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In Pursuit of Women Scientists: Using Science Plays to Promote Women Entering STEM Disciplines

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Fine Arts at Virginia Commonwealth University.

by

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Abstract

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Higher education currently seeks to increase female enrollment in STEM. Women face many challenges attempting to breach this male dominated arena with misconceptions, gender stereotypes, and few female role models. With the recent trend in higher education to encourage more women to enter the STEM disciplines and K-12 schools cutting funding for arts programs, theatre may be losing its value in the education system. The value of interdisciplinary studies is beginning to be forgotten during the grade school years as school boards battle budget cuts, but we can remind society of it through science plays. Theatre artists use other disciplines such as psychology, history, and science to enhance their work, but I argue that theatre can also help promote the needs of other disciplines.

Science plays have become increasingly popular over the last two and a half decades and have done much for theatre. Science plays can assist in addressing the issues facing women attempting to enter STEM disciplines. The majority of science plays feature historical people

and can therefore provide the much needed role models and address the other issues and misconceptions. To do this, science plays featuring women should target middle and high school girls as well as their teachers, parents, and guidance counselors who often discourage girls from pursing STEM interests.

Chapter 1
Why Science Plays?

Even though plays dealing with science have existed for quite some time, it is only with their recent growth that has led to the conception of the term, 'science plays.' Consequently the definition of what exactly constitutes a science play has been the topic of frequent debate with a wide range of answers. 'Science play' is a very broad term for this vast genre. Some definitions include any plays that even mention science, including science fiction, while others limit it to only the ones in which the science itself plays an integral part and without it, there would be no play. What makes it a science play versus a play that simply has science in it? Most definitions agree that science plays deal with people and the science in their lives and society. "If the scientists as people are at the core of dramatic work, or the science as such, then the social implications cannot be detached. And the point where science and society meet are exactly those which are of greatest interest for the stage" (Zehelein 91). Science plays span across different cultures, periods, disciplines, and styles of theatre. Many of them, such as *Arcadia,* by Tom Stoppard, and *Legacy of Light*, by Karen Zacarias, feature two time periods which intertwine at the end of the play. No consistent criteria, format, or formula exists for the genre, which accounts for the disagreement in the genre's definition. It appears to be a genre characterized by the content of the text over other theatrical elements such as directing or design.

Because it is such a complex and debated term, Eva-Sabine Zehelein devotes an entire chapter to it in her book, *Science: Dramatic Science Plays in American and Great Britain, 1990-2007.* She quotes playwright and Emory University Professor of Physics, Sidney Perkowitz's definition, as "one in which scientists and scientific ideas, ethical issues or interactions with society are important dramatic elements, but where the science is confined to known limits or reasonable projections" (88), believing it to be the best one that she has found. The genre is so complex that Zehelein breaks it down into three subgenres: science-in-theatre, history of science in theatre, and borderliners (ones where science has only a minor role). She believes that a science play to some extent addresses ethical issues on the role of science and scientists in and for society, man, and nature (99). For my purposes, the definition of a science play is any play which explores a scientist and the role that real science plays in his or her life or society.

Although science plays have existed for centuries in western theatre[1], more have been written after 1990 than before. Only four plays are considered as meeting the qualifications before 1800, four between 1800 and 1900, and thirty-one between 1900 and 1990. They are becoming increasingly more popular with fifty-nine plays premiering since 2000 with twelve of them written just between 2005 and 2007 (Zehelein 2). Several new sciences plays recently received their premieres in 2015, including Tom Stoppard's *The Hard Problem,* Tom Morton-Smith's *Oppenheimer,* and Lauren Gunderson's *Ada and the Memory Engine.* There are now even playwrights who write science plays almost exclusively, Lauren Gunderson, as well as

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[1]Science plays date as far back as the Renaissance with plays such as Christopher Marlowe's *Doctor Faustus*. Even though Faustus practices an abandoned science, alchemy, it was a science practiced at the time, hence its inclusion in the genre.

playwrights who began their careers as scientists and turned to the theatre, such as Sidney Perkowitz[2]. It is intriguing that some scientists have ventured to playwriting as the writing of their research tends to be dry; they are not the best spokesmen for their fields (Shepherd-Barr 2006, 47-48). Perhaps this is the reason they turn to the theatre as a way to creatively discuss and explore the research process. In 1988 Tom Stoppard wrote *Hapgood,* a physics play integrating spy games and Heisenberg's uncertainty principle. While it contains one of most significant theatricalizations of this scientific principle, it was poorly received leading Stoppard to revise or cut many of the lengthy scientific explanations before its more successful production at the Lincoln Center in 1994 (Shepherd-Barr 2006, 88). Sylie Drake's review in the *Los Angeles Times* claimed that "Stoppard always has something interesting to say, but there is such a thing as too much, particularly when ideas and language become diversionary tactics." The popularity of science plays stemmed from Stoppard's 1993 play, *Arcadia,* and was given another boost with Michael Frayn's 1998 play, *Copenhagen* (Zehelein 4). It can be assumed this popularity was due in part to both being already well established playwrights at the time that these plays premiered in London. The commercial success of these two plays most likely led to many professional theaters producing science plays more frequently and actively seeking out new ones for production (Zehelein 4).

Numerous sources cite several factors that have contributed to the rise and continued popularity of science plays. Science has become, to a certain extent, common knowledge, so

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[2]Lauren Gunderson studied under Sydney Perkowitz at Emory and wrote one of her first science plays for him. Her husband is also a scientists, a virologist (Gunderson Interview).

audiences are able to more easily understand the topics and ideas than they were able to in the past[3]. There has also been an increase in the concern of ethics in many arenas, including science, and science plays frequently ask ethical questions. Events such as the bombings of Nagasaki and Hiroshima during World War II have caused scientists to come under ever increasing ethical scrutiny, which has been further strengthened with recent developments, such as cloning and stem cell research. Scientists have begun to write books for a lay audience as well as reading science plays such as *Arcadia* and Brian Green's *Elegant Universe* and major scientific biographies on Albert Einstein, Steve Jobs, and the innovators of computers have emerged. Major funders for scientific work also want the knowledge made public such as the Alfred P. Sloan and the National Science Foundations.

The science and technology of today has a much more direct impact upon on the everyday life of an individual than ever before and science plays address society's relationship to science (Shepherd-Barr 2006, 52). We do not typically see what a scientist does on a daily basis or the process that they go through, but rather only the end result, so these plays provide us with an insight. Science is conducted by real people who experience life just as anyone else does. Scientists fail, have disagreements, and succeed. Everyone faces sacrifices in life, which has become a common theme in these plays, allowing audiences to connect with the characters. In addition, the increase in interdisciplinary studies has likely advanced the prominence of science plays, as they blend the hard sciences with the humanities in a way that

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[3]Required education through the twelfth grade that includes science and math, the use of technology in the daily life of the average person, and medical advances announced on the nightly news.

no other art form does.

In combination with the increase in their popularity, the way in which science has been featured in the plays has evolved as well. Older plays primarily feature the morality of the scientist, public responsibility, and the individual's pursuit of truth. While those themes have not disappeared, contemporary science plays tend to deal with moral ambiguity and the unreliability of memory as in David Auburn's *Proof.*

Furthermore, science plays allow for innovations as playwrights begin to incorporate the science more intricately. Just as any genre or form has its own assets, science plays provide their own unique value to theatre. With science plays we can "learn about the unique possibilities of the stage" (Shepherd-Barr 2006, 9). Science plays have allowed playwrights to employ diverse theatrical conventions; perhaps this exploration is reflective of the scientific method (Shepherd-Barr 2006, 43). Theatre's move away from realism makes science an appropriate subject as it allows for unique theatrical devices to convey science's abstract ideas that realism is unable to convey. *Photograph 51,* by Anna Ziegler, and *Silent Sky,* by Lauren Gunderson, employ the use of letters to connect time and space allowing for the use of more diverse staging opportunities that can reflect the science of the play similar to how Fermat's Last Theorem does in *Arcadia*. The staging and interwoven eras of *Arcadia* are heavily influenced by the science in the play showing that things once mixed, cannot later be separated. As genetics are explored in Damien Atkin's *Lucy,* the audience is brought into Lucy's mind between scenes to experience the world the way she does with autism. "One might say that the further science plays get from realism, the closer they get to real science; and the more

compelling the science play, the more it tends to depart from straight realism" (Shepherd-Barr 2006, 43).

"One of the main contributions of science plays is their collective challenge to the notion of realism, both in life and on stage" (Shepherd-Barr 2006, 41). Science and science plays seek the question of what is real and offer alternatives to realism. Emilie du Châtelet and her discoveries on the properties of light explore that question of reality. Science and art also find similarity in that they seek the meaning of life and to understand it. Theatre, regardless of form or genre, brings together two types of people, performers and audiences, to engage them in a dialogue. By bringing science into the theatre, performers and audiences are able to confront the issues that science has brought into their daily routines. They combine political and cultural topics so significant that these plays will remain relevant for quite some time.

While science plays cover diverse fields, such as mathematics, Darwinism, genetics, and astronomy, physics dominates the genre. As it deals with the physical universe, the concepts can easily be explored through physical action on the stage. Physics tends to have the highest profile names of any field with Stephen Hawking, Galileo Galilei, Isaac Newton, Albert Einstein, and Emilie du Châtelet. Most of these physicists are also closely related to political events, as with Galileo and his belief in heliocentrism, and physics is closely linked to catastrophic inventions such as the atomic and hydrogen bombs, making for fascinating theatre. Physics also has an incredible rate of new discoveries over a relatively short period of time allowing most audiences to have some cultural context and memory and therefore a stronger connection with such pieces (Shepherd-Barr 2006, 62). Physics plays are so common that

Kirsten Shepherd-Barr in her book, *Science on Stage: From Doctor Faustus to Copenhagen,* discusses them before any of the other fields in science plays.

Even though science has become an important part of modern life, some find it confusing and intimidating. Science plays can provide an opportunity to immerse such audience members in the subject through a dramatic plot and relatable characters, and perhaps even lead to an interest or basic understanding. As with any piece of theatre, a good science play must first entertain if it has any hope of achieving its "vital role in helping us understand our encounter with the increasingly urgent questions and issues posed by science" (Shepherd-Barr 2006, 218). Theatre reflects the culture of the time and science plays clearly reflect the current culture, even for those who prefer to avoid science, as they cannot escape the impact it has upon their daily lives.

As with any form of artistic expression, playwrights of science plays utilize artistic license. Many science plays, especially those with historical figures, are based in fact. For example, in *Legacy of Light*, Emilie du Châtelet did have a romantic relationship with Voltaire, she did make significant discoveries on the properties of light, and she did die shortly after the birth of the child she is pregnant with in the play. *Legacy of Light* also features actual quotations from Voltaire including, "O Lord, make my enemies ridiculous. And God granted it," and "we are full of weakness and errors, let us mutually pardon each other our follies. It is the first law of nature." *Photograph 51* implies that Rosalind Franklin never married or had children as it was incompatible with her work. However, her sister Jenifer Glynn, wrote one of Rosalind's biographies, *My Sister Rosalind Franklin,* and in it states that in fact "Rosalind never decided that science and marriage were incompatible and that her life was to be devoted only

to science" (57). It just so happened that she never married. Whether or not Ziegler intended to change the character of Rosalind with her use of artistic license, she did. In the play, Rosalind, is seen as an almost masculine woman so focused on her work that she cares little for anything else. This artistic license does allow Ziegler to tell the particular tale of Rosalind Franklin and her part in the race to the discovery of the Double Helix. Although one of the goals of a science play is to hopefully inspire interest in a particular scientist or topic in the audience, it is important to remind the audience that while some plays may be more accurate than others, no play is one hundred percent historically accurate; if they were, it may result in rather boring theatre. The playwright of a science play should also be aware of the effects of their use of artistic license, intentional or not, especially regarding female scientists and how the changes they make may send a particular message to an audience about women in the sciences, as is the case with *Photograph 51.*

It has only been within the last ten years that significant study of science plays has begun. Currently, only two major texts exist: Kirsten Shepherd-Barr's 2006 *Science on Stage* and Eva-Sabine Zehelein's 2009 *Science: Dramatic Science Plays in American and Great Britain, 1990-2007.* Mad Cow Theatre in Orlando, FL began a science play festival in 2014 and the California Institute of Technology recently began offering one as well. Christopher Newport University, through Associate Professor of Theatre, Denise Gillman, has been able to offer a course in science plays and so has the City University of New York, through Marvin Carlson, Distinguished Professor, Department of Theatre, and Brian Schwartz, Department of Physics and Vice President for Research. The Ensemble Studio Theatre in New York has a partnership with the Alfred P. Sloan Foundation to commission playwrights to write science plays and

Massachusetts Institute of Technology works with a local theatre company. Scholarship in the field is growing, but remains limited in comparison to other areas of theatre scholarship.

With the rising interest in science plays, the need for more resources and scholarship on the genre has grown. As new plays are written every year, it becomes more difficult to remain current. Kirsten Shepherd-Barr compiled the most comprehensive list in the appendix of her book, *Science on Stage,* published in 2006, but it is already quite out-of-date. Given the recent development of this genre and its popularity, scholars find it difficult to provide current and comprehensive reflection and information. Professor Denise Gillman saw the need for a more complete and updatable list and thus decided to create an online catalog of science plays. The online catalog will also include articles and reviews of various productions, as well as featured plays that are updated every so often. Gillman was inspired to take on this project as she is "passionate about these plays and what they have to offer. [She hopes] to share that passion with others" (Gillman). This catalog serves as an extension of her research having previously conducted significant work on science plays and directing many of them including, *Arcadia, Great Men of Science Nos 21 & 22, Legacy of Light, Photograph 51,* and *Silent Sky*. She hopes that educators, students, directors, and producers, as well as anyone with an interest in science plays will use the catalog as a resource (Gillman). Currently, she has an estimated 200 plays for inclusion.

I was honored with the opportunity to work with her on this project. By the time I began work, Gillman had already complied her list of most of the science plays and filled out the index[4]

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[4]The index sheet can be found in Appendix A.

sheet that she had created to provide consistent and useful information on each play beyond a simple synopsis. The index sheet also includes information on production history and links to reviews. I was brought into the project to consult on the creation of the site and finding a template. I began by researching other online play catalogs such as the New Play Exchange, Doollee.com, Howl Round, and Curtain Up among others. Based on my initial discussion with Gillman and what she was looking for along with my personal preferences and what I hoped to find as I began my research on science plays, I compiled a list of the pros and cons for each site. From there we created a list of what we needed in the online catalog and what was preferred. One of the biggest things was that the site needed to have was a search bar and it should be easy to navigate. It also needed to be a site that could be easily updated with new plays as they are written and with links to new articles about science plays and reviews of various productions.

While most of what I did was technology related, it was valuable experience. I was able to discover what goes into creating something like this that will hopefully be a valuable resource to many as it will hopefully become a significant resource for scholarship on science plays. As theatre artists we are always thinking about how the audience will perceive a play and its various elements. In researching the type of template to be used, I had to think about that as well. What would make this a valuable and user-friendly resource for scholarly work? What should the layout of items be? What needs to be included and what does not? After all, this is a product for an audience, just like a play.

Despite the existence of science plays for centuries, their emergence as a genre is relatively new and scholarship about them even more so. With the dramatic increase in the

number of plays, many of them produced yet unpublished, hopefully the creation of the online catalog will allow for easier and more thorough scholarship. They touch upon important issues of contemporary society, and even audience members who shy away from the sciences are directly affected by them. They have become very important in today's theatre. Science plays offer many areas of exploration and study including something as seemingly simple as the definition of what they are (hopefully a single accepted definition will develop), the value of the genre, what they can do, and what they can offer. This thesis will explore one possibility: using science plays featuring women scientists to encourage young girls to pursue a degree and career in the sciences by targeting them, their parents, teachers, and guidance counselors during middle school and high school.

Chapter 2
Women in STEM Disciplines

STEM stands for science, technology, engineering, and mathematics, and it has become an important discussion in higher education as a result of the belief that the United States of America needs more college graduates in these fields in order to regain or maintain, depending on who you speak with, supremacy in innovation. The major concern is that the decrease in the number of STEM degrees will harm the nation's economy as other countries, particularly those in Asia, surpass the U.S. in STEM education. The concern over the loss the country's dominance dates back to the 1950s during with the Cold War and the Space Race. According to the U.S. Department of Commerce in 2013, STEM workers only make up six percent of the workforce. As a result, President Obama set up a council that called for a million new STEM graduates and 100,000 new teachers in these fields over the next decade (Anft). Concern does exist for potential damaging effects in producing so many graduates that there will not be enough jobs, despite a July 2011 report from the Department of Commerce that STEM jobs would grow by seventeen percent by 2018 (Anft). Still a few years away, we will see if this prediction comes true.

As a result in the increased attention and research in STEM, there has been a recent push to increase the numbers of women in those fields. STEM has a problem: a large gap exists between the number of men and women majoring in these fields from undergraduate to

doctoral programs. In 2013, only one fifth of the country's Ph.Ds. in physics were awarded to women with only half of that number being American (Pollack). This gap increases as students continue on through their education. One third of high school seniors express interest in pursuing STEM, yet the enrollment rate is lower. 28 percent of students, male and female, begin college with a STEM major and many switch to a non-STEM major, particularly during their freshman and sophomore years[5] (Soldner). In 2013, this attrition rate was down to 40 percent from 60 percent several years prior (Anft). The U.S Department of Education's 2013 *Statistical Analysis Report,* found that of all the students seeking a bachelor's degree beginning their freshman year in a STEM field, 48 percent switched to a non-STEM related discipline. While men who leave STEM in college are more likely to leave college all together, women who leave STEM will graduate college with an unrelated degree with men at 23.7 percent and women at 14.2 percent. Of those who remain in college after choosing another area of study, 32.4 percent are women, while 25.5 percent are men (Soldner). Unfortunately, only 0.3 percent of females even will enter college with a computer science major, and ultimately 60 percent of those women change to a non-STEM major ("Women"). The National Science Foundation reported that in 2002, the percent of women in engineering in undergraduate education had gone up to 20.9 percent from 1993 where it was at 15.9 percent. However, in 2012, women in engineering saw a slight decrease to 19.2 percent, but this is only one part of STEM. The Foundation also found a similar trend in physics and economics during those years, but a steady decrease in computer science from 28.3 percent in 1993 to 18.2 percent in 2012.

[5]The US Department of Education found that twenty-four percent left STEM during their first year, fifteen percent their second, and eleven percent their third (Soldner).

Colleges and universities have begun addressing the issue of major switching in a variety of ways including redesigning programs to get students into labs sooner with more hands-on assignments (Anft).

Why do so few women receive a STEM degree and why do their numbers remain low? Quite a few factors contribute to the statistics. The most common are gender stereotypes, lack of female role models in the fields, the belief that a career in the sciences do not mix well with having a family, and the stigma of scientists as work absorbed loners. Even though other factors exist related to one of the aforementioned, such as demographic characteristics, precollege preparation, and performance in STEM courses (Soldner). In order to increase the number of women in STEM, their specific needs and issues must be understood and addressed.

It comes as no surprise that few women enter the STEM disciplines, when they are discouraged from doing so at a young age, hearing such things as: "Don't touch that. It has germs." " Wouldn't you rather play with your dolls than your brother's chemistry set?" "I think the advanced computer programming class and the AP physics class might be too much for you." and "You really want to join the robotics club? Wouldn't you prefer the creative writing club?" Parents and guidance counselors deter females from exploring the STEM fields in middle and high school, so why should they choose a college major to which they have had no exposure? The US Department of Education's *STEM Attrition: College Students' Paths Into and Out of STEM Fields Statistical Analysis Report*, found that 49 percent of the students with only precollege math left STEM as opposed to 21 percent with courses in advanced math (Soldner). The media and society also confirms and encourages these gender biases at a young age. Girls are encouraged to play with dolls and Easy-Bake-Ovens, while boys are encouraged to play with

toys that promote an interest in fields such as engineering, with erector sets and Legos. Gender stereotyping on television depicting women's aversion to math and science reinforces "that stereotype in some women viewers' attitudes and behaviors" (McAllister 222). Of the women who do choose a STEM major in college, many begin to fall behind their male classmates who have had earlier exposure to the material and these women quickly begin to lose confidence in their capabilities, again reinforcing the myth that there are certain things men can do that women cannot. Females who do remain in these classes often find themselves teased by the males in the class and often the professor who does not take the women seriously. Many women will receive a STEM degree but in the end pursue other careers, such as Eileen Pollack who was one of the first two women at Yale to receive a Bachelor of Science degree in physics in 1978, and is now a professor of creative writing at the University of Michigan (Pollack).

To counteract these attitudes, we must rethink about how we relate to girls from the time they are born. Even simple things such as discouraging them from taking things apart to put them back together or from exploring their interest in frog or bugs can be harmful. Something as simple as letting boys play in the mud but not girls, reinforces gender roles. Gender roles are a social construct, not a biological one. If a girl consistently hears what she cannot do or express interest in relation to boys, she will carry this belief with her. Toys geared toward boys feature building and mathematical reasoning, while toys geared toward girls feature domestic activities such as cooking, cleaning, and child care. Fortunately, toys for girls have begun to encourage building and mathematical reason (although still with pink and princess themed Legos and play tool sets, among others). Regardless of color and theme, children should be allowed and encouraged choose their own toys without interference. While

a start has been made, much still needs to be done in terms of addressing society's gender biases. Although not solely a U.S. problem, the belief that women are not as capable as men does not permeate other Western cultures in the same way. France, Italy, and Bulgaria accept women as scientists much more easily. "For example, between 1959 and 2008, Bulgaria sent 21 girls to the International Mathematical Olympiad, while the U.S., from 1974, when it first entered the competition, to 2008, sent only 3; no woman even made the American team until 1998" (Pollack).

Gender biases continue to influence women after graduation. Some women want families and many are concerned that they cannot have both a family and career, particularly one in the sciences. STEM careers are not seen as "family-friendly" because of the amount of time and dedication they require compared to other fields or jobs (Will). Traditional societal gender roles dictate that it is the woman's responsibility to take care of household and child raising duties. Because of this, men have been able to have both a demanding career and a family as they have fewer responsibilities at home. Men can simply come home and play with the children before their bed time, while women must make the dinner, do the laundry, help the children with homework, and drive them to and from extra-curricular activities among other responsibilities. Co-parenting, however, has increased as more women financially support the family. While things are certainly changing as men begin to take on more responsibilities at home and with the advent of the stay-at-home dad, the stigma still remains, and many women feel forced to choose. The basic fact that women are the ones who go through pregnancy plays a role. The tax a pregnancy takes on a body in addition to all of the doctor appointments and other necessary preparations such as preparing a nursery, takes time

away from job responsibilities. Even for women who have access to resources, such as family members, babysitters, and supportive husbands, to help them raise a family while they work, many worry about battling their maternal instincts and feeling guilty for not being there enough for their children. The society ideal of what a mother should be combats the requirements of a career.

The lack of female role models in STEM fields plays another major role as to why so few females receive a degree in one of these disciplines. A male dominated faculty creates an unwelcoming academic environment. Sadly even "women in STEM are pretty selective about who they will let into the clubhouse, and while they may say that they want more women on the faculty, they want to be quite selective about which women are allowed to join the club" (Jones). In 2013, only fourteen percent of physics professors in the United States were women (Pollack). A 2012 study at Yale showed that physicists, chemists, and biologists are likely to choose a young male scientist over a woman with the same qualifications. Professors at six major research institutions were considerably more willing to offer the man a job. When told to hire the woman, they set her salary on average, nearly $4,000 lower than the man's. Surprisingly, female scientists were just as biased (Pollack). Girls consistently hear what they cannot do and find no evidence to counteract such assertions. Role models serve a vital role in the development of any child, and studies have proven their importance and the difference they make compared to a child without a role model. Role models can be positive or negative and each provides valuable experience for the student. A positive role model shows the student what to aspire to and how it can be done, while a negative role model shows the student what not to do and why; hopefully the student will learn from both. Negative role

models have important detrimental effects, but STEM lacks sufficient female role models all together. While female role models do exist, they are not as well-known as the men in the fields and few reside in the academic arena where they can be seen by and mentor female students. Women in STEM careers outside of academia do exist, but are less well-known than their male counterparts, so even if a female student were to stay in an all-male faculty environment, she still has limited access to a female role model. An important component of a role model when one has a personal relationship with them, is the mentorship that the role model provides. As a mentor, the role model can provide crucial advice on what to do and not to do, how to navigate the field, make job contacts, conduct proper research, and what pitfalls to avoid. A mentor also encourages students and Pollack, in her study on why there are still so few women in STEM, found that women are not encouraged to continue. Pollack's own thesis advisor never encouraged her to go on to graduate school and years later when she asked him about it he replied that her thesis was extraordinary but that he never encouraged anyone to continue on in math (Pollack). Without encouragement anyone can feel as if they are not good enough and lose faith in their abilities. A female mentor can give a female student insights into being a woman in the career that a male mentor cannot. Most of the female role models a girl observes during her life reinforce societal gender roles of a woman's domestic duties and responsibilities and what jobs are considered suitable for a woman and those that are not. STEM fields simply need more female role models. Christopher Newport University's November 2015 production of *Silent Sky* even addressed this issue with a pre-show talk entitled "Female Role Models Needed: How to Change Attitudes About Women in Physics, Engineering, and Computer Science."

The stigma of scientists as work-absorbed loners also permeates the STEM fields. By nature women are considered more social than men. Women in general tend to avoid jobs and situations where they would be isolated for prolonged periods of time, whereas men often prefer them. Gender stereotypes of men promote self-reliance and consider asking for help a weakness, while women are expected to ask for help and encourage others to seek help as well. It is then natural that men would be drawn to careers that promote an individual's accomplishments versus a group's. This idea of the work-absorbed loner also brings with it the idea of the "geek" (Cutler). While the stigma of "geek" is typically considered a negative one for both boys and girls, it is generally considered worse for a girl. Girls tease and bully each other just as much as boys do, however, the way in which girls do it often is much worse ("Female Bullies"). Girls in middle and high school become increasingly aware of these stereotypes and attempt to "fit in," resulting in fewer girls retaining their initial interest in the STEM fields. During this time girls also worry that a boy will not like a smart or "geeky" girl and so they begin to hide their mathematical and scientific abilities. Many positive role models exist, particularly on television shows such as *The Big Bang Theory, NCIS,* and *CSI,* and films such as *Contact* starring Jodie Foster and Sandra Bullock in *Gravity.* Unfortunately young girls who fall victim to this stigma do not watch these affirmative examples; television shows and films geared towards elementary and middle school children need to begin to incorporate them as well. The Disney film *Big Hero Six* does include two women studying science, although it focuses more on the young boy and the characters' heroic efforts against a villain and not the science itself.

Fortunately a popular middle school series *Girl Meets World* on Disney Channel aired an episode titled "Girl Meets STEM[6]" on January 8, 2016 that discussed gender disparity in science. The show follows middle school student Riley Matthews and her friends as they learn important life lessons. "Girl Meets STEM" begins with a science class assignment the teacher, Mr. Norton has been doing for thirty-five years, to be completed in pairs each having a boy and a girl. At precisely 3:15 P.M. one partner is to come and drop a "mystery marble" into a beaker filled with a clear solution where it will overnight break down into a sludge-like substance and the next morning in class the other partner will determine what elements were in the marble and what it needs to make the solution clear again. Riley's partner, Farkle immediately takes control telling her to drop the marble after school and he will do the rest. She is unsure why, but she feels that something is wrong and it is when she arrives after school that she discovers what the problem is: only girls have arrived to drop the marble. She attempts to convince the girls to not complete the assignment calling it a "social injustice," but she is the only one that does not do it. The next day in class she delivers an impassioned speech about how girls cannot learn science if they do not practice it and that they cannot become scientists if they do not learn it. Unfortunately her speech is met with apathy by the girls and the boys are confused insisting that it was not intentional. Farkle claims that he was just better at science and wanted them to receive an A, to which she responded that she likes science, but how can she get better unless her friends let her try. Farkle then realizes what he has done and apologizes, although

[6] Prior to this episode the only female character interested in science was Isadora Smackle, a student at another school appearing intermittently and depicted as a stereotypical "geek."

the rest of the class does not catch on quite as quickly. In the end it is only Riley and Farkle that are successful as the assignment was not about the marble which is in fact dirt, but an experiment in social behavior. Riley's parents and teachers talk to her and her friends about how research shows that middle school girls begin to lose interest in STEM subjects and they begin to play the gender roles they think they are supposed to play. After school when reflecting on the day with her best friend Maya, Riley realizes that everything was easier when they only saw each other as friends and not as girls as boys. She tells Maya, who is not interested in science that she needs to care, that she has to care now or her options later in life will be limited. She says that "we let what happened here come between us. It's sludge. All of us have unlimited potential" ("Girl Meets STEM"). It is a valuable statement made by a character many middle school girls know and will hopefully take to heart. Her science teacher tells the class that in thirty-five years very few have figured out the assignment and the majority of girls each year agree without a second thought to drop the marble and "it is valuable for young men and women to learn the value right now of working together as equals" ("Girl Meets STEM"). Hopefully more television shows with middle school audiences will also have episodes or characters that promote the everyday girl in STEM that takes leadership and insists on pursuing her interests regardless of anyone who stands in her way.

Women in STEM has become a very important topic of discussion in higher education and it has begun to have an effect on K through 12 education. As public schools receive funding cuts, they cut the arts and extra-curricular programs, not the STEM programs. In addition to an episode discussing gender in STEM, the Disney Channel series *Girl Meets World* aired an episode in the fall of 2015 entitled "Girl Meets Creativity" in which the characters' middle

school is eliminating all fine and performing arts classes as a result of budget cuts. The students are quite upset and attend the School Board meeting using their creativity to demonstrate to the board members what will be lost without art classes and that it will impact STEM as creativity and science work together; "Creativity feeds science and science feeds creativity" ("Girl Meets Creativity"). Schools have also begun to institute a variety of agendas and events to enhance students' success and interest in these fields in order to increase their school rankings and image. For example, Newport News Public Schools in Virginia, has provided several opportunities that target students as early as elementary school, such as offering the Summer Learning Lab, where they "previewed the upcoming year's science content and standards while working on crucial reading, writing, and math skills through problem-solving projects" (Stodghill). Middle and high school students have STEMulating Minds, where they work with business and industry partners "to engage in activities in the areas of video game design, robotics, computer systems technology, and architectural drawing" (Stodghill). Professional development opportunities are offered for the school system's teachers. They can attend workshops and classes over the summer "to hone their expertise in STEM education, and…get a firsthand look at STEM jobs in action" (Stodghill). St. Catherine's in Richmond, VA, an all-girl school for grades K through 12, has begun to offer a STEM program as well. Because of this program, the school was chosen to host the Nation Coalition of Girls' Schools conference "From STEM to STEAM: Girls' Schools Leading the Way" in June 2015. This conference discussed empowering female voices and strengthening their skills around problem-solving and decision-making, as well as how to spread the word about women who are currently in STEM fields. They want to inspire the next generation to become women in STEM (Scheckelhoff).

All of the national attention to STEM has affected other areas outside of education as well. Politics has been the driving force of this issue because of its concern with the economy. Businesses have also become involved primarily through participating in programs offered through schools, such as the National Aeronautics and Space Administration (NASA) with Newport News Public Schools' STEMulating Minds, and by offering scholarships to students seeking a STEM degree. For the last few academic years, Thermo Fisher Scientific offered two $10,000 scholarships and four $5,000 scholarships for college students in STEM majors (Showalter). Many companies offer scholarships specifically for women in STEM, such as Sony's $10,000 scholarship for girls who plan to become video game designers (Koebler).

The increasing involvement in promoting STEM in the United States will not diminish any time soon. More parts of society will become invested in the cause in a variety of ways and for a variety of reasons. Some may support STEM in general, while others may support a particular facet such as women or minorities in STEM. Regardless of the reasons, STEM and STEM education, particularly for women, has become a national agenda that continues to pick up traction every year. If the U.S. continues to seek a major growth in STEM jobs to keep up with other countries in terms of innovations and "look for those scientists only among the males…you are going to have to go much farther toward the bottom of the barrel than if you also can search among the females" (Pollack).

Chapter 3
Women in Science Plays

As nothing can exist in isolation, there can be no surprise that, given the national attention regarding women in STEM, science plays have begun to feature more female scientists in recent years. While both historical and fictional characters have appeared, the majority are historical and center around a few that are well-known. Eighteenth century French physicist Emilie du Châtelet, eighteenth century German astronomer Caroline Herschel, and twentieth century British chemist Rosalind Franklin are favorites among playwrights, with each featured in multiple plays. With her extensive study on science plays, Gillman notes that "more plays are being written about past female scientists and the reclaiming of women's history in modern science and more fictionalized stories with women as the primary scientist/protagonist." While currently not considered their own subgenre, perhaps one day science plays featuring women may become one. The genre opens up many possibilities including the "investigation of the role of gender, gender construction and representation" (Zehelein 322).

Tom Stoppard is certainly an important male playwright of the genre with his screenplay *Galileo,* his play *Hapgood*, and his play *Arcadia* featuring the young Thomasina, based on English mathematician and writer Ada Lovelace as a child, and her scientific mind. Men certainly can effectively portray the struggles of female characters and it is important that they do so as what they see, hear, and experience provides a different and unique perspective.

Male playwrights do write science plays featuring both men and women scientists, however, it is important to look at the significant female playwrights who do so as well.

While Karen Zacarias has thus far written just one science play featuring female scientists, *Legacy of Light,* she has contributed greatly to the genre with it. Zacarias has also written one other science play, *Einstein is a Dummy,* about a fictional day in the life of Albert Einstein as a boy and it was actually through this play that *Legacy of Light* was born. Zacarias, in conducting research for *Einstein is a Dummy*, came across Emilie du Châtelet in a footnote and "was fascinated that motherhood was literally killing her and that she had nine months to try to complete all her work" (Zacarias Interview). Zacarias sympathized with Emilie, believing that her artistic career would be over with the birth of her third child and "understood on a human level what may have been [Emilie's] drive, her fear, and complex feelings of loving both her children and her work" (Zacarias Interview). Written in 2007, *Legacy of Light,* like Tom Stoppard's *Arcadia,* features dual time periods. With this structure, Zacarias examines "how much has changed and how little [has] changed for women in science and working mothers" (Zacarias Interview). *Legacy of Light* has become a significant work in the science play genre, receiving several productions over the last eight years including the premiere in 2009 at Arena Stage and later at Cleveland Playhouse, San Jose Repertory Theatre, Dennison University, Christopher Newport University, Mad Cow Theatre, Barksdale Theatre, and Lyric Stage Company, among others.

The most significant female playwright of the science play genre is Lauren Gunderson, writing exclusively for it. Her most recent play, *Ada and the Memory Engine,* premiered in October 2015 featuring British mathematician, Ada Lovelace and her work and relationship with

scientist Charles Babbage. Gunderson's plays almost always feature historical figures. *Silent Sky* depicts astronomer Henrietta Leavitt and *Emilie: La Marquise du Châtelet Defends Her Life Tonight* is another play about Emilie du *Châtelet.* Gunderson writes science plays because she believes that they are "inherently dramatic, emotional, and human. These qualities of an often self-described 'cold' field are reinforced and explored by theatre. [She believes] this helps audiences connect with science as a part of humanity, not solely a technical pursuit" (Gunderson Interview). In the blog on her webpage she states that she believes artists and scientists should connect more frequently. Even Zacarias believes that "for STEM to be more effective…it should become STEAM (add the A for arts)" (Zacarias Interview).

The majority of science plays feature historical figures. These historical women demonstrate the perseverance required when they faced more challenges than women do today. They allow modern audiences to connect with these characters, as many of the issues they face remain the same, such as balancing a career with family and the view of science as primarily a man's domain. Gunderson believes that history serves science plays/stories well because "theatre has a long history of using history to talk about the present. A metaphor or symbolic historical struggle can be more powerful than a direct representation of a modern struggle" (Gunderson Interview). Historical figures and settings also allow for the science to remain real and keep it out of the science-fiction genre.

While less common, playwrights have written about contemporary women in science. David Auburn's *Proof* with Catherine, Damien Atkins' *Lucy* with Vivian, and the character of Olivia in *Legacy of Light* serving as examples. Each of these women work on very specific and real subjects that an audience is made aware of: a proof for prime numbers, the genetics of

autism, and the "birth" of a planet. However, as the details of their work are purposefully left vague, the playwrights instead highlight the struggles that each character faces. It is the universal struggles that audiences relate to, just as with the historical characters. Regardless of the time period, this shows that scientists are just as human as anyone else. Even though a more difficult undertaking, writing contemporary science plays, featuring men or women, can certainly be accomplished without going into the realm of science-fiction.

Using science plays featuring women, one can study the history and progress of women in STEM fields. Typically female scientists in plays begin with the eighteenth century's Emilie du Châtelet. She was able to accomplish a great deal and it is believed that her parents were supportive of her passion for science, she was able to publish her own work under her own name, but work with her partner, Voltaire was published under his name alone. Astronomer Caroline Herschel lived around the same time in another part of Europe, so her depictions provide a broader view. We can then study Marie Curie in Jean-Noel Fenwick's *Les Palmes de M. Schutz* followed by Henrietta Leavitt at the turn of the twentieth century. Next comes Rosalind Franklin in the 1950s before we begin to see contemporary women. Through a chronological study, one can clearly see the slow but steady progress of women's acceptance into STEM fields.

While a twentieth century woman may publish her scientific research in her own name and hold significant positions, she will still face the many challenges women in science have always encountered. Emilie du Châtelet and Olivia in *Legacy of Light* and Vivian in *Lucy* all struggle to balance their responsibilities as a mother with those of their work. Just over a century after the time of Emilie du Châtelet, Henrietta in *Silent Sky* is invited to come work at

Harvard. However, not everyone is thrilled that women are being brought in, and Peter, protégé of the department head, Dr. Pickering, even huffs at this fact. As it turns out, Dr. Pickering only began hiring women when he "got fed up with the boys he was sent and said… that his housekeeper could do better, so he hired her. And she did better" (*Silent Sky* 13). Henrietta believed that she was going to be allowed to complete her own research and use the telescope, The Great Refractor, but upon her arrival at Harvard finds that she was only hired to do the math for the men who are actually doing the real scientific work. Henrietta can only conduct her own research after hours without pay. Just as Caroline Herschel never married, the women that Henrietta works with at Harvard are unmarried, although one previously was. Henrietta even states that "I couldn't work if I was married" (*Silent Sky* 36). An audience sees her struggle to balance her work with her personal life throughout the play as her sister writes to her of all the family moments Henrietta is missing including the birth of her nephew. Rosalind Franklin in *Photograph 51* also spends the majority of her time consumed with her work, and much of the play simply skims over the details of her personal life. Fortunately unlike Henrietta, Rosalind is able to conduct her own research instead of completing the tedious calculations of a man's. Although she discovered upon her arrival that she was actually brought in to assist a man, she is able to assert herself and in the end does have greater control of her research. The men do assert their authority though by diminishing her credibility by commenting and focusing on her appearance instead of on the work she is presenting. Appearance would likely have not mattered if she were a man. The men also lessen her credibility hinting at the unreliability of a woman because it takes her a while to send images to Don, a colleague at another institution and claim that she has no theory to analyze her own

work. These are, for the most part, fictionalized moments and accounts, but they do speak to the general attitudes and beliefs regarding women in science during these eras.

The modern depictions of women also reflect the current attitude of women in science. In *Legacy of Light,* when meeting their potential surrogate, Millie, for the first time, Olivia has to clarify that she is in fact the scientist as "most people assume Peter is" (*Legacy* 20). Her husband Peter even states that "Olivia is a tenured scientist at the Department of Terrestrial Magnetism at the Isaac Newton Institute. The first and only woman to have a tenured senior science position there" (*Legacy* 20). It is a sad truth that in too many places today so few women hold these positions; however, Peter is very proud and supportive of his wife's accomplishments. Even though women still struggle to find their place in the sciences, Peter represents what has changed. As a school teacher, a traditionally woman's career since the late nineteenth century, Peter breaks gender norms. His support of Olivia demonstrates that even though a significant portion of the population still believes women incapable, there are those who have begun to see women as capable scientists. Millie does not question Olivia's career once she knows, and the fact that Olivia is a scientist, while an undertone for the rest of the play, does not receive primary attention. Nevertheless, this brief introduction does much in communicating modern societal beliefs and attitudes.

Vivian in Damien Atkins' play *Lucy,* struggles to balance her work and personal life just as the historical women did. Vivian is so consumed by her work that her daughter Lucy spends most of her time with her father, Vivian's ex-husband before the play begins. As an archeologist who often goes abroad for research, Vivian has been so busy that she is rarely home. She has no art work on her walls and rarely returns calls. It is so bad that her assistant

even comments on it. When Vivian has to care for Lucy for an extended amount of time, her ex, Gavin, mentions that she will have to adjust to the new routine, especially given Lucy's autism. Vivian's work in archeology does fall by the wayside with Lucy's arrival; however, she replaces it with new research that consumes her: the genetics of autism and seeing it as a leap forward in evolution, not a disability. This new work even leads to the estrangement and firing of her assistant. While, her new research does involve her daughter, Vivian still struggles to find that balance.

Proof depicts another aspect of modern women in science. Catherine's ability to discover an important mathematical poof is the heart of the play's second act. Her sister Claire and father's former student Hal's doubt of Catherine's ability is complex. While there is some doubt because she is a woman, it also lies in her limited education, similar handwriting to her recently deceased father, use of the same type of journal her father used, and her display of some of the same erratic habits as her mentally unstable father. The fact that the doubt is founded in logical and practical reasons shows the progress of society's view of women's ability to conduct complex mathematics. While Hal and Claire to do not directly state that their doubt is related to Catherine's gender, it is certainly alluded to. Would they still doubt her if she were a male, even if all of the other factors remained the same? Would her innate abilities with a limited education have been questioned? It is a play that deals with the theme of trust, mostly trusting Catherine, a character written by a man. How much of the actions of the other characters are influenced by gender? A production may choose to enhance this illusion or to downplay it, just as with her mental instability. In the end, Hal does believe that Catherine wrote the proof, but only after extensive consultation with other male mathematicians who

determine that the proof contains techniques too recent for her father to have been able to do. The men also found that the work has no dates as the journals her father wrote do. *Proof* also demonstrates how math can be just as an integral part of a woman's life as it can be of a man's. Robert tells Catherine that math is in her blood, "even [her] depression is mathematical" (Auburn 10). Just as *Legacy of Light* shows a supportive husband in Peter, *Proof* shows a supportive father in Robert.

Society still continues to doubt women's abilities in mathematics. *Proof,* written in 2001, the film *Mean Girls,* released in 2004, and the play *Victoria Martin: Math Team Queen*, written in 2007, reflect contemporary society's attitude. In *Mean Girls,* we do see an adult female mathematician, however, it is acceptable as she is "just" a math teacher. The main character Kady is quite good at math. Unfortunately, when she plans to join the Mathletes team, her friends warn her that is would be considered "social suicide." This is partly because she is a girl and partly because of the view of a person interested in or good at math as a nerd. Kady not only refuses to join the team until the end of the film, but also even purposefully fails her Calculus tests and quizzes to get the attention of the boy who sits in front of her. By the end of the film when he learns she is in fact good at math, he has no problem with it. The play *Victoria Martin: Math Team Queen* also depicts a high school girl joining an all-male math team who are described as geeks. Victoria, forced to join the team, insists upon hiding it from her friends and boyfriend since it is deemed "the black hole of the popular universe" (Walat 58). The boys on the team, except for the freshman Jimmy, really did not want her there to begin with, but when a teammate moved, the principal insisted that the team become co-ed. The team believed they would finally make it to the state competition, but when Victoria joins the

team they believe that they will not make it. Victoria does make mistakes at her first competition which costs the team a victory, however, she does begin to prove herself. Once she demonstrates her abilities, the rest of the team accepts her as a member. The team goes on to the state competition and wins third place. *Mean Girls* and *Victoria Martin: Math Team Queen* demonstrate the attitudes and acceptance of women in science – specifically math here – begins at a very young age and that the acceptance only happens once she proves herself. These plays also show how important it is to middle and high school students to "fit in" and that they will hide or downplay their interests and skills to do so.

While still ever and quickly growing, the list of science plays featuring women remains only a very small portion of the entire genre. Most of the well-known and popular science plays such as *Doctor Faustus, Copenhagen, Galileo Walking among the Stars, Life of Galileo,* and *Oxygen* feature men. The following list of plays featuring women in the STEM fields, while representing the majority of them, is by no means a comprehensive one. It represents what will hopefully become a substantial subgenre.

1. *A Disappearing Number* by Simon McBurney, set in two eras, explores a present day fictional mathematics lecturer as she attempts to explain concepts to her husband and students.
2. *Ada and the Memory Engine* by Lauren Gunderson, depicts British mathematician Ada Lovelace and her work with Charles Babbage and his early work on the mechanical general-purpose computer at the dawn of the Industrial Revolution.

3. *Arcadia* by Tom Stoppard, set in the early Nineteenth century, brilliant student, Thomasina, comes to understand chaos theory and the second law of thermodynamics almost two centuries earlier than anyone else.
4. *Comet Hunter* by Chiori Miyagawa, set in the mid Eighteenth Century focuses on female astronomer, Caroline Herschel, her discovery of several comets and her relationship with her brother.
5. *The Effect of Gamma Rays on Man-in-the Moon Marigolds* by Paul Zindel, centers on a 1960s high school girl who grows marigold seeds that have been exposed to radioactivity for her science class project.
6. *Emilie: La Marquise du Châtelet Defends Her Life Tonight* by Lauren Gunderson, explores the famous physicist as she defends her life and loves.
7. *Emilie's Voltaire* by Arthur Giron, a comedy set before the French Revolution centers on the relationship between the writer and physicist.
8. *Experiment with an Air Pump* by Shelagh Stephenson, deals with a female geneticist.
9. *The Explorers Club* by Nell Benjamin, shows a woman scientist and explorer as she joins the all-male club.
10. *FZZN GRRL* by Mojie Crigler, centers on a teenage girl who builds a nuclear reactor for her school's science fair.
11. *The Genius* by Howard Brenton, focuses on a present day female mathematics student, Gilly, works with brilliant mathematician Leo Lehrer to help him complete formulas he has been unable to do alone.

12. *Glory Enough* by Sidney Perkowitz, depicts Rosalind Franklin being overlooked by the Nobel Prize Committee for her work in the discovery of the double helix.
13. *Great Men of Science Nos 21 &22* by Glen Berger portrays historical physicist Emilie du Châtelet.
14. *The Hard Problem* by Tom Stoppard centers on Hilary, a psychology student having received a research position at a prominent brain science institute.
15. *Legacy of Light* by Karen Zacarias, is set in Eighteenth Century France and present New Jersey focuses on two female physicists: historical Emilie du Châtelet with her work on the properties of light and fictional Olivia who believes she has discovered the birth of a planet.
16. *Les Palmes de M. Schutz* by Jean-Noel Fenwick, depicts Marie and Pierre Curie's discovery of radium.
17. *Lucy* by Damien Atkins, deals with a contemporary anthropologist who begins to apply Darwin's Theory of Evolution to her daughter's autism.
18. *Manya* by Susan Marie Frontczak, is a one-woman play about Marie Curie.
19. *Photograph 51* by Anna Ziegler, set in England in the early 1950s focuses on female geneticist Rosalind Franklin and her role in the race to discover the double helix.
20. *Proof* by David Auburn, set in contemporary Chicago, focuses on Catherine, a fictional, but ground-breaking mathematician.
21. *Radiance: The Passion of Marie Curie* by Alan Alda set in Paris at the turn of the twentieth century, highlights the challenges she faced when women simply did not take a prominent role in science and academia.

22. *Remembering Miss Meitner* by Robert Marc Friedman, is a one-act play about a female physicists overlooked by the Nobel Prize Committee.
23. *Rosalind, A Question of Life* by Deborah Gearing is another play that explores Rosalind Franklin's work in the discovery of DNA's structure and her lack of recognition.
24. *Silent Sky* by Lauren Gunderson, is set at the turn of the Twentieth Century and focuses on female astronomer Henrietta Leavitt while working at Harvard and her discoveries on Cepheids.
25. *Stella* by Siobhan Nicholas, is set in both the past and present as a contemporary radio astronomer, Jessica Bell, researches the life and work of Eighteenth Century astronomer, Caroline Hershel.
26. *Thread of Life* by Rita Nachtmann also focuses on Rosalind Franklin's role in the discovery of the double helix.
27. *The Verge* by Susan Glaspell, explores a female botanist in her creation of new plants and her elaborate experiments.
28. *Victoria Martin: Math Team Queen* by Kathryn Walat, set in a contemporary American high school focuses on a fictional high school girl joining a competitive all-male math team.

The importance of women in science plays cannot be overstated. It represents the diversity of the genre as well as the historical trend in society's attitudes and responses to women in these fields. Any playwright writing a STEM role model for a woman should be admired, but female playwrights, particularly those who write exclusively for the genre such as Lauren Gunderson, deserve particular attention. While the roles of male scientists offer the chance for

an audience to connect with them through their trials and humanity, female scientists offer a greater opportunity for this connection as they face more than just the struggles of the work itself, but also in being able to participate in the research.

Chapter 4
Reaching Young Women

Theatre not only reflects society, but also frequently seeks to educate and motivate an audience. Science plays featuring women are no exception; they can motivate young girls to seek a STEM career and change society's attitudes regarding women in these fields. Theatre uses other disciplines to help better understand and create theatre through dramaturgy, so why not use theatre to help promote the needs of other disciplines? The incorporation of the arts into STEM, a movement known as STEAM, benefits everyone involved and highlights the creativity and collaboration often required by the sciences. The STEAM movement was conceived by the Rhode Island School of Design in Providence, RI with the goals of transforming research policy to place art and design at the center of STEM, encouraging integration of art and design in all levels of education, and influencing employers to hire artists and designers in order to drive innovation (*STEM to STEAM*). While no simple solution exists for increasing the number of women in these fields, science plays can assist in this endeavor by addressing many of the obstacles women face in pursuing such a career through their stories and role models.

While STEM programs for girls are important at all levels, a stronger effort must be made beginning during the middle school years and continuing through high school. As a result of various factors, girls begin to opt out of science and mathematics courses during this time (Heaverlo 4). In her dissertation study, Carol Heaverlo found that "interest and confidence are

impacted by one's belief in their ability to do well on a specific task," and boys and girls were found to have equal motivation to succeed academically, but girls were less confident in a successful outcome and reported increasing levels of anxiety and lower levels of self-confidence throughout high school (24-25). Heaverlo's study also affirmed that a student's level of self-confidence in high school is the strongest indicator for young women choosing a STEM major in college, and therefore, outreach programs must begin in middle school to build their confidence in mathematics and science. Science plays can assist in building this confidence and interest through providing relatable examples of female role models and opportunities for engagement with the material.

The use of performing arts to teach STEM has already been implemented. On February 22, 2016, *The Washington Post* published an article, "Teachers are Using Theater and Dance to Teach Math- and it's Working," that discussed how elementary schools are using dance to teach children mathematics. Wolf Trap Foundation for the Performing Arts partnered with a local school to integrate arts into the classroom and researchers found that pre-kindergarten and kindergarten students in classes taught by Wolf Trap-trained teachers gained about 1.3 months of math learning in the first year over their peers and by the second year they were 1.7 months ahead (Balingit). They did not necessarily learn additional mathematic concepts, but they did have a stronger grasp of the material. The article also stated that even teachers who worked with Wolf Trap "continued to use what they learned in their classrooms, even when they were no longer working with teaching artists…it demonstrated that a year or two of training could have a lasting impact" (Balingit). These lessons can be a challenge and take longer to plan, it have been proven effective. "Some children can struggle with math because

it's abstract. Children can get emotionally invested in acting out a story, though, that involves counting" which is important and keeps them from getting bored and distracted (Balingit).

Middle and high school girls can be exposed to science plays by reading them in literature and drama classes as well as science and mathematics classes. This will offer students the opportunity to engage in the material in a new and exciting way while also promoting interdisciplinary studies. Literature and drama classes can examine plays that relate to what students are learning in their science and mathematics classes and discuss the thematic ideas surrounding the topics and society, as well as the impact upon daily life. Likewise science and mathematics courses can use these plays to approach the material in a unique way to pique the interest of students in addition to providing a historical context. *Silent Sky* and *Photograph 51* are illustrations of this as they focus on the process and dramatize the historical moments of scientific discovery made by women. By finding new ways to enliven the material, students will retain the material better and seek opportunities to further explore the topic through advanced courses and extracurricular activities. Professor Gillman believes that "when the complex knowledge of science and mathematics is put within the context of a story it often makes it accessible…every middle school and high school science and mathematics class would greatly benefit by gaining knowledge and understanding of these subjects through drama." If the plays read feature women, it promotes the abilities of women to students and provides the examples of female role models girls so desperately need, even if the gender aspect is never directly addressed in classroom discussion.

Ideally plays should be seen. Teachers should seek out opportunities for students to see science on the stage, whether as a class requirement or optional extra credit opportunity.

Seeing productions allows students to more fully understand the concepts being discussed and the passion scientists have by bringing it to life. For example, the second act of *Legacy of Light* opens with Olivia speaking to a Girl Scouts troop[7] and the performance of this monologue demonstrates the passion she has more clearly than silent reading could. The technical aspects and staging can offer the chance for visual learners to experience education in an accessible way as well. Professional companies and universities producing science plays should reach out to local middle and high schools inviting students to performances or holding weekday matinees exclusively for them[8]. Changing the traditional lecture lesson of most science and mathematics classes has its benefits as well in terms of gaining the students' attention. Assistant Professor Dr. Anna DeJong of the Physics, Computer Science and Engineering Department at Christopher Newport University agreed that plays can be helpful in this regard and suggested that short plays even be performed for grade school children.

When school groups attend performances of science plays, students should engage in classroom discussions or lectures before and more importantly after the play, as well as in talkbacks with the cast and crew. Prior to seeing a play, teachers should prepare students for what they will experience as well as give them questions to consider during viewing. Professor Gillman believes that it is best to first discuss the story and characters with students and then discuss the science or math second, after seeing a play with students. Talkbacks with cast and

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[7]Zacarias mentioned in her interview that she has received numerous letters from young girls inspired by this monologue and interested in learning more about Emilie.

[8]This would also be beneficial for the producing company or university providing exposure and publicity.

crew can provide students with a unique perspective in demonstrating the importance of interdisciplinary studies by explaining how the dramaturgy and science influenced their characters, their objectives, and the story itself. Seeing any play must be accompanied by some form of engagement, but it is particularly important with science plays as the concepts are layered in with traditional story elements.

Perhaps the best way of engaging students in the material through science plays is involving them in the production itself as actors, technicians, or resources for understanding the material presented. Professor Gillman hopes that science and drama teachers in middle and high schools might collaborate in such an endeavor. Girls involved in productions learning about the science may find the incorporation of it with theatre fascinating and thereby gain an appreciation for the subject and interdisciplinary studies. When middle and high schools produce science plays with women characters, teachers should encourage girls in relevant science and math classes to come and discuss the subject with the cast and crew. This would allow opportunities for girls to use their education outside of the classroom and homework assignments and promote their abilities to others. Many plays, particularly ones with specific educational components, are frequently accompanied by discussions with the audience as either a salon series or talkbacks, and allowing these same girls to assist or lead them can reach more in promoting their abilities in the subject. Such experiences for young girls would also increase their confidence in these subjects. Heaverlo's study asserted that involvement in STEM targeted extracurricular activities such as 4H, science fairs, and math and science clubs play an important role in a girl's confidence and path towards a science career (27). Middle and

high schools producing science plays offer another such opportunity for their students who may not otherwise participate in STEM activities.

Even though the ideal time to interest young girls in STEM is prior to entering college, experience with science plays at the university level is still valuable if only to increase the acceptance of women in these majors. Shannon Farrow, an undergraduate student at Christopher Newport University, played the role of Henrietta in the Theatre Department's November 2015 production of *Silent Sky* directed by Professor Gillman. In her interview she discussed the uniqueness of this experience and what she has taken away from it. During the rehearsal process, faculty members from other departments were brought in to discuss the science with the actors and Farrow asked one why she had chosen to pursue a science career. The faculty member responded that she had always struggled with dyslexia and numbers came easier to her. Farrow took from this that "women in science are like all people in all fields - whole, complex, and often defined by the way they overcome perceived obstacles." After seeing this production, Farrow hopes that "girls and the women who influence them will start to see themselves in Henri's story, instead of seeing a one-dimensional scientist who is so removed from their lives." In addition, she noted the direct way in which the play poses questions as opposed to other plays she has been a part of; if science is to find answers, it must ask very direct questions. Farrow's experience is precisely what young girls need to see with science plays: real women, passionate about their work, asking direct questions so that they might see themselves one day achieving such feats in science.

While plays dealing with scientific concepts in detail may be ideal, plays that make math and science relatable to young audiences are important, too. *Victoria Martin: Math Team*

Queen by Kathryn Walat never discusses specific mathematical concepts, but it is important as it frames the story in a relatable way and promotes a girl's ability despite preconceived stereotypes. All of the characters are high school students, from freshman to seniors, and deal with the same issues that many face during this time such as fitting in, discovering who they are, and relationships[9]. The boys on the math team, initially unenthusiastic about Victoria joining the team, learn to appreciate her and she becomes a valued member. In the end, this play promotes girls and boys having equal mathematical abilities. It also provides an excellent opportunity for a classroom discussion regarding assumptions with gender stereotypes in STEM and how peers influence each other's interests and behaviors. Scene thirteen, titled "Another Lesson," provides a literal lesson to students as Victoria comes to the conclusion that she needs to do what she wants regardless of what others think; girls should not be afraid to participate in STEM activities and others should not jump to assumptions. *Victoria Martin: Math Team Queen* presents many relevant and relatable elements to high school students for discussion, importantly centered on a mathematical extracurricular activity making it a valuable script for exploration in the classroom.

While fictional role models cannot be discounted, examples of real role models are an important part of encouraging girls to join STEM. Despite the fact that many young people have fictional role models, Dr. DeJong expressed concern in her interview that such examples, specifically those that are women scientists in film, are often one dimensional and a love

[9]One character explores his homosexual feelings for another boy on the team and Victoria struggles to keep her involvement on the team a secret from her popular friends as its importance in her life increases.

interest of the main character. She also asserts that real role models girls can interact with are ideal, however not every girl has that luxury. Role models play such an important component in shaping our youth that Dr. DeJong makes an effort to attend career fairs to be an example of a woman in a planetary science career (DeJong). When choosing films and plays featuring women in STEM careers, it is important to ensure that the examples are relatable, multi-dimensional, and play a significant role in the story being told.

Relationships are very important to a high school girl, so demonstrating as early as possible that having a family is possible with a STEM career is vital, and *Legacy of Light* is a prime example. Boys and young men seeing such examples are vital too so that they do not discourage girls from pursuing STEM interests. While both Emilie and Olivia face complications in growing their family as Emilie has pregnancy complications and Olivia is infertile after surviving ovarian cancer, it is not the science in their lives that obstructs their paths. Both women do seek to complete as much work as possible before the babies are born knowing that things will drastically change with their arrival. Regardless of career choice, a growing family limits one's time that can be devoted to any type of work. Emilie already has had one child and still continues her work though we see her attention divided between her work and arranging her daughter's marriage. *Legacy of Light* shows that it can be a struggle to balance a career and a family, but that it can be done. Science can be perceived as more difficult to balance because its "discoveries are often the result of insane focus, single-minded pursuit of one solution or answer [and] women are asked in our society to have tremendous split focus" (Farrow). Such focus can have a cost, but Zacarias shows in *Legacy of Light* that it is possible to split one's focus to achieve a balance and that everyone must find that balance in their own way as Emilie and

Olivia do. Gunderson also understands this and wants to show young girls in her plays "that scientists fall in love and have friends as well as make staggering discoveries and world-changing theories" (Gunderson Interview).

Science plays can be incorporated into the curriculum in a wide variety of ways and each offers its own benefits. Unfortunately, time is the biggest challenge that any teacher faces. There always seems to be too much material to cover and too little time in which to do it, regardless of the subject making the incorporation of science plays problematic. Teachers spend the majority of the year preparing students to take standardized tests such as the Regents exams in New York State, the Standards of Learning tests in Virginia, and Advance Placement exams. Jessica Duet[10], mathematics teacher at Massaponax High School in Fredericksburg, Virginia, mentioned that once students have taken the test, she and her colleagues find themselves "scrambling for things to do" and this would be something new but still relevant to course material, and she would consider incorporating science plays with some of her upper level students at the end of the year. Although better than nothing, the incorporation of science plays into the curriculum is likely to have a larger impact earlier on in the year as well as in the first year or two of high school. Many teachers and administrators may look upon this as an ideal but impractical prospect as the results of standardized test scores influence most decisions.

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[10]Duet received her bachelor's degree in mathematics and was licensed to teach separately and was fortunate enough as one of a few women in the department to not face the traditional challenges. She currently teaches Algebra I and AP Statistics.

Science plays can be incorporated into the curriculum in many ways: as part of class, as an extracurricular activity, or as extra credit opportunities. Summer camps and outreach programs can take advantage of what science plays have to offer young girls without the constraints of standardized tests and time. Regardless of how science plays are used to promote STEM careers to young girls, what is important is that the examples are relatable women whose story is featured prominently in the play. Discussions must also be had, not just about the story and the characters, but also about the science and the woman that has chosen such a career path. Children wish to become their role models and science plays can provide examples of the much needed female role models in STEM. "The arts are vital for inspiring people to reflect and think and change. Inspired children are children that want to learn" (Zacarias Interview). If more women are wanted in STEM careers, science plays can provide a new and creative way to do so through the magic of storytelling.

Chapter 5
Reaching Parents, Teachers, and Guidance Counselors

Promoting the abilities of women in STEM to parents, teachers, and guidance counselors is just as important as it is to the young women and girls under their mentorship. The main purpose in also targeting these groups is that they provide important guidance and encouragement that can steer young women and girls towards or away from STEM careers. While their suggestions steering girls away from STEM may be given in what they believe to be the best interest of the student or even subconsciously, encouragement is linked to the confidence that is so important to continuation and success in these fields. Science plays can demonstrate to these mentors that women can and have found success in STEM careers and the challenges they face in hopes that mentors will encourage girls who show interests in these fields, assist in confronting the challenges they face from others, and hopefully create more opportunities for girls to explore and develop these interests. It is important that parents, teachers, and guidance counselors see science plays, attend talkbacks or salon series, and participate in school productions of such plays. The goal of increasing the number of women in STEM through science plays is just as multifaceted as other methods and mentors must be a part of any strategy.

The strongest chance a young woman has in building confidence with STEM is when her parents, guidance counselor, and teachers all support and encourage her from the beginning. In different ways, they each influence a girl's interest in the subject, the effort she will put forth

in STEM classes, the types and numbers of advance classes she will take, and the STEM related extracurricular activities in which she will be involved. While some may purposefully steer girls away from these interests, most do so unknowingly and science plays can help illuminate such subconscious actions so that they become more aware of them. "There is a great deal of research indicating that parents have a strong influence on their child's academic choices and experiences which directly or indirectly influences career opportunities" (Heaverlo 98). Heaverlo's study used filmed classroom sessions which were shown to the instructor afterward and most teachers interacted with girls differently than with boys. Upon viewing the footage, they were shocked at their actions when they had believed that they were treating all of the students equally[11] (26). The same study found "that girls have received less instructional time in the classroom, less help, fewer challenges resulting in a lack of encouragement, lower self-confidence, performance, and persistence in STEM courses" but have also found that "girls will perform at the same level as boys in the classroom when there is representation from positive female role-models, they receive encouragement and the educational tools necessary to succeed" (26-27). Duet believes that as a woman teaching high school mathematics, she likely has an easier time than male teachers as she can use herself[12] as an example, and can use her own experiences to encourage them. She has many students who are talented in her classes but are also interested in the arts and do not realize that science plays and the many opportunities to integrate the arts into STEM even exist. Encouragement from teachers like

[11]The study does not state the male to female ratio of the instructors.

[12]Duet has found that most of her students believe her degree is in education and are surprised to learn that it is not.

Duet serve as a prime example for young women to look up to. The results of Heaverlo's work indicated that teacher influence was statistically one of the most significant predictors of STEM development (92).

Most of the plays that can be used to encourage young women and girls to pursue a STEM career can also be used in the education of their mentors. However, while the ideas being conveyed are almost identical, the differences must be addressed for a successful venture. Walat's *Victoria Martin: Math Team Queen*, while suitable for younger audiences, would not be for their mentors; all five characters in this play are high school students so even though it may illuminate their daily struggles to adult audiences, it would be unlikely to capture their attention and convey the message regarding women in mathematics that the play conveys to students in a relatable way. *Arcadia* is a more suitable option with its main value here in demonstrating the passion a young girl can have in learning and studying scientific principles and in understanding complex principles such as Fermat's Last Theorem. Stoppard also demonstrates with this play that a young girl can make great discoveries as Thomasina was on the brink of one before she died in a fire. The most important aspect that the mentors need to see in science plays is women who have already accomplished much in their career. Fictional women in such plays as *Proof*, *A Disappearing Number*, *The Genius*, and *Lucy* are certainly suitable options; however, accounts of real women in science, whether they are historical or contemporary, will serve these purposes better as many adults look for proof over utopian idealizations when changing their beliefs and behaviors. *Legacy of Light*, *Photograph 51*, *Silent Sky*, *Comet Hunter*, *Ada and the Memory Engine*, and *Emilie: La Marquise du Châtelet Defends Her Life Tonight* serve as prime examples of the best plays to present to the mentors of young

women and girls. The lack of female role models in STEM careers is not only a problem for students, but also their mentors who also can fall victim to gender stereotypes. After all, how can they know any different when they saw nothing to contradict such notions in their own youth?

The ways in which to reach the mentors are essentially the same as reaching the young women and girls. The first and most basic is seeing the plays and attending talkbacks or salon series. The discussions regarding the plays certainly can center on the science itself, but conversations regarding the gender aspects of the play would naturally be most productive with an audience of mentors. Topics discussed remain similar to those conducted with students with adjustments as well as minor alterations depending on whether the majority of the audience are parents, teachers, or guidance counselors. Many colleges and universities offer counselor visit days if not every year, then every other year. As colleges and universities seek to increase female enrollment in STEM majors, admission offices can unite with theatre departments to produce a science play with featuring a woman at the time of the counselor visit day holding a special matinee performance with talkback geared towards how guidance counselors can encourage girls in these fields as part of the day's itinerary. Similar events could be held during university open houses or admitted freshman days, although the majority of the students attending those events are juniors and seniors in high school and reaching them before they have likely made decisions regarding their future major is best.

Mentors can also be exposed to science plays through production. If middle and high school theatre departments produce these plays, there are many opportunities for parents, teachers, and guidance counselors alike to participate. Not only can these mentors offer their

expertise in their field, be it lighting, science, dramatic literature, or costumes, but also they can learn about women in STEM and how and why young women and girls can be encouraged to pursue their aspirations in these fields. Their involvement would also assist in the promotion of the incorporation of the arts into STEM and the importance of it. Administrators and school board members should be invited to attend performances and participate in small production aspects, such as participating in talkbacks or salon series as their decisions regarding budget cuts and daily school activities affect all students, even though most students do not have personal interaction or mentorship with these persons. The involvement of adults from a variety of areas would also show students wide spread support for women in STEM. In whatever way mentors are exposed to science plays, after portraying Henrietta, Farrow's "hope is that for parents and guidance counselors who see [*Silent Sky*], there will be this connection of 'look how far we've come!' Our girls have so much more access, more resources, more opportunity, why not encourage them to seize it?"

Each play highlights a different stigma that women in science face, so when choosing a play for production, the particular message the school wishes to send to its students and their mentors must be a factor in the decision. This will be most beneficial after preliminary steps have been taken such as identifying key questions or concerns expressed by parents during parent/teacher conferences, student meetings with teachers and guidance counselors, and during talkbacks or salon series connected with earlier science play productions and the demographic is better understood. If the main concern is that science and mathematics are too difficult for girls then plays such as *Arcadia*, *Photograph 51*, and *Proof* are good choices. If the main concern regards women in physics specifically, *Legacy of Light*, *Emilie: La Marquise du*

Châtelet Defends Her Life, and *Remembering Miss Meitner* would be appropriate choices. Science plays can be chosen not simply to promote women in general in STEM but also to promote specific disciplines and assuage certain concerns based upon the local demographics.

In whichever way mentors experience science plays, the indicators of female STEM success from Heaverlo's study should be incorporated in some fashion and clearly conveyed. The indicators are:

1) a classroom environment that allows for learning

2) encouragement of responsibility and effort

3) helpful assignments, encouragement of questions

4) asking questions that challenge the student to think

5) communication of high expectations

6) help with the work

7) talking about possible careers in each STEM subject, and

8) encouragement of application of material outside of the classroom (93).

All mentors need to participate in the creation of each of these indicators to fully cultivate the talent of young women and girls in STEM areas[13]. *Silent Sky* serves as a prime example. Henrietta asks thought provoking questions as she attempts to decipher the meaning of the blinking Cepheids and the discovery of period-luminosity relation and she has the encouragement of her colleagues. Annie communicates the high expectations required of their

[13]Playwrights should also consider these indicators when writing science plays featuring women to assist in this effort.

work, provides Henrietta access to necessary equipment in allowing her to stay at the office after hours in order to work on her own research, and even encourages Henrietta when she is frustrated and on the brink of giving up to "keep working. Think about how you're thinking. It's in there" (*Silent Sky* 49). *Silent Sky* also displays the importance of art in science as Henrietta's epiphany that the blinking stars are tonal occurs when listening to her sister play the piano. Other plays also assist in the promotion of these indicators. Olivia in *Legacy of Light* encourages the members of the Girl Scout Troop to "become scientists and carry the torch and shine light on everything we still do not yet know about the universe" (64). Emilie asks questions regarding the properties of light as Olivia does regarding the formation of a planet that she has discovered: "How did our embryo Vega B come to be?" (*Legacy of Light* 36). She goes on to discuss the accepted theory of planet development, but then states that she believes "Vega B is following a very different path and that a sudden gravitational collapse will allow it to obtain its planetary shape in a fraction of the time of other planets" based on questions she asked regarding her findings (*Legacy of Light* 36). *Photograph 51* demonstrates that Rosalind Franklin's questioning of the patterns and shapes she found on the x-rays assisted in the discovery of the double helix. Vivian in the play *Lucy* examines what autism is and what her daughter and others with it experience. Without questions there would be no attempt to find answers and thus no discovery. Science plays can demonstrate the importance of questions, often asking the important questions and mentors must encourage young women and girls to ask questions and in turn ask them challenging questions to develop their skills in these areas as well as making global and personal discoveries.

Heaverlo's study also points out the significant factors in science and mathematics that discourage girls from pursuing STEM careers. There are fewer in this category; however, they are very powerful, as negative experiences tend to be more memorable than positive ones. These factors are:

1) receiving less instructional time

2) fewer challenges

3) reinforcement of gender stereotypes, and

4) different feedback and encouragement from than the male students (95).

The study focuses on these issues inside of the classroom; however, parents and guidance counselors need to be aware of them as well, as they can promote these issues in homework and course selection. Being aware of what specifically causes young women and girls turn away from STEM is just as important as what encourages them so that old behaviors which might contradict those that promote women in these fields can be avoided.

Communication of the indicators that a female student would likely or unlikely pursue a STEM career in Heaverlo's study can be made a part of already established middle school and high school events. School employees must first be educated so they can confidently communicate to the parents who entrust the teachers with their children's education. For teachers[14] and guidance counselors it can be incorporated into staff meetings and professional development workshops. Including the importance of interdisciplinary values during these

[14]Teachers of all subjects should participate and highlighting how their actions and disciplines have an impact upon women in STEM should be promoted to avoid resistance leading to ignoring of this vital information.

sessions is vital as well. The arts promote creative thinking often required in scientific and mathematical innovations. St. Catherine's School in Richmond, Virginia hosted the National Coalition of Girls' Schools conference "From STEM to STEAM: Girls' Schools Leading the Way" in June of 2015 promoting STEAM's incorporation of "even more innovation with the addition of arts and design to complement science, technology, engineering, and mathematics [that] more than 500 educators and school leaders from around the world" attended (Scheckelhoff). More events such as this, even at the school staff level, would do a great deal for the cause.

Once teachers and guidance counselors have a thorough understanding of these indicators and concepts, they can be incorporated into the parent and family events hosted by the school. While parent/teacher conferences and communication e-mails are a good start and certainly should be utilized in this endeavor, other efforts are necessary and parents need to see that the entire school supports this. Parent and Back-to-School Nights are great events to integrate this information, but so are middle school graduation activities and parent organization meetings such as a Booster Club or PTA. Creating special events dedicated entirely to promoting women in STEM is desired when time and resources permit and when they do not, promoting other events in the area available to students over school breaks and the summer. A perfect opportunity would be when a school produces a science play as it would allow the explanation of why this play was chosen by the school and would endorse the integration of the arts and sciences in addition to promoting the production itself and hopefully attracting new audience members.

There are many similarities in how to use science plays to reach young women and girls and their mentors, but there are important differences. The biggest similarities and

subsequently the most important factors in promoting STEM careers to both groups are providing examples of female role models and opportunities to engage in STEM activities with encouragement. Students and their mentors need to see that it is possible for women to succeed in STEM fields and children want to grow up to be like their role models. How can a girl want to be a scientist if she never sees examples that could become her role model? Even with role models present, if no opportunities are available with encouragement, then girls are unable to cultivate their interests and talents; after all, an athlete can never become an Olympian without the opportunity to learn the sport itself. Science plays provide both the examples of role models and engagement opportunities with encouragement when accompanied by discussions. Certain plays are meant for younger audiences and each play is unique in what and how it addresses concerns, topics, and STEM disciplines. Historical characters are generally preferred over fictional ones, although it is more important to depict historical role models to the adult mentors. The biggest difference lies in also addressing the important indicators that promote women entering STEM fields, as well as those that discourage then. Understanding and utilizing both types of indicators is vital and hopefully girls and young women witnessing their mentors applying them that ultimately choose a STEM career will integrate them into their own careers and interactions with they may have with students and children. Just as promoting STEM to female students through science plays is multifaceted, so too is reaching their parents, teachers, and guidance counselors, who must all work together in order to have the greatest impact.

Chapter 6
Science Plays and the Future

The genre of science plays will continue to grow and develop with new plays that fulfill its current needs while also finding new and creative uses for them. Even though more science plays are written each year and more women are being featured, certain areas either have minimal representation or are lacking altogether: plays with contemporary scientists, plays that focus on the science and personal life equally, plays written for younger audiences, and plays featuring women in computer science and mathematics. As such a unique genre, science plays can accomplish a variety of things, including the incorporation of the arts into STEM[15]. These plays have much to offer and their potential has only just begun to be explored in the different ways science can be incorporated into the text; the relationship between science, scientist, and society; and how they can be used outside of the theatre. Science plays promote interdisciplinary studies which can easily attracts people who do not traditionally participate in or attend theatre, and promotes the creation of new and exciting things in the future of theatre and STEM.

As the genre and its popularity grows, science plays have a bright future. Scholars may

[15] Science and the arts were not always considered separate disciplines. Walt Whitman wrote his poem "I Heard the Learn'd Astronomer" in 1865 and this special genre of plays can help remind us of that as Gunderson does at the end of *Silent Sky* when Henrietta reads this poem.

never agree upon a clear definition as the plays do not follow an established formula or set of rules as other genres do. More colleges and universities have begun to produce these plays, incorporate them into dramatic literature and theatre history courses, and even offer special topics courses on them. Diversity in science plays is likely to continue to expand as well. In her interview, Gunderson stated that she "will continue telling stories of women in science, with hopes to write much more about the diversity factor of science, not just in gender but in race too." It is also very possible that more playwrights such as Gunderson will emerge writing solely for this genre as there are many opportunities for creativity and diversity in how the science is incorporated into the script, as well as the type of science and the message to convey. The expanse of the genre is its greatest asset and allows for unlimited future possibilities.

Regardless of the STEM discipline, science plays need more contemporary examples displaying the current issues and challenges scientists, particularly women, encounter today. This is especially true for examples of contemporary women scientists, because although much has changed, women have still yet to achieve equality in the workplace. If science plays are to be used to encourage young women and girls to enter STEM careers, and to promote the encouragement of their mentors, contemporary examples are important. Writing contemporary examples can be difficult as the playwright needs to be careful about not entering the realm of science fiction; however, many have successfully written contemporary science plays that do not. Even though more contemporary examples are written each year, the number of science plays that take place more than fifty years ago still surpasses those that are set in more recent times. Plays such as *Legacy of Light* that are set in both historical and

contemporary eras are an acceptable alternative to plays set only in modern day, as there is a female scientist in both. *Arcadia* despite being set in two different eras, does not feature a contemporary example of the female icon as the historical Thomasina is the only scientist in the play. This need is being addressed, but more plays featuring a real contemporary female scientist need to be written in order to provide young women and girls with role models that they can meet and follow throughout their lives. The majority of the historical science plays feature real women, their work, and the challenges they face, and that is what contemporary science plays lack but need.

A major concern for modern women considering a STEM career is the difficultly in being able to balance it with having a family and if science plays are to help in promoting such careers to young women and girls, then more plays addressing this concern are needed. Currently, the only significant play, if not the only one, addressing this issue is *Legacy of Light.* Many science plays do incorporate family in some fashion, such as *Lucy*, *Silent Sky*, and *Proof*, yet none of them deal with the woman protagonist having a family of her own and her attempt to find a balance between family and career. This struggle is not limited to STEM careers; women face this struggle in any career that demands a significant amount of time, focus, or travel, but women tend to view STEM careers as more challenging to balance with family than others. While more plays are needed exploring this concern, much can be gained from discussing the plays that already exist. "Since many of the science plays explore the past lives of women in science these stories often reflect the extreme sacrifices women made in the past to pursue their dreams. Often, these plays tell the story of a woman who sacrificed family and marriage for their love of science. [For] young girls and women reading and exploring these plays it is

important for them to know what struggles women faced in the past and, hopefully, learn from them and their circumstances. And celebrate the strides women have made and are making to work within the sciences and mathematics" (Gillman Interview). Seeing the challenges women faced in the past can inspire young women and girls to look beyond those that they face today and pursue a STEM career.

Plays in astronomy and genetics featuring women dominate the subgenre, yet very few plays about computer science and mathematics currently exist, much less ones that feature women. Many subcategories such as Quantum Physics also lack plays featuring women, but computer science and mathematics are the larger categories in need of more plays. *Proof* has been known as the "math play" since the beginning of the twenty-first century, received many awards, and is frequently read and produced at universities and professional theatres, yet it did not inspire a wave of math plays. Other mathematics plays have been written and feature women such as *A Disappearing Number* and *The Genius*, but none have gained the notoriety that *Proof* has. On the other hand, computer science has even fewer plays which is likely related in part to its recent emergence as a discipline and most science plays being set well before the invention of the computer. Computer science has become an ever increasingly important component of everyday life as computers are needed for many school assignments and jobs and computers are found in cars, cellular phones, televisions, and most other commonly used electronics. The average person now needs a basic understanding of computer science, and each year what is included in basic computer skills grows with many jobs now expecting employees to be able to learn new software quickly. Lauren Gunderson's new play, *Ada and the Memory Engine* has added to the computer science category where plays are

sorely needed and hopefully, as computers and technology continue to play a vital part in society, more playwrights will write computer science plays featuring both men and women.

If science plays wish promote a STEM career to young women and girls, plays whose target audiences are middle and high school students are important. These plays alone cannot be used for this purpose; young women and girls must be exposed to ones that are meant for adult audiences as well. Plays with adult target audiences provide examples of role models, address many challenges women in STEM face, and show women who have already accomplished a great deal or are on the brink of making their great discovery. These are incredibly valuable aspects that they need exposure to; however, science plays that target younger audiences provide different experiences that can make an important impact upon them. Such plays can connect with their audiences on a more personal level, discussing the everyday situations, challenges, and emotions that students encounter. *Victoria Martin: Math Team Queen* depicts male and female high school students in various grades that are relatable and face the same situations most youth encounter such as fitting in, fear of bullying, and self-discovery. Characters their age are more relatable, and relatable characters can encourage young women and girls to pursue their interests and not bully others that do not fit within accepted middle and high school social norms. In educational theatre students play roles where the characters are much older than they are and it does offer valuable acting experience. Alternately, science plays with similarly aged characters allow student actors to connect more with their roles and learn more from the experience than they would if they were simply reading or watching another in these roles. Having these roles available to middle school students who are younger and have less acting experience is more important than having them

available to high school students because the younger students are when being exposed to these opportunities, the greater the impact they will have upon them. Middle school students can find success with this whether the characters are middle or high school students. Combining science plays that reach both youth and adult audiences will increase the chances for young women and girls to continue an interest in mathematics and science and pursue a STEM career, but currently very few plays exist that depict middle and high school students and the science in their lives.

As the variety of topics, the way in which science is incorporated, themes, and people presented in science plays grows, so too will the ways in which they are utilized. Science plays are currently used in traditional theatrical ways, but their potential is just as vast as the genre itself. Science plays can easily promote STEM disciplines to anyone, including young women and girls, as well as speaking for job equality for men and women, particularly in these fields where gender inequality is larger than others. *Silent Sky* uses Henrietta's insistence of equality in the work she is allowed to complete, access to equipment, and that the sky is sexless as a parallel to Annie and her fight for equality in women's right to vote and to wear pants[16]. They can also be utilized in classrooms from K-12 to universities to help students learn about specific concepts, as well as the history and people of the disciplines and their discoveries, and to spark the students' excitement and desire to learn. Science plays serve as a significant bridge between the arts and hard sciences and can be used in any way one can imagine to bring the

[16] *Silent Sky* also discusses gender in other ways such as using the telescope that she is unable to use as a woman at Harvard as a phallic symbol.

two together, being such a unique genre.

Science plays have significantly grown as a genre at a time when increasing the number of women in STEM has become a national interest. The STEAM movement is emerging out of STEM and science plays can serve both movements well in their efforts to interest young women and girls to pursue a career in science, technology, engineering, or mathematics. Simply taking students to see a production or having them read a science play is not enough; students also need to discuss the play in terms of the science, plot, character, and gender. Their mentors need exposure to these plays with discussion as well, in order to help eliminate some of the barriers young women and girls face from their parents, teachers, and guidance counselors that are often unintentional. As the genre continues to diversify and more subgenres emerge, it is unlikely that scholars and theatre practitioners will agree upon a definition or set of guidelines in the near future, but it cannot be argued that is not a significant and important trend in contemporary theatre. After all, "ideas and the lives of scientists can open up new worlds of discovery and knowledge by telling sciences' unique story" (Gillman Interview).

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Appendix A

Online Catalog Index Sheet

Science Play Catalogue/Index (Please print)

Play title _____ **Author (s)** _____

Publisher _____**Publication Date** _____

Genre _____

Primary Discipline _____ _____ **Secondary Discipline** _____

Scientist (s) _____

_____

Source Texts _____

_____

Character Breakdown _____

_____

_____

Setting _____ **Time Period** _____

Synopsis of Play _____

_____

_____

_____

First Performance Date _____ **First Producer** _____

Performance History _____

_____

Review Links _____

_____

Entered by _____

Play Text (circle) **In Library** **In Digital Library** **Not Available** **Please Order**

Appendix B

Interview with Denise Gillman

Question: Why do you think science plays are important?

Answer: As a theater artist and educator, I think stories are a fundamental means of connecting, educating and enlightening. Plays that explore scientific themes, ideas and the lives of scientists can open up new worlds of discovery and knowledge by telling sciences' unique story.

Question: Do you think science plays are under performed/read by high school and college students?

Answer: This is a hard question to answer specifically since I don't have any specific data to support my responses. What I can say is I think every middle school and high school science and mathematics class would greatly benefit by gaining knowledge and understanding of these subjects through drama. When the complex knowledge of science and mathematics is put within the context of a story it often makes it accessible. I know most high school drama departments want to perform musicals and there are a few wonderful science play musicals such as Fermat's Last Tango, Louis Slotin Sonata, Einstein's Dream and Galileo Galilei. My hope for the future of these science plays within the middle school or high school is that some adventurous science teacher would add one of these plays to their class reading assignments. Or better yet, read the play or portions of it in the class with their students and use the plays as a springboard for classroom discussion or exploration. Another hope is that some adventurous science teacher and drama teacher would team up and collaborate on one of these plays. One of the great benefits of these plays is how interdisciplinary they are. So what would be better than a science and drama teacher coming together across disciplines to make a unique educational experience for their students?

Question: Do you believe that science plays featuring women in the STEM fields could encourage middle and high school girls to enter the STEM fields in college?

Answer: If you can imagine it, you can become it. I firmly believe this. If you give young girls and women the opportunity to see themselves reflected in these science and mathematics stories they can begin to imagine themselves in these professions. One of the great benefits of

these science plays for me is the reclaiming of the work and accomplishments of many female scientists from the past such as Emilie du Chatelet, Rosalind Franklin, Lise Mitner, Henrietta Leavitt and Caroline Herschel to name but a few. The more young girls know that women already have a major place in the history of modern science, hopefully, the more they will be inspired to follow in their hard fought foot steps

Question: What do you believe that students should do/talk about before and after reading or seeing a science play?

Answer: I have always been a big proponent of reading and/or seeing a play and then engage with it. Before talking about any aspects of the science or mathematics, I like to engage with them about just the basic story first. What did you think of the story, characters and their actions? Then I usually begin to explore aspects of the science or math within the play. I think it is important to engage with them about story first and then the science/mathematics second.

Question: What fields do you believe women are underrepresented in science plays?

Answer: I think the two fields where women seem to be underrepresented are Physics (including Quantum Physics) and Mathematics. Now this is a very broad statement that can only be supported by my general survey of the science plays that I know at this time. Physics and Mathematics have been very male dominated fields. I am not saying there are not women in these fields, but the masculine culture surrounding these disciplines have been harder for women to penetrate.

Question: Would you agree that more plays featuring women in science that also have a family of their own need to be written? Why or why not?

Answer: Hopefully, as women make more and more strides into the fields of science and mathematics more science plays will emerge that reflect all the struggles woman face as they pursue their passion for the sciences. I think it is important to note that women in many different professional settings face tremendous obstacles to finding a balance between career, marriage and family. Since many of the science plays explore the past lives of women in science these stories often reflect the extreme sacrifices women made in the past to pursue their dreams. Often, these plays tell the story of a woman who sacrificed family and marriage for their love of science. I think for young girls and women reading and exploring these play it is important for them to know what struggles women faced in the past and, hopefully, learn from them and their circumstances. And celebrate the strides women have made and are making to work within the sciences and mathematics.

Question: Are there any trends you see with women in science plays? Has this trend changed over time?

Answer: The major trends I am seeing now are: more plays are being written about past female scientists and the reclaiming of women's history in modern science and more fictionalized stories with women as the primary scientist/protagonist.

Question: Why did you decide to create an online science play catalog?

Answer: I am passionate about these plays and what they have to offer. It is my hope to share that passion with others.

Question: What do you hope/anticipate that the catalog will be used for and by whom?

Answer: It is my hope that scholars, educators, directors, producers, and anyone else with an interest in science plays will use it as resources.

Appendix C

Interview with Lauren Gunderson

Question: Why do you believe science plays are important? What can they do for modern audiences?

Answer: Science in inherently dramatic, emotional, and human. These qualities of an often self-described "cold" field are reinforced and explored by theatre. I think this helps audiences connect with science as a part of humanity, not solely a technical pursuit.

Question: What inspired you to write *Silent Sky?*

Answer: If science is inherently dramatic women in science is even more so because of the biases and blockades set against them. I want to tell a heroic story where the main character is allowed to be emotional as well as brilliant, ambitious as well as self-aware, and is surrounded by other women as opposed to being the only women in the story.

Question: Henrietta says that she won't marry because it means that she can no longer work. One of the reasons girls today shy away from science careers is the belief that they cannot have successful careers and a family. While things were different at the beginning of the twentieth century, most science plays are set in the past and cannot disprove this. Why do you think most science plays featuring women are set in the past? Do you think there is a need for theatre to portray contemporary women in science and the contemporary struggles they face and what they have overcome in the last century?

Answer: Science is ever changing, but with time theories are more fully understood for their lasting impact. I think that's why history serves science stories. We know what theories "survived" to be proved right over the long term. Also theatre has a long history of using history to talk about the present. A metaphor or a symbolic historical struggle can be more powerful that a direct representation of a modern struggle.

Question: Henrietta is very passionate about her work and I think she is a great example that women can find science interesting too. She does have trouble balancing her work with her personal life though with Peter and her sister. Why does she have this problem? Is it because

of her passion or because to accomplish what she needs to she must devote all that time?

Answer: I think most very passionate, ambitious, visionary people have trouble balancing their lives. It's not a women's issue nor a scientist's issue, but a human issue. It also makes for WAY better drama if Henrietta's life is hard. It would be a boring play if everything were easy for her.

Question: Do you have plans to write another science play in the future? If so would it be one representing a contemporary woman or a woman in an underrepresented science field in science plays such as computer science?

Answer: I always write science plays so yes! I just finished a play about Ada Lovelace and Charles Babbage called *Ada and the Memory Engine* which premieres this October in Berkeley. I am curious about writing more contemporary stories of science, but as I mentioned earlier, it's harder to pin down the ground breaking science to dramatize when it's contemporary. It either becomes science fiction or obsolete too quickly. But I will continue telling stories of women in science, with hopes to write much more about the diversity factor of science, not just in gender but in race too.

Question: My research as proven that parents and guidance counselors play a part in girls' decisions to choose nonSTEM majors in college. Part of my thesis will be how to target them to encourage girls in their pursuits of STEM. How do you think science plays can reach parents and guidance counselors so that they will encourage and not squash the STEM dreams of middle and high school girls?

Answer: I hope that science play can make science careers seem exciting, welcoming, provocative, empowering, and fun for girls and boys. I also hope to help offer more science heroes for girls to look up to. Women who are not just smart but fully alive, emotional, flawed, beautiful, funny, and kind. I want to show girls that scientists fall in love and have friends as well as make staggering discovering and world-changing theories.

Question: Was Sydney Perkowitz might have been your thesis adviser? And your husband is a scientist?

Answer: My husband Nathan is a virologist trained at Harvard and Stanford. Syd was not my advisor on this play but was an early professor of mine at Emory. I wrote one of my first science plays for his class.

Appendix D

Interview with Karen Zacarias

Question: What inspired you to write this play?

Answer: I was doing research on my children's musical EINSTEIN IS A DUMMY and came across Emilie as a footnote and read about her and her amazing science. I was fascinated that motherhood was literally killing her and that she had 9 months to try to complete all her work. When I became pregnant with my third child, I was convinced that my artistic life would be over...so I understood on a human level what may have been her drive, her fear, and complex feelings of loving both her children and her work.

Question: Why did you choose to portray a historical female scientist alongside a contemporary fictional one?

Answer: I wanted to examine how much has changed and how little has changed for women in science and working mothers.

Question: Why did you decide to have Millie be a descendant of Emilie other than increasing the connection between the two time periods?

Answer: Emilie has two legacies...her work ...and the young daughter who she never saw again after she married her off.

Question: What performance space did you envision your play in? Proscenium? Arena? Thrust? Or does it not matter? With many science plays the staging is important to the concepts presented in the play so I was wondering about the intent.

Answer: I think this play could work in all three types of stages...since it's mostly about actors, a tree, and time, space, and matter.

Question: Why did you choose New Jersey for the present setting?

Answer: Because it seems a very accessible, quotidian and unromantic setting as compared to France.

Question: Why do you think science plays are important?

Answer: Theater can activate the poetry of science in a very vivid and comprehensible way. Theater also lets us into the mind and lives of scientists and reminds us of their humanity.

Question: I have found a lack of modern women dealing with contemporary issues in science plays (especially regarding balancing family and career). *Legacy of Light* is really the only one Denise Gillman or I can really think fits that bill. There are a few others, but not with the same significance and prominence. There are also very few plays with women in math or computer science. Do you have any plans to write a play dealing with any of these?

Answer: I'm always open to great stories by great women. (Have you read the play: *Photograph 51*? by Anna Ziegler (it's about the woman behind the DNA)

Question: Do you think it is possible to use science plays to encourage girls to enter various STEM fields? If so how/why? If not why not?

Answer: I think the arts are vital for inspiring people to reflect and think and change. Inspired children are children that want to learn. I have had so many letters sent to me by young girls excited to learn about Emilie...and deeply inspired by Olivia's monologue to the girl scouts. I actually think for STEM to be more effective...it should become STEAM (add the A for arts).

Appendix E

Interview with Shannon Farrow

Question: What have you learned about women in science through your experience?

Answer: Discoveries are often the result of insane focus, single-minded pursuit of one solution or answer. Women are asked in our society to have tremendous split focus. You know, we hear jokes about how women's brains are wired to multitask better than men (which is not at all to mean that all women are better at multitasking than all men), but by getting to know Henrietta, I have gained respect for this amazing focus required to arrive at an answer that has never been reached before. She used the resources she had, and they were very limited, to make a great discovery. In the play, Gunderson explores the cost of Henri's focus--cost to her friends, family, happiness, and health--and the great reward as well. We need to be honest about the sacrifices women make and the energy and discipline required by a life in the sciences.
I have also learned how what might be viewed as a disability can help with this focus. Henrietta Leavitt (and, historically, though not in our play, Annie Jump Cannon) had a hearing impairment, yet some believe this helped make her suited for the tedious work of astronomical computation. One of the professors with whom I've talked about the play, and about women in science, when asked how she "got into" science, told me that she has dyslexia and always struggled to read and write. Numbers came naturally to her, and because reading was so difficult, her family encouraged her in math and science. Women in science are like all people in all fields--whole, complex, and often defined by way they overcome perceived obstacles.

Question: What is different from this role from other roles you have played in non-science play?

Answer: "Our play is about life and death and discovery. We are mapping the universe. This is not a kitchen sink drama. We are communicating truth, but the truth for these characters is *heightened."* --Denise Gillman, director

Professor Gillman captured it beautifully. This play is anything but subtle. There is a presentational, educational aspect of a science play to be reconciled with the way we are comfortable acting. Professor Gillman has to remind us over and over that we are not doing realism. And that's hard to grasp because we are portraying real people and the show is couched in real historical events. But everything we are presenting to the audience is heightened, high stakes, major discoveries--it's really a fantastical way to view these events. I

am excited to tech the show because I know that being in view of the night sky and its vastness is really going to help us heighten these characters and events.
Also, I believe most plays are driven by one or a few major questions. Yet I've never done a play where the major questions are asked so bluntly, so directly, and by my character. It's intimidating! And exhilarating.

Question: What have been some of the challenges you feel are unique to playing this role?

Answer: There are ways in which I as an artist and the character of Henrietta as a scientist are very connected--passion and wonder are driving forces for us, we are dedicated to our work, inspired by nature--but there are many more ways in which we are quite distinct. We are exploring Henri as an introvert, we know she has a hearing disability, and it is easy to see how she finds it difficult to connect with people. She has had one best friend her whole life--her sister. She is constantly having her expectations disappointed. She struggles to communicate, especially her feelings. I guess emotional intelligence is one of the skills I use most as an actor, and to be Henri, I need to cultivate this unawareness, bluntness, innocence, while still using my actor brain. That dual consciousness is a challenging layer for me. Cultivating the hearing impairment and ovarian cancer which takes over my body in the second act require research and practice and are such useful obstacles.
The breakneck speed of moving through her life is challenging. It feels like the moments change very quickly, and so living in those moments, making discoveries both on the lines and even in the scene transitions--because I rarely exit and re-enter the space--is an exciting challenge.

Question: What about this role speaks or stands out to you?

Answer: To be bloody honest, I think Henrietta and I both struggle with selfishness, and discovering that there is much more beyond ourselves and that we are a small part of it, and seeing how that both expands and focuses her is a great journey and a great hope for me. You cannot get around the fact of how she abandons her family and how deeply she hurts Margie--whom she loves more than anyone in the world. But the redemption of their relationship (and of her and Peter's) is so beautiful, so grace-filled, such a powerful reminder that we hurt those we love most and that we are forgiven by those who love us most.
I love Henri's hunger and her questions. They've expanded me.
Also, the grand scope of the role. This week in rehearsal, Professor Gillman said, "Only a few other people in history have made the kind of leap that Henrietta makes. Isaac Newton, Albert Einstein, Charles Darwin, Henrietta Leavitt." Sure, that's the kind of thing that a director says to her young actor to push her forward, but it really was inspiring for me. This is not an ordinary woman, and it's not an ordinary role.

Question: As you are looking at something similar for your thesis perhaps you have given this some thought. What about *Silent Sky* do you think can speak to young girls considering a career in the sciences and what about it could speak to parents and guidance counselors to encourage those girls?

Answer: It's no shock that a lot of girls love narratives. We see it in their play--they love living inside stories, and I think history is a great forum for that. Think about American Girl dolls, right? *Silent Sky* has roots in history, and I think that aspect draws girls in. It's going to be visually stunning, and then the story starts and it's about these women blazing a path in the sciences, making discoveries that no one ever asked them to make, doing so much more than was expected of them. That's exciting! I believe girls who watch it will catch that bug of wanting to make a difference and wanting to do something that's never been done before. I know I have. And my hope is that for parents and guidance counselors who see it, there will be this connection of "Look how far we've come!" Our girls have so much more access, more resources, more opportunity, why not encourage them to seize it? There is something powerful about watching a woman's life, her *whole* life--her work, her frustrations, her family drama, falling in and out of love and making friends and getting sick and leaving a legacy. I hope girls and the women who influence them will start to see themselves in Henri's story, instead of seeing a one-dimensional scientist who is so removed from their lives.

Question: What would you share with young girls, parents, and guidance counselors about this role and women in science?

Answer: My character says about getting to Harvard, "Following this curiosity was not easy. I had to insist, which requires a dedicated desire unmatched by reason, which is called passion." Please, please, do not squelch curiosity. Please, set about doing everything you can to fan curiosity because it is a spark that flames into passion. What else could we want for our girls than that they pursue a *dedicated desire*? That's the kind of woman I want to be and be surrounded by. What's stopping girls is the belief that they are not equipped, they can't make it, they would have to give up having a family. Both the lie that they have to choose and the lie that they can have it all are destructive. Be honest, don't speak to what you don't know, and help put girls in contact with women working in STEM careers, so that they have examples. What would Henrietta ever have accomplished with Willamina and Annie--her great mentors, collaborators, and supporters?

Question: What would you say to girls who view science as a "nerd" or "geek" interest/career?

Answer: Who made you believe it was bad to be a nerd or a geek? You don't have to let people tell you what you want to be, what it's cool or fun to be. You know when you are having fun, when you are doing something you love. Don't stop searching before you've found it! (Here's a challenge: Find an adult who you want to be like when you grow up, and ask them what they were like as a kid, and in high school, and in college. You might be surprised!)

Question: If you have any, I would love to hear about any other thoughts regarding your experience with this science play that you may not have shared in the previous questions.

Answer: *Silent Sky* is a hymn--science is the melody, but the harmonies we're exploring are religion, music, gender equality, etc. Science doesn't have to be limited. Artists are allowed to love science. Scientists are allowed to love art. They're allowed to seek God, to dance, to raise children. And whoever you are, if you look deeply into your life's work, I think that you'll see the scientific process of questioning, searching, discovering, revising, and repeating.

Vita

Danielle Hartman was born on March 16, 1985 in Rochester, NY. She studied at Christopher Newport University in Newport News, VA where she directed the world premiere of *The Yellow Wall* by Kristen Wren and participated in the Honors Program. In 2007 she graduated with her B.A. in English with a concentration in writing and Theatre with a concentration in directing/dramatic literature. She then went on to work at Christopher Newport University's Office of Admission working with scholarship applications and prospective student interviews and at Busch Gardens Williamsburg in various technical roles. In May 2016 she will graduate from Virginia Commonwealth University in Richmond, VA with her M.F.A in Theatre Pedagogy: Dramatic Literature. During her time at VCU she taught multiple classes including Dramatic Literature, Effective Speech, Intro to Stage Performance, and Intro to Acting II. Also won the 2015 42nd Annual Playwriting Competition at Wichita State University with her play *Core of Temptation* and her work with science plays won the 2016 Association for Theatre in Higher Education/Kennedy Center American College Theatre Festival Region 4 prize in Innovative Graduate Work.