating them outside, because two scientists have not listened to the speech given by Franklin.

Crick and Watson have to pay a high price for the inaccurate model of DNA – they are obliged to give up their research on DNA structure. However, Crick and Watson are still interested in the genetic field and they continue their work on DNA, but unofficially. The mistake of the two scientists has convinced Franklin that only her mode of working can succeed, therefore she carries on a patient and rigorous attitude. Franklin's main aim now is to prove that both A and B forms are helical. The problem is that her calculations do not lead to this conclusion. She condemns the theory presented on Wilkins' conference that the x-ray patterns indicate a helix, as in her opinion it is not supported by any credible research.

The turning point of the play is when Franklin manages to take the x-ray photograph 51 which explicitly shows that B form of DNA is helical. The photos that had been taken before photograph 51 could not prove it, because the micro-camera, which was used to take the pictures, did not function well due to humidity. Franklin has used salt solution to regulate the humidity in the camera. In the beginning, an improved machine has enabled Franklin to discover that DNA consists of two forms: "dry" crystalline form "A" and heavily hydrated paracrystalline "wet" form "B"; and later to obtain photograph 51 which proves that B form is helical. Photograph 51 was crucial data to understand the double helix of DNA structure, as it was difficult to imagine that A form is not helical, if B form was.

This was the information that Crick and Watson exactly needed to continue their research on DNA structure and eventually they get Photograph 51. First Gosling's character slips the photograph to Wilkins without Franklin's knowledge: "I did think it was his right to see it. I knew it was the best photograph we had." (36) Later, Watson arrives to London, where he meets with Wilkins who hands him a photograph 51, being unaware that Watson and Crick are still seriously thinking about discovering the DNA structure. Watson underlines how thoughtlessly Wilkins has presented the priceless photograph to him: "You offered it up, like a leg of lamb we'd share for dinner." (41) As soon as Watson sees the photograph, he is astonished by the finding. The play cites the fragment of *The Double Helix* in which Watson describes his

reaction: “The instant I saw the picture my mouth fell open and my pulse began to race.” (41) After Watson sees the photograph 51 action unfolds very rapidly. Watson immediately leaves Wilkin’s office and gets on the train back to Cambridge. On the way he sketches the image of photograph 51 on a newspaper and as soon as he arrives, he rushes to Francis Crick to tell him the news. They start to work on DNA structure with double speed, because they know that other scientists, like Linus Pauling, also do similar research and the discovery of “the secret of life” is just a matter of time. In the meantime, Crick receives an unpublished Rosalind’s paper from Max Perutz Randall, his colleague in Cambridge. The paper contained “the latest calculation, confirmation that B form is helical, and the diameter of that helix” (Ziegler 46) – in other words it includes all the necessary data that are indispensable to discover DNA structure. After analyzing all these information, Crick and Watson draw the conclusion that DNA consists of two chains running in opposite directions. Franklin is of course unaware of the race “for the double helix” that is going behind her back. She does not know she is running out of time, therefore she is still doing research slowly, methodically, in isolation, while Watson and Crick are working successfully as a team. Soon they figure out the complete structure of the DNA – the discovery that later will bring them the glory of being Nobel Prize Winners. Franklin, shortly after the discovery of DNA double helix, goes down with ovarian cancer. She addresses the audience with the following words: “I have two tumors. Twin tumors. Twins scampering around my body on tricycles, dropping handfuls of dirt as they go ... For a moment I think of naming one Watson and the other Crick.” (55) The play concludes in 1958 with Franklin's death at the age of 37.

In the end of the play there is an imaginary meeting of Franklin and Wilkins who debate on how they could have avoided the failure. By “what if” statements characters single out the reasons of their inability to discover DNA structure. Here, once again, the author of the play underlines the flaws of Franklin’s character: If she’d been “(...) more open, less wary. Less self-protective”, “(...) take more risk, make models, go forward without certainty of truth” (57) then Franklin and Wilkins’ team probably would have succeed. However, the imaginary scene does not have the function of portraying the wrong model of scientist. The experience of Franklin is a universal

lecture about human nature. Franklin, like everyone, at some point had to take certain decisions and naturally some of them brought negative results. There is nothing wrong about that, though – we are imperfect and the fate of human nature is to fail. Whatever we do, there will always exist some “what ifs”. In *Photograph 51* the motif of fate prevails and is expressed by Rosalind in her final speech. “There is some point in life when you realize you can’t begin again. That you’ve made the decision you’ve made and then you live with them or you spend your whole life in regret” (59) A similar conclusion is presented in the final scenes of *Copenhagen*. Heisenberg, Bohr and Margrethe are dead and no decision can be taken back and no word can be erased - the irreversibility of human’s actions is a fate and “the secret of life”.

III. 4. Facts and Fiction

Anna Ziegler takes a number of liberties regarding the time and nature of some specific events presented in *Photograph 51*. For instance, the final scene of play gives the impression that Franklin died shortly after Watson and Crick had published their paper on DNA structure in *Nature* in 1953, while in reality she died just 5 years later. However, timeline changes work very well in the play – the action is fast, fluid and vigorous.

The controversial aspect of the play is the representation of how Watson and Crick come by Franklin’s data, particularly photograph 51 and the King’s College department report which included Franklin’s latest calculations. In the play, photograph 51 is sneaked by Gosling to Wilkins and later passes on to Watson without Franklin’s permission, while the official version is that Franklin's graduate student had given the image to Wilkins as Franklin was preparing to depart from King's College for a new assignment. One may speculate if the data was shared legally, but the fact that can be put beyond any doubt is that Wilkins showed the photograph to Watson without Franklin’s knowledge²¹. The play also records how Watson and Crick got hold of the paper that Franklin had written and that was attached to the annual department report. Franklin’s biographers and contemporary scholars suggest that the way Watson

²¹ In *Double Helix* Watson writes "Rosy, of course, did not directly give us her data. For that matter, no one at Kings realized they were in our hands." (qtd. in Wade)

and Crick acquired Franklin's data is more than suspicious. Some claim that the report was passed to Crick by Max Perutz Randall, his colleague in Cambridge and that it was confidential; others think that the report was not a secret, although it was still unpublished. Watson and Crick did also little to acknowledge Franklin's contribution to the discovery of DNA structure. In *Nature*, a science journal, there was published a series of three articles on the discovery of DNA structure, and the prominence was given to Watson and Crick, while Franklin's article was only a supplement to Watson and Crick's papers. Moreover, in their articles Watson and Crick only hinted at Franklin's contribution to their hypothesis²².

In the Anna Ziegler's opinion Watson, Crick and Wilkins stole Franklin's data in the sense that they did not emphasize the importance of Franklin's contribution: "Watson, Crick and Wilkins could certainly have done more to acknowledge her, especially in accepting the Nobel." (qtd. in Ballantyne) However, Ziegler did not want her play to revolve around the historical controversies. The point of *Photograph 51* was to show in a relatively humorous manner the tragic flaws of the personality of one of the scientists who was involved in the most important scientific discovery of the 20th century and to render some universal problems regarding human life.

III. 5. Structure and Staging of *Photograph 51*

Photograph 51 was staged in Ensemble Studio Theatre in New York and Theatre J in Washington and both performances were remarkably fast-paced and dynamic. The structure of the play was crucial to achieve the impression of fluidity of the performance. *Photograph 51* has no scene and act divisions – the play consists of rapidly following events. In the notes to the play Ziegler stresses that "the play is truly one long scene and each of its movements should transition as quickly as seamlessly into the next as possible." (5) In the play the changes of movements are manipulated with the light, for example, the character in the center of the attention is highlighted

²² Interestingly, it is said that Franklin has never discussed with Crick and Watson the extent of their reliance on her data and that she has never stated publicly that she was cheated by her colleagues. Some claim that Franklin was simply not interested in taking part in the race of discovery of the double helix of DNA structure. Franklin had given up the research at King's College shortly before the discovery was made by Crick and Watson.

while others remain in the shadow. The play has also intradiologic intermissions like “Back in the lab” (25) or “Rosalind is studying a print.” (29), that separate some specific events.

As it was said before, in *Photograph 51* different modes of storytelling are introduced, but it does not make the action lose its pace. The different narratives are overlapping and blurring in the way that the audience might fail to distinguish them. Some “scenes” are mostly held in retrospect; in others, realism predominates or the present action is commented from the point of view of the bygone days. The juxtaposition of the various narratives generates humor in the play. The characters talk over each other, and Gosling comments character’s behavior in a witty and funny manner. The scientists can be even divided into comic pairs: the first one makes Watson and Crick and the second – Wilkins and Franklin. The conflicted relationship between Wilkins and Franklin is also a source of comical situations in the play. The best example is the following scene:

(Rosalind and Maurice work with Ray between them)

MAURICE: Could you please ask Miss Franklin if she would mind terribly if I were to work with her on the B form of DNA.(...)

RAY. Miss Franklin, Dr. Wilkins would like to know if you might consider –

ROSALIND. Please tell him that I will not collaborate and I don’t appreciate his desire to infringe on my material.

RAY. She says she will not collaborate –

MAURICE. And why is that precisely?

ROSALIND. He knows perfectly well.

RAY. She says you know perfectly –

MAURICE. My lord, what’s there to be afraid off??

RAY. He says “my lord” –

ROSALIND. I’m not afraid of anything! (30)

The vivid exchanges of the characters take place on a simple and practically decorated stage. In Ensemble Studio Theatre the setting was a micro laboratory with all the necessary equipment and two white tables: the first on the center, the other on the left part of the stage. In Theatre J the stage was decorated even more sparingly: there were two tables with a camera to take x-ray photos and some chairs. The ordinary setting of the stage is not coincidental – it enables a quick exchange of actors

which accelerates the pace of the action. Interestingly, the antiseptic look of the stage “with a narrowing focus that cleverly puts the characters under a metaphorical microscope,” (Pressley) resembles the titular photograph 51.

III. 6. Conclusion

Photograph 51 is certainly an innovative play in its organization of the structure. The play is one long scene with just slightly signaled divisions like shifting lights or one-sentence intradiologic intermissions. However, in opposition to *Copenhagen*, the action of the play is linear – the drama traces the history of the discovery of DNA structure starting from Franklin’s arrival to King’s College and ending with her death in 1958 – therefore the audience is not forced to make their own associations which would integrate the play into a logical text. The audience is not temporally separated from the performance either, as the actors address the audience using direct speech. The fourth wall is broken; the actors do not pretend that they are unaware of the presence of the audience.

Moreover, the narration of *Photograph 51* falls far from the traditional. The realism of the play is questioned as various modes of storytelling exist simultaneously. The present, past and imaginary space are mixed together and one may think that many narratives functioning at the same time would confuse the audience, but in fact it makes the play even more complex. The events presented in *Photograph 51* are told from different perspectives and the audience can take into consideration various voices while shaping their own opinion about the issues involved in the play.

On the other hand, *Photograph 51* is traditional in the sense of having a central conflict. The play is driven by the conflict between Franklin and Wilkins who do not manage to create a workable team and in result do not manage to discover autonomously the structure of DNA. Franklin is certainly presented as a tragic hero: she has made the crucial calculations and analysis indispensable to figure out the right DNA structure, but in the end it is not her who makes the groundbreaking discovery. Other scientists have taken advantage of Franklin’s data, and they succeed by working in a team. The play also introduces the ethical dilemma if one scientist has the moral right to use the findings of another scientist without his/her knowledge or permission.

The characters are psychologically complicated, but some of their personality traits are exposed. For instance, Franklin's peremptory attitude and defensiveness are especially striking. She does not hesitate to make direct comments to Wilkins like "you don't command my respect." (29) Franklin is not easy to get along with, but the reader/audience does not have a particular disliking for her. The image of the uncongenial heroine is broken by Franklin's hard and systematic work which results with the great contributions to DNA structure. In addition to that, she is robbed from the achievements by other scientists who use her data to win the race of the discovery of DNA double helix.

While commenting *Photograph 51*, a few words must also be said about the representation of science in the play. *Photograph 51*, like *Copenhagen*, makes use of an event from the history of science that holds a particular mystery. It concentrates on the role of the key scientists involved in the process of discovery, and attempts to find out what was Franklin's contribution to the discovery of DNA, why she and Wilkins were not able to invent the DNA structure independently, and to what extent other scientists took advantage of Franklin's data and if they robbed her from credit. The play again gives more questions than answers and the reader has to shape his/her own opinion about the issues introduced into the play and presented characters.

It might be said that the play is a metaphor of the titular photograph 51: the actions of the characters are recorded in the play and taken under the microscope. A photograph, like a drama, registers some events that are past and gone, but it does not reveal what was in characters' minds when they were taking certain decisions, it does not explain the character's motivations or the nature of the relationships between them. Moreover, the decisions that once have been taken cannot be reversed anymore; "(...) you live with them or you spend your whole life in regret." (59) – says Franklin's character. In *Copenhagen* it is death that makes human action irreparable, while in *Photograph 51*, birth is the point in life after which one cannot really begin again. Once life starts, a human is fated to take some wrong decisions, because human nature is imperfect.

Photograph 51 is similar to such canonical plays like *Arcadia*, *After Darwin* or *Copenhagen* in the sense of deriving some philosophical ideas from the biography of

an authentic or fictional scientific character. However, it makes the audience focus more on the history and personalities than on the science itself. For instance, in *Copenhagen* the uncertainty principle is associated with the figure of Heisenberg and his biography. Heisenberg became a real dramatic character like Hamlet or Antigone, therefore he and the scientific principle that he has invented lost authenticity. Moreover, the metaphor built on the uncertainty principle, precisely the inability to understand other's intentions, is framed by the history and biography, and described by the traditional language of the theatre. The understanding of this metaphor depends heavily on the textual conveyance, while the performance just reinforces the idea introduced into the dramatic content.

In the next chapter I will discuss a play in which science is manifested mainly in the performance. The recent science plays such as John Borrows and Luca Ronconi's *Infinities* and various productions of the Theatre de Complicite link performance techniques and science in the innovative way that deviates from literary works such as *Copenhagen*. As the next chapter will demonstrate, such plays are not based on one fixed, monolithic text, but various scripts that may be used in the performance. They depend more on the visual and physical experience of the audience rather than on the text.

Chapter IV

Exploring the subject of memory: *Mnemonic* by Complicite Company

IV. 1. Introduction

In this chapter I am going to discuss a play that in some aspects differs from the plays that have been already analyzed in this dissertation. *Mnemonic* (1999)²³ is a play that has not been written by a playwright but it was devised by Complicite company, and conceived and directed by Simon McBurney. In other words, *Mnemonic* is not a classic pre-written text that has been later performed in the theatre, but a play created exclusively by Complicite company and its director, and subsequently performed by the Complicite Theatre. Before I start to analyze *Mnemonic*, I will briefly introduce to the reader the Complicite company, as the understanding of the play lies in the nature of its performance.

The British Theater Complicite deviates from the traditional theatre as its style emphasizes on a corporeal, surrealistic, and poetic image that supports the text. It was founded in 1983 by a small group of actors, influenced by two French mime artists, Jacques Lecog and Phillippe Gaulier, who decided to create a “physical theatre” performance group²⁴. The acting of the group was based primarily on movement, less on the text. After a few years the company developed its techniques and shifted to “disruptive theatre” which integrated and balanced text, music and action in one performance²⁵. The latest Complicite productions combine modern technology (the sound and lighting effects, visual imagery, the use of video projection) with traditional

²³ The initial performance of *Mnemonic* took place at the Salzburg Festival in 1999 and at Riverside Studios in London in November in the same year, when it was awarded the 1999 Critics’s Cricle Award for Best New Play. It was revived in 2001.

²⁴ The British theatre company Complicite (original name Théâtre de Complicité) was founded in 1983 by Simon McBurney, Annabel Arden, and Marcello Magni in 1983. Currently Simon McBurney is the artistic director of the theatre. Complicite was, and still is, one of the most experimental devised theatre groups in Great Britain. It has devised over 26 productions, traveled to 41 countries, and has won more than 25 international awards. The first Complicite production, *Put It On Your Head* (1983), consists of the genres of silent film and circus. Other early productions include an expressionist version of *Help! I’m Alive* (1990), and a tumbling version of William Shakespeare’s *The Winter’s Tale* (1992).

²⁵ The first text-based play devised by Complicite was *The Street of Crocodiles* (1992), which was inspired by the life of the Polish author, Bruno Schulz.

corporal and mime acting. It also involves text, which is understood by Simon McBurney not only as a literary form but also as action: “We always begin with a text. But that text can take many forms - I mean it can equally well be a visual text, a text of action, a musical one as well as the more conventional one involving plot and characters.” (McBurney)

Complicite is also a unique theatre because all of its productions are a result of the creative and exclusive work of the company. The name Complicite originates from the French word ‘complicité’ which means ‘partnership.’ The idea of partnership or collaboration is the key method of the company. On Complicite’s website we find that:

There is a principle of working collaboratively, and in particular having designers involved right from the start of any production. There’s a strong emphasis on the performer’s body: (...) rehearsals will involve lots of games, physical explorations and improvisation.

Each Complicite production is the collective work of the company’s members, director, actors and even of people who do not work for the company but who may contribute creatively to production²⁶.

Mnemonic was initiated by Mcburney’s idea to create a performance about community, continuity, and its connection to memory – issues that he considered interesting and relevant to the contemporary times. Mcburney presented the concept of the new play to the members of the company and they immediately started the process of devising the production. They began with merely investigating their own memories and understanding how they function. The original text was simply what they remembered, for example from their childhood, and where they came from. With the passage of time the idea of memory was transformed into a multi-layered performance that consisted of various texts.

The final version of *Mnemonic* is a thirty-five-scene-play without any act divisions. It juggles scenes between two storylines and two interrelated time periods. The first and main narrative is about Welsh- Lithuanian Alice, a contemporary woman, who mysteriously left her boyfriend Virgil to look for her never seen father in Eastern

²⁶ For instance, Complicite while working on *Mnemonic*, invited to collaboration a wide range of neuroscientists.

Europe. The second narrative centers on the 1991 discovery of the Iceman, a frozen body found in the Northern Italian Alps that thought to be more than five thousand years old. The Iceman narrative complements the main story, and “part of the play’s brilliance lies in its ability to show how such seemingly disparate narratives relate one to another.” (*Science on Stage* 144) However, the two narratives function within a third, bigger narrative, which is about private and cultural recollections. *Mnemonic* explores the mysteries of the memory by storytelling that relies on corporal expression and the transformative power of unanimated objects.

In this chapter I will discuss the nature of the *Mnemonic* performance as an inclusion of the physical theatre genre and how science is presented in a such performance. I will also define the role of the dramatic text in relation to the performance as well as the structure and the convention of the play, and the dramaturgical strategies that it operates.

IV. 2. Performing memories

The traditional science plays perform science by merely explaining it to the audience. For instance, in Bertolt Brecht’ *Life of Galileo* the protagonist employs the heliocentric model of the universe by using the chairs. It contrasts the demonstration of science in the contemporary science plays like the French trilogy *Les Variations Darwin* (2004) by Jean Francois Pyre and Alain Prochiantz. During the performance of the drama one actress replaces her head with a cabbage as an actor kisses and eats it. The aim of this scene is to link together two different emotions - violence and tenderness - that are common for all animals. This abstract representation of science that directly addresses the audience is similar to the physicality that is characteristic for the *Mnemonic* performance.

In the beginning of the show, Simon McBurney, the director of Theatre Complicite, and here also the actor, comes out on the bare stage (that has only a stone and a chair) and starts to talk to the audience about memory, setting up the context for the play. The speech given by McBurney directly to the audience resembles a casual lecture about the biochemistry of memory. The actor explains how people have

used to think about the memory and how it really works according to the latest scientific findings.

Modern theories of memory revolve around the idea of fragmentation. Different elements are, apparently, stored in different areas of brain. And it is not so much the cells that are important in the act of memory, but the connection between the cells, the synapses, the synaptic connections. And these connections are being made and remade. Constantly. (...) And with the thousands of these connections being sprouted as I speak, we can think of memory as a pattern, map. But not a stable, neatly printed ordnance-survey map, but one that is constantly changing and developing (3-4)

The lecture conveys the idea that memory is not stored in individual brain cells, from where recollections can be easily retrieved, but that memory is fragmented and it constantly undergoes the act of reshaping – the act which is creative. Throughout life the synaptic connections between our cells are changing and each time we try to remember something, it comes out different. The climax point of McBurney's lecture is when he stresses that re-membering does not happen out of our will, but that it is the creative act of imagination – the act that sometimes brings different results than we expected.

McBurney softens the didactic convention of the lecture by joking, swearing and using a broken chair to illustratively pinpoint the most important moments of his speech. The opening lecture to the audience is also included to the textbook drama version, although during the performance the text serves only as a support, as McBurney speech is aimed to be semi-improvised. There are of course constant elements of the speech, for instance when McBurney explains the meaning of the titular 'mnemonic':

mnemonics are frequently useless objects which are there for no other reason than to help us remember. For example, we carry a wedding ring to remind us that we are married, or a watch to remind us of the time. (...) And I am carrying this rock in my pocket to remind me not to go on for too long. And a second rock to remind me to take another rock out of this pocket which is there to remind me to tell you to turn off your mobile phones (5-6)

In this very moment McBurney is already engaging the audience to the performance. While talking about the mnemonics, he reminds the audience about switching off their phones and as a result the audience is reaching into their bags. In

these few sentences McBurney does not only explain to the audience what mnemonics mean, but also gives a sense of connection between the performance and memory.

The main point of the lecture comes when McBurney asks the audience members to cover their eyes with masks and hold leaves in their hands (which have been located in plastic bags and taped to the back of the seats.) It is clear that the eyeshades and the leaves have the function of mnemonic devices that aid the audience to investigate their childhood memories and, later, to go back to their collective past. The audience is immersed in the act of remembering by answering the questions, such as what the shoes they were wearing at their first day of school, or what they were doing in autumn 1991. Later, the audience is persuaded to imagine that they are holding the hand of their mother in their left hands and their father's hand in their right. "This family linkage is extended through several sets of grandparents, suggesting that to feel the leaf's veins is to feel the pattern of ancestry." (Reinelt 376) As McBurney develops these linkages further back in time, and he finally concludes, "(...) it means that you are related to everyone sitting in this theatre." (7)

The scene with the participation of the audience introduces two different time lines: "the private kind [of time], our own (...) that we can revisit and that becomes solely to us, and the public sense of time, cultural memories of events shared by us all." (*Science on Stage* 146) The scene also represents the play's accomplishment to replace the use of science from the micro level - which was lecturing the audience about the chemical process of creating and retrieving the memories - to the macro level, which was persuading the audience to go back in time to the human's collective past. A significant part of the performance is McBurney's trickster personage who, with the help of a seemingly casual lecture, manipulates the audience's memories in the way that the audience becomes a creative participant of the performance.

At the end of the lecture the audience is asked to remove the masks, but McBurney is not there anymore – at least not in the role the audience is used to know him. McBurney has turned into another one of us – sitting with an eyeshade and stroking a leaf. The audience did not notice that in the last a couple of minutes they have been listening to McBurney's voice-over, while McBurney was transforming into

one of the audience members to later become Virgil's character who will try to contact his lost lover, Alice.

IV. 3. A journey back in time to chaos

The story of the play begins with Virgil who investigates his memories to understand why Alice has left him after the funeral of her mother. Virgil is waiting in his English flat with a mobile phone and his memories of Alice and of their last encounters, while Alice is travelling across Europe in pursuit of her phantom father, although she is not sure if he is alive. Both characters are looking for something that in some way does no longer exist, but that is indispensable for them to go on with the present and to think about the future. They wish they would organize their past to embark on a new stage of their lives.

However, the audience already knows that Alice and Virgil will not be able to retrieve the past. The failure of Alice and Virgil's investigations has been announced in the first scenes of *Mnemonic* when Virgil introduces the chaos theory by saying: "(...) the pattern of the leaf is chaotic. (...) The further back we go, the more chaotic our interrelationships become. In other words we do not know where we come from." (11) It means that the same leaf that was demonstrating the long line of human ancestry also shows that the pattern of our ancestry is fractal and unpredictable. In other words, we see that the veins of a leaf are interlinked according to some pattern, but we are not able to comprehend why the veins form a particular sequence, not another one. These veins are our past, our ancestry that is chaotic and unpredictable.

The theory of the chaotic past contradicts the notion of predictability (or destiny) which states that we might understand why something happened if we looked for some events from the past that could explain it. For example, Man's character tells Virgil that he has phoned him because he was sorting out some stuff and he found the picture of Virgil and Alice that made him start to think about Virgil. This may suggest that it was predictable that Man would call Virgil, because he found the photograph of him and Alice. But in fact it could happen that Man would not find Virgil and Alice's picture and then he would not call Virgil and would not converse with him about memory. Thus, it leads to the same conclusion that human life is directed by a

coincidence; that “it’s all out of control, it’s chaos and we don’t know why or how chaos occurs but there is a pattern to it, this pattern is completely unpredictable. It’s a question of how we live with that unpredictability” (Complicite 13) The dichotomy of chaos versus order is also presented in other science plays written by Tom Stoppard – *Arcadia*. From *Arcadia* we learn that everything is gradually diffuses into a state of disorder and entropy, but in the end an order can be found within that chaos. This notion is expressed by Valentine statement: "In an ocean of ashes, islands of order. Patterns making themselves out of nothing." (101)

In *Mnemonics* the notion of chaos is prevailing: chaotic is a state of mind, the weather, nature, and, finally, the universe. The sense of chaos stays in opposition to the setting of the stage: Virgil, while sharing his recollections with Man, sits in an ordinary room equipped only with a bed, a table and a plastic layer that serves as a wall. Virgil does not understand why Alice has gone, leaving him only a short message on the answering machine: “You have to wait now and this time you follow me.” (15) The sentence is an evident contradiction (you have to wait and follow) that will be repeated many times during the performance like the reminder of characters’ state of turbulence and instability.

IV. 4. Crossing borders

The idea of disorder is reflected in the structure of the play: *Mnemonic* is fragmented into many stories that are overlapping or run simultaneously. The characters all the time change location, and the space around them reforms constantly. The dialogues consist of short sentences and repetitions so the action is fast-paced, sometimes even difficult to follow. The audience may fail to recognize if they are witnessing the character’s imagination, memories, dreams, present or past events. The most intricate is Alice’s narrative and her journey to Eastern Europe. While Virgil stays in his solitary room (most of the time naked) and his only contact with the world is telephone and television, Alice is meeting a shifting stream of strangers, for example a German hotel maid, a Greek taxi driver, an American traveler or new found family like Alice’s Ukrainian half-brother. All of them are in continual motion as they are constantly seeking for or fleeing from something: “Across the whole of Europe,

thousands of people running for their lives... a mass migration.” (Complicite 53) In Germany, Alice encounters Simonides, a taxi driver, who has left Greece to look for a better life. In the symbolic scene Simonides leans over the grave of his dead father, his ancestor, and tells him that he was going to work for BMW in Germany, but his candidature was rejected due to his father’s convictions (his father was a communist and fought as a partisan in the Second World War). Simonides decides to erase the shameful past by buying a first-class ticket to Germany, although he can hardly afford it. Eventually, Simonides’ dreams do not come true, he ends up as a taxi driver, but he does not stop thinking about a better future nonetheless: “I don’t look back, you know, you know this is a first rule for a taxi driver, don’t look back or you will have a crash. No, my friend, I am interested in what is in front of me. I believe in the future.” (50) The German maid, who later comes across as Simonides’ wife, also advises Alice not to try to recapture the past: “In the past you always arrive too late. Too late. Don’t go back, go home.” (46)

Alice, however, keeps looking for her father. She does not possess even memories about him, only a broken Russian watch that belonged to him. With the passage of time she manages to find a sister-in-law, who gives her a box of her father’s belongings; a lighter, a scarf, and a pair of old shoes. These seemingly useless objects inform about Alice’s father’s origins, profession, and even personality. The BBC Man, an international correspondent rummages through her father’s things and tells Alice that her father was: a motor cyclist, “look at the way the right [shoe] is worn more than the left” (51); Jew as the scarf is “A tallith. A prayer shawl” (52); and a smoker which is indicated by lighter. Interestingly, the more Alice knows about her father, the less she is able to relate to her past, to her ancestry. She does not feel like a Jew and she does not understand when the BBC Man has said that she is carrying five thousand years of Jewish’ struggle, migration and history.

Interwoven with Alice’s narrative and other smaller stories is an account of the discovery of the Iceman, a five-thousand-year-old corpse found at a three thousand meters height of the Northern Italian Alps in 1991. The Iceman narrative was inspired by *The Man in the Ice* (1995) written by the archeologist Konrad Spindler, who has described in his book the discovery of the Iceman . In *Mnemonics* the role of the

Iceman is taken up by the same actor that plays Virgil (Simon McBurney). As soon as the Iceman is discovered by two German tourists, Helmut and Erika, he brings together scientists from all over Europe and the US, who are going to search the scientific facts about the Iceman's body and life. The scientists team led by Konrad Spindler investigates the innards of his corpse, the scraps of the clothes and his weapons. The Iceman is immediately stripped of humanity and dignity – he becomes an object, a property that is displayed for the public eyes. There is a debate whether the Iceman belongs to Austria or to Italy, as the Iceman was discovered on the border line of these two countries. However, not only the authorities of both countries claim the ownership of the body, but also random people who have heard about the Iceman in media, for example the German Woman: "Hello, hello, this is Anna Schmidt calling from Munich. I've just seen the Iceman on the television and I think he is my grandfather." (32)

The interest that revolves around the Iceman generates humorous situations in the play, although most of the times it is a black humor. The Iceman is not treated like a human being, but like a treasure or a commercial product that has a price. At the moment when the body is officially announced as an ancient monument, the audience hears the generated sound of applause and is observing the transformation of the Iceman into a chair. The scene has a symbolic meaning – the Iceman is not a living flesh any more (represented by the actor), but an unanimated object.

The discovery of the Iceman raises the ethical discussion about the moral rights of scientists to deprive a human from his dignity in the name of aggrandizing knowledge about science. Konrad Spindler, the chief archaeologist of the actual case, describes the Iceman only in the scientific terms. He represents forensic science: he speaks in long monologues that just list facts and gives very little opinion and very little insight into his character:

X-ray of the body show rib fractures testifying to his violent life. On the left side the fifth, sixth, seventh and ninth ribs showed healed fractures. All five had healed well. But on the right side, the third, fourth, fifth and sixth are broken and somewhat out of position. There is no sign of calcification. (...) This is why he lay on his left because his ribs were broken. (56)

In the play Spindler invokes the atmosphere of objective, laboratory science. On the other hand, there is Virgil, who is interested in the personal life of the Iceman, and his individual past. While Spindler is listing more and more facts about the Iceman corpse, the audience is able to hear Virgil's voice over: "How many children did he have? What world did he use to signify summer? ... or this place? How many songs did he know? Had he yet heard the story of the flood?" (57) Virgil, in opposition to Spindler, represents the "subjective science" that is not free from the personal view. By dint of Virgil's character the audience is able to see a human side of the scientist as well.

A multinational team of scientists and journalists are attempting at putting together the pieces of the Iceman's life by studying the artifacts he left behind. It parallels Alice's attempt to find the truth about her father, following the trail of his watch, shoes, prayer shawl while travelling through Germany, Poland, Latvia, and Ukraine. The scientists find close to the Iceman objects that are seemingly meaningless, but which enable them to estimate the age of the Iceman, the last hours of his life, his ailments, even what his last meal was before death. In the end of the play the delegates from all over the world meet at a conference in Bolzano to give an account of the examination of the Iceman corpse and his belongings, and to present the possible theories regarding his past. The encounter of the delegates is depicted in a humorous fashion, as experts glean a completely incompatible range of information about the Iceman's personal life:

Greek Delegate And as conclusion what I wanted to say is that he was up there because he was businessman, I mean a Neolithic businessman, (...)

English Delegate This areas is famous for transhumance of sheep and has been so for at least 5,000 years. (...) They are remarkably loving creatures which brings me to my point, basically I'm saying that he's a shepherd. Thank you.

French Delegate Merci. Alors on trouvé que l'objet qu'il tenait dans son poing...était un antibiotique naturelle...

US Delegate We can't understand you, I'm afraid.

French Delegate Oh... well, I too will try in English. (*Pause.*) So, maybe he was a doctor. Thank you. (*Complicite 68-69*)

The audience does not know if the hypotheses given by the delegates are at least reasonable as well as they don't know if Alice's father was really a motorcyclist or

a Jew. However, *Mnemonic* is not a play that explores facts about people's past lives, neither has it any clear destination. Alice finds her father in Moclavic, a small village in Poland, but she eventually abandons the idea about meeting him. The father has been sleeping in an apple orchard, on the grass, between the trees, but Alice does not wake him up, she walks away. When she has the possibility to confront her past, she understands that it is impossible. She realizes that the man who is lying on the grass is her father and at the same time a stranger. She could meet him, but it would not change her childhood experience, which would always remain without him.

When Virgil asks Alice what happened when she saw her father, she simply responds that she does not remember. She can describe her father's face but she cannot explain why she has left the apple orchards and in what circumstances. Alice's story is suspect like the stories of diverse range of travelers that Alice has met and multinational academic team of researchers. It is not because "the people are consciously lying but because memory is mutable. The frustrations of trying to get the story, any story, straight are compounded by the disruptions of contemporary technology." (Brantley) During the performance the audience hear the familiar noises of traffic jams, trains, an answering machine, television, cell phones and a mixture of languages (apart from English the dialogues are written in German, French, Greek, Czech and Polish). *Mnemonic* expresses the voice of the technology-driven era. Contemporary people live their lives surrounded by various, fragmented stories that can never be taken for granted. McBurney writes about it in *Mnemonic's* program note:

We live in a time where stories surround us. Multiple stories. Constantly. Fragmented by television, radio, print, the internet (...). We no longer live in a world of the single tale. So the shards of stories we have put together, some longer some shorter, collide here in the theatre, reflecting, repeating, and evolving like the act of memory itself. (qtd. in Sommer)

When Virgil tells Alice the story about the Iceman's death and she asks him if it really could happen like that, Virgil concludes: "How can we possibly know? It's just one theory. A story. It's one way of going there, isn't it? A story. We need stories" (73)

At the end of the play the diversity of characters and their various stories blend into one powerful image, one powerful transformation which makes the climax of the

show: the cast members are looking at the displayed naked body of the Iceman in the museum in Bolzano. Suddenly, they start to walk towards the body of the Iceman and one after another they lay themselves on his place, slipping into the arranged pose of the corpse, and “roll off again, just as generation succeeds generation in never ending cycle.” (Complicite 75) It is clear that the cast members’ transformation into the Iceman, signifies that his frozen, five-thousand-year-old ancient body represents every man. “The substitution makes a ‘family of man’ statement, linking everyone in an image of sameness.” (Reinelt 376) This is why cast members were looking at the exposition of the Iceman body not with interest, but with empathy. It was the moment of catharsis: In Iceman they saw themselves, their own history. In one version of the London program of *Mnemonic* John Berger wrote:

All bodies have so much in common, more than we habitually remember until we see one naked, or until we deliberately touch one another. The similitude, however, is not the conclusion but the starting-point. It is where empathy begins. It is how one can put oneself in somebody else's place. In the gully, for example, five thousand years ago. (qtd in. Reinelt 376)

In the play the naked body symbolizes the unity between people. The nakedness reveals to us an irrefutable fact that we are all the same, all vulnerable, all weak, all lost in the unpredictable chaos of life, and the only way that we can handle our weakness is to accept it. Throughout the performance one question is retrieved all over again “What does nakedness remind of us?”, and Capsoni character answers: “It reminds us that our fears are natural, that we are all vulnerable. So, let us agree that we are both frightened, stark naked and that we climb this mountain together. (...) And once you start you cannot look down.” (19)

IV. 5. Conclusion

Kristen Shepherd-Barr in her book *Science on stage*, classifies dramas like *Mnemonic* as alternative science plays. She explains that such a taxonomy is not to set up the opposition between “alterative” works and more mainstream science plays, but to “explore their differences and especially how they utilize science in relation to the audience.” (200) In the case of *Mnemonic*, science is not mediated through the plot or the character, like in traditional science plays, but is addressed directly to the audience. On the opening lecture of the play, the audience is literally experiencing

science by remembering their childhood and collective past with the aid of mnemonics (an eyeshade and a leaf). The metatheatricity of *Mnemonic* is even more powerful as the play not only performs the main ideas involved into the play, but also engages the audience in the way that they are inherent part of the performance. The play is a sort of experiment that “immerses the audience in certain aspects of neuroscience and biochemistry.” (*Science on Stage* 203) From the beginning, the attention of the audience is attracted toward science itself, not to a character or the plot.

The uniqueness of science plays such as *Mnemonic* also lays in the process of making the performance and the way of utilizing the text. *Mnemonic* is not written by one particular author in isolation, and it is not one monolithic, coherent text. The process of making *Mnemonic* had been initiated by Simon McBurney, the artistic director of the Theatre Complicite, who wanted to create a production about the memory and its connection to the individual and collective past. During the Complicite workshops this idea was developed by the collaboration of various individuals like actors, writers, and a wide range of neuroscientists. Their work was transformed into the final text form of *Mnemonic*, a multilayer play consisting of many interrelated stories.

Another important aspect of the performance making is that the text serves only as a starting point. The real story is not told in the dialogues, but through the physicality of the actors²⁷. For instance, Alice and the Iceman narrative can be summarized in merely a few sentences: Alice heads east across Europe in search of the father, while an international team of scientists are making a forensic examination of the ancient body of the Iceman found in the Northern Italian Alps. Of course, the point of *Mnemonic* is not these two stories but how they are told and how they individually address the audience through the performance. When the cast members are transforming one after another into the Iceman, which expresses their empathy and unification with the ancient body, it is not demonstrated in the dialogues; “(...) this

²⁷ It is very near the concept of the postdramatic play, which is produced not to remain faithful to the text, but to be effective in the performance. The postdramatic plays function within a performative aesthetic in which the text is subordinate to the action that happens on the stage.

empathy [is showed] through the images of bodies and their fascination with each other and their gradual, emerging equivalency.” (Reinelt 376)

The idea of the transformation of the bodies and the objects is central to the play. During the performance the audience is witnessing the characters’ journey through space and time, reality and fiction of memory. The characters are played by actors who are from Greece, England, France, Germany and other countries – many times all of them are speaking in native languages and the translation or projected subtitles are not available for the audience. Moreover, the actors, who are constantly in motion, are playing various roles, for instance McBurney is once Virgil, once the Iceman; or Scientists turn into Journalists and vice versa. The physicality of the actors, their movements are mediating the ideas introduced into the play. In *Mnemonic*, the transformation of the objects and the bodies suggests “that we humans carry pasts concretely within our container-selves, in our brains, our postures, our nakedness.” (Reinelt 375)

The scientific ideas introduced into the play, and the audience involvement in the performance, are reinforced by the setting of the stage. Apart from Virgil’s room equipment, there is also a rock, a chair and another table on the stage – these props are particularly interesting as their function changes while the action of the play unfolds. For instance, the rock once is a mountain where the Iceman is discovered, another time it is the grave of Somonides’ father; or in the final scene of *Mnemonic* the broken chair becomes the puppet of the Iceman. The table has a special function of connecting the past and the present, like in *Arcadia*, although in *Mnemonic* not the objects occupy the table, but human bodies. Virgil, who is the character of the present narrative, by lying down naked on the table, transforms into the five-thousand-years-old Iceman.

The bareness of the stage and ordinary props facilitate the quick transformation of the bodies and objects. Science plays, like *Copenhagen* also abandon a sophisticated setting and props to eschew realism. In such science plays the manipulation of the stage makes the realistic convention questioned, but its suggestion is always present. The audience is able to imagine the objects that are missing on the stage. In *Mnemonic* “no subconscious furnishing occurs because the

assumption of realism is prevented.” (*Science on Stage* 213) During the performance the audience is asked to locate the masks on their eyes and stroke the leaves in their hands to immerse into their own memories. From the beginning the audience is transported into another reality – a reality of individual recollections. In other stages of the performance the importance of the connection of the memory and the performance is emphasized by the curtains that are painted with a pattern reminiscent of neurons.

The performance is not only supported by the stage props and setting, but also by the usage of sound, lighting and visual projection. Elyse Sommer wrote in her review of *Mnemonic* that the play is “a visual feast of movement, light and sound.” She continues:

No less remarkable than the performances is the dazzling stagecraft: Michael Levine’s set design evokes every shift in the play’s ever changing landscape. Paul Anderson’s lighting is nothing short of brilliant, especially when he accompanies a telephone conversation between Virgil and Alice with her image projected into his bare chest. Christopher Shutt’s sound effects further enhance the overall originality and effectiveness.

The uniqueness of *Mnemonic* lies in its ability to balance with live performance, sound design, visuality and text. All of these elements that are combined with the physical movements of the actors make *Mnemonic* a successful “alternative” science play. *Mnemonic* starts with an overload of data and confusion caused by many overlapping stories, but it ends with the audience experiencing the familiar feeling of understanding that the mysteries of the human condition, the sadness and violence of the past, the melancholy of the relationships, the experiences that shape our lives, are worth to remember.

Conclusion

The aim of this dissertation was to demonstrate that drama, performance and science have natural affinities. Science is a mine of illustrative archetypes, topics and ideas which create insights into human behavior and provide the terms of complex ethical discussion. Plays involve science into their dramatic content and performance in completely different ways and the objective of this dissertation was to present this diversity, which indicates how creative the interface between science and the humanities might be.

In the Introduction, a specific number of research questions were enunciated, to which this dissertation attempted to answer. The main question was how the science functions in the analyzed plays and how these plays rework conventional paradigms of perception of science. In *Copenhagen* science is the source of the powerful metaphors which talk about the conditions of human's life, for instance the metaphor of the uncertainty principle demonstrates that as our access to other people's minds, thoughts and memories (even our owns) is very limited, we cannot judge them easily. The play explores scientific ideas in order to reveal truths common for all people. The hard science introduced into the play, does not make *Copenhagen* difficult to understand, but it is an integral and comprehensible part of the drama storytelling and performance. *Copenhagen* introduces difficult scientific laws, like uncertainty and complementary principle, or fission and Schrodinger's wave function without lecturing the audience. These laws are in *Copenhagen* translated into literary language and later enacted on the stage. Such treatment of science changes our perception about it. Science is not just numbers and incomprehensible mathematics, but the device which has the power of bringing about a critical appraisal of human nature.

In *Photograph 51* the harnessing of science is more conventional, in the sense that it is not presented in an aesthetically integrated way. Science is employed on a textual level, but not on a theatrical one. In other words, the story of *Photograph 51* is told with the use of traditional theatre language which excludes the interdependence

of the structure and the content of the play. However, *Photograph 51*, like *Copenhagen* modifies the common perception about the science. From *Photograph 51* we learn that the process of making a discovery is not easy and straightforward way but a winding and jolty path. A race for discovery is frequently won by the scientist who is clever, slick, tricky, rather than by the hardworking and conscientious person. The scientist has to make fast decisions appropriate to situation that emerge and know how to take advantage of the opportunities. According to *Photograph 51* Rosalind Franklin lost the race for the discovery of the DNA structure because she lived in the times when a woman-scientist was discriminated and because she could not develop a workable and useful professional relation with the certain people. *Photograph 51* like *Copenhagen* shows that the decisions we make and the words we use can change the course of our life and that we cannot simply make a journey back and reshape our past.

The motif of impossibility of retrieving the past appears also in *Mnemonic*. Here, the science is employed mainly in the performance. The audience, like the characters participate in the creative act of retrieving memories and recapturing the past. There is no temporal and special distance between the audience, actors, cast members, and even the artistic director of Complicite company: everyone who is present in the theatre creates the play. *Mnemonic* demonstrates that science is an integral part of our everyday life. We are making science while doing some mental and physical activities: when we are thinking and talking the synaptic connections in our brain are reshaping and our memories are shifting and developing. *Mnemonic* conveys the notion that people carry science in their physicality, in their usual movements. This idea is reflected in the performance of the play. The actors are in the constant motion – their bodies and their movements express what the play is about.

In that sense *Mnemonic* bears some hallmarks of other science plays like *Copenhagen* and *Arcadia*. *Mnemonic* can be classified as a metatheatrical play because it performs the themes of the play. For example, the theory of disorder is reflected in the mind of characters and in their movements. The objects and people are chaotically transforming on the stage and the space around them reform constantly. Another common feature that links *Mnemonic* and more traditional science plays is that

Mnemonic has easily identified story: a contemporary woman, Alice, leaves her boyfriend Virgil in pursuit of her past. This story is complemented with the Iceman narrative, the discovery of the ancient body in the Northern Italian Alps.

However, in *Mnemonic* the problematic issue is to determine the main character and the tragic hero. In case of other analyzed science plays the identification of the tragic hero is obvious: in *Copenhagen* it is Heisenberg who cannot explain why he insisted to meet with Bohr in Copenhagen in 1941, in *Photograph 51* it is Rosalind Franklin, whose contribution to the discovery of DNA structure was not acknowledged. In *Mnemonic* the main character might be a Virgil, who is investigating his memories to understand why Alice abandoned him; it might be Alice who eventually does not manage to recapture the past, and finally it might be the Iceman, whose ancient body was dehumanized and turned into the commercial product that has its price.

The resolution of *Mnemonic* also suggests another idea. In the climax of the show the cast members, one after another, turn into the prehistoric body of the Iceman. This is the act of common empathy, that indicates that actors and everyone in the theatre is a tragic hero: someday all people will turn into ashes and their history will be past and gone, impossible to retrieve. This is consistent with the opening lecture of the play, during which the audience is investigating their memories to quickly realize that their past is collective, and that they are related to everyone in the theatre. The notion of common history and other ideas of the play, are expressed by the mime acting, and physicality and visuality of the performance.

The “alternative” or “postdramatic” plays like *Mnemonic* brings us directly to another question: What a science play is? Is it a play that uses the conventions of traditional drama or is it a play like *Mnemonic* which represents innovative and groundbreaking techniques of performing? This question is at the core of performance studies, a field that has been attracting a tremendous attention in the recent years. It is certain the science playwriting is crossing more and more borders, which makes its identity an abstract concept. Thomas Postlewait in an influential article for *Theater Survey* stresses that: “Just as the popular concepts of *theatricality* and *performativity* are in danger of meaning everything, and thus nothing, so too is our discipline in danger of crossing so many borders that it loses its way...” (184) On the other hand,

the phenomena of science plays, as a constantly developing new genre of drama, is enthusiastically received by the theatre-goers and critics. The fruitful intersection of science and theatre has brought powerful works that embrace a multiplicity of themes and theatrical strategies.

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