Spring 2002

The Motivational Stories of How Women become Scientists: A Hermeneutic Phenomenological Inquiry

Sandra White Watson

THE MOTIVATIONAL STORIES OF HOW WOMEN BECOME SCIENTISTS: A HERMENEUTIC PHENOMENOLOGICAL INQUIRY

Sandra White Watson

THE MOTIVATIONAL STORIES OF HOW WOMEN BECOME SCIENTISTS: A HERMENEUTIC PHENOMENOLOGICAL INQUIRY

A Dissertation

Presented to

the College of Graduate Studies of

Georgia Southern University

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Education

in

Curriculum Studies

---

by

Sandra White Watson

May 2002

March 6, 2002

To the Graduate School:

This dissertation entitled "The Motivational Stories of How Women Become Scientists: A Hermeneutic Phenomenological Inquiry" and written by Sandra White Watson is presented to the College of Graduate Studies of Georgia Southern University. I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Education in Curriculum Studies.

Dan Rea

Dan Rea, Committee Chair

We have reviewed this dissertation and recommend its acceptance:

Delores Liston, Committee Member

Ming Fang He

Ming Fang He, Committee Member

J Hughes

Jay Hughes, Committee Member

Jane A. Page

Jane A. Page, Dept.Chair

Accepted for the College of Graduate Studies

G. Lane Van Tassell,
Dean, College of Graduate Studies

DEDICATION

Dedicated to my husband, mother, and sons. Your unwavering support and encouragement has made this achievement possible.

Aaron Glenn Watson

Viola Conway White

David Christopher Hudnall

Alexander Jake Watson

ACKNOWLEDGEMENTS

I would like to extend my appreciation to Dr. Dan Rea for providing feedback, offering suggestions, loaning me materials and guiding me throughout the dissertation process. I first became interested in science motivation as a student in one of his doctoral classes. That interest has since become an integral part of my dissertation and my life. I would like to thank him for serving as committee chair and for his unwavering encouragement and support.

I would also like to thank Dr. Delores Liston for her insight on the feminist perspective of this dissertation. It was in her doctoral classes that I found myself as a feminist and an author.

Sincere appreciation is also extended to my other committee members, Dr. Jay Hughes and Dr. Ming Fang He, for their direction and insight. The enthusiasm offered by these two committee members was especially encouraging and uplifting.

Without the women scientists who volunteered to share their stories as participants, this research inquiry would not have been possible. The candid stories and feelings they shared served as the data for this project. My sincere thanks is offered to each of them for giving so generously of their time, memories, and emotions.

VITA

SANDRA WHITE WATSON

Education

• Western Kentucky University	1979-1983	B.S.	Biology
• Georgia Southern University	1994-1996	M. Ed.	Science Education
• Georgia Southern University	1997-2002	Ed.D.	Curriculum Studies

Employment in Education

• Science Teacher	Butler County High School Morgantown, Kentucky	1986
• Teacher	First Baptist Church School Franklin, Kentucky	1988-1989
• Teacher	First School Jesup, Georgia	1990-1991
• Teacher	Christian Park Academy Jesup, Georgia	1991-1992
• Science Teacher	Wayne County High School Jesup, Georgia	1992-Present

Work-Related Experience

• Sophomore Sponsor	Wayne County High School	1992-1995
• Prom Committee	Wayne County High School	1996-2001
• Discipline Committee	Wayne County High School	1997-1998
• Junior Sponsor	Wayne County High School	1996-2001
• Y Club Advisor	Wayne County High School	2001-Present
• Freshman Sponsor	Wayne County High School	2001-Present
• Teacher Empowerment Committee Chair	Wayne County High School	2001-Present
• Discipline Committee Chair	Wayne County High School	2001-Present

Accomplishments

- 1999: Presenter: Georgia Science Teacher's Association Regional Conference (Atlanta, Georgia) "From Balancing Birds to the Electric Flea Circus: Motivating Students in Science."

- 2000: Published in The Middle School Journal: The serious benefits of fun in the classroom.
- 2000: Presenter: JCT Conference on Curriculum Theory and Classroom Practices (Bergamo Conference Center, Dayton Ohio): "Spaces of hope: The work of Bryan Deever."
- 2001: Published in GSU Educational Forum: Standards based reform: Is the cure worse than the disease?
- 2001: Presenter: National Science Teacher's Association Southeastern Area Conference (Memphis, Tennessee) "Fun with physics and physical science."
- 2001: Presenter: JCT Conference on Curriculum Theory and Classroom Practices (Bergamo Conference Center, Dayton, Ohio): "Girls just wanna have fun: Motivating girls in science with serious fun."
- 2002: Presenter: Pathways to Change: An International Conference on Transforming Math and Science Education in the K16 Continuum (Washington D.C.) "The motivational stories of how women become scientists: Dissertation results."

Grants Received:

- Georgia Southern University Graduate Student Professional Development Fund 2000
- Georgia Southern University Graduate Student Professional Development Fund 2001

Affiliations:

- Georgia Science Teacher's Association: member
- National Science Teacher's Association: member
- Professional Association of Georgia Educators: member
- American Educational Research Association: member
- American Association of University Women: member

ABSTRACT

THE MOTIVATIONAL STORIES OF HOW WOMEN BECOME SCIENTISTS: A HERMENEUTIC PHENOMENOLOGICAL INQUIRY

MAY 2002

SANDRA WHITE WATSON

B.S., WESTERN KENTUCKY UNIVERSITY

M.Ed., GEORGIA SOUTHERN UNIVERSITY

Ed.D., GEORGIA SOUTHERN UNIVERSITY

Directed by: Professor Dan Rea

The under-representation of women in science careers is well documented (Astin, Green, Korn, & Riggs, 1991; Felder, Felder, Mauny, Hamrin, & Dietz, 1995; Green, 1989; National Science Foundation, 1996, 1998; Seymour & Hewitt, 1997; Strenta, Elliot, Adair, Scott, & Matier, 1994; Tobias, 1990, 1992). While important information has been published concerning various factors that influenced women to pursue science careers (American Association of University Women, 1992; Debacker & Nelson, 2000; Samuels, 1999), very few research projects have allowed women scientists to share their personal experiences of what motivated them to become scientists in their own voices.

The purpose of this inquiry was to investigate the elicited stories of seven women research scientists so that their retrospective motivational experiences with science as girls and young women inside and outside the formal school setting might be better understood. This inquiry examined specific motivational factors and experiences that encouraged or discouraged these women to pursue careers in science. These factors included the motivational influences of gender perceptions, science experiences, and social interactions. From the collective experiences offered, emergent themes were identified and interpreted. These motivational themes were compared with motivational findings in the literature review. Educational implications of the identified themes for these and other women considering careers in science, women's parents, science educators and society, are discussed.

TABLE OF CONTENTS

Page

Table of Contents (continued)

Table of Contents (continued)

Page

Page

Table of Contents (continued)

Page

Table of Contents (continued)

Page

Page

CHAPTER I

INTRODUCTION AND PURPOSE

This study is a hermeneutical phenomenological inquiry into the stories that female scientists reported about what motivated them to become practicing scientists. The purpose of this dissertation is to better understand how female scientists interpret the influence of various experiential factors on their motivation to become scientists. These factors include the following: science experiences, social interactions, and gender perceptions across three developmental periods: preschool to elementary, middle to high school, and undergraduate to graduate school. This inquiry explores how these factors influenced their science motivation and opened up the possibility of their becoming female scientists.

Related Studies

Although my study is similar in some ways to the studies of female scientists mentioned in this section, it is unusual in its focus and methodology. My study focuses on the subject of female scientists' motivation across three developmental periods. Other similar studies address the issue of science motivation on a more generalized level; they do not ask respondents to recall specific science-related experiences, social interactions, and gender perceptions at distinctly different developmental levels. Therefore, my study extends the findings of other studies by exploring the nature of science-related experiences, social interactions, and gender perceptions at the pre-school to elementary school level, the middle to high school level, and undergraduate to graduate level. Also, none of the other similar studies employ a hermeneutic phenomenological approach to the exploration of the motivation of women to pursue science careers. Approaching my study from a hermeneutic phenomenological perspective allowed the respondents to revisit their lived-science experiences, reevaluate them and interpret them. A hermeneutic phenomenological methodology also allowed me, as the researcher, to blend my science stories and beliefs (forestructures) with those of my respondents resulting in a fusion of horizons, that is a fusion of our interpretations of the text, so that new discoveries could be made about the identities of both researcher and respondents. No other similar studies take this unique methodological approach of which I am aware.

Wasserman (2000) conducted a study in which she interviewed all 86 living female members of the National Academy of Sciences. The focus of Wasserman's inquiry was the identification of factors that allowed these women to persevere in science when so many other women had not. Because Wasserman interviewed so many women, her inquiry was limited by time and space constraints. My inquiry limited the participant number to seven, therefore allowing for more in depth data collection. The participants were permitted to present extensive accounts of relevant lived experiences pertaining to their journeys toward science careers. They also had a chance to revisit the recorded transcripts to further revise and amplify their interpreted meanings. The extensive amount of information gathered will provide greater opportunities for the identification and interpretation of emergent themes.

Matkins' (1996) dissertation employed a case-study approach to tell the stories of six women scientists and to identify any enabling or potentially disabling factors that influenced their success leading to science career development. She then compared the factors that emerged with masculine and feminine characteristics found in science education literature and feminist research. Matkins' research took a narrative biographical approach; she did not ask her participants to reflect upon any meanings they may have derived from their experiences.

Davis (1999) conducted a case study similar to Matkins' study in which she interviewed three women scientists to determine "why some women choose and continue to pursue science careers, and which structures and mechanisms within the science community provide them ways to construct identities as legitimate and mature practitioners, and which do not" (p. 133). She further explored the barriers they may have experienced toward achievement, the successes and rewards they accomplished in their careers and how they see science and their careers. The types of questions that Davis asked of her participants were "descriptive and structural in nature" and designed to gather as much information as possible about each issue (p. 133).

Pattatucci (1998) explored the career challenges of women in science in an open-ended manner with an edited book in which the contributors were asked to "write an essay about their experiences as women in science" (p. xi). She indicated that the main purpose of the contributors to the volume was to explore what boundaries exist for women in science and how "they might be transcended to eventually create a scientific environment in which women can thrive" (p. 13). The women who participated in Pattatucci's study concentrated mainly on the encouraging and discouraging factors that they faced as young women in science at the university level and at the job site, although the adversity they faced as young girls in science was also acknowledged. Therefore, the preponderance of information from this study applied to the dilemmas faced by women graduate students of science and women conducting postdoctoral research in science.

Very little information was garnered concerning the developmental periods ranging from preschool through high school.

All of the aforementioned studies are similar to my research inquiry in many ways. Like the previously mentioned studies, my inquiry explored the positive and negative factors influential in encouraging or discouraging women to pursue careers in science. My study also compared the influential factors identified by the women scientists with those found in the literature. My study differs in that it asks the respondents to recall specific encouraging and discouraging factors across three developmental periods. My study is also different in methodology; it is a hermeneutic phenomenological study that asks the respondents to elicit in-depth personal meanings from their lived experiences and allows for the presentation of my own attitudes and beliefs (forestructures) relevant to the study. My phenomenological questions allow and encourage the respondents to explain what it was like to have experienced a particular motivational phenomenon. My study goes beyond asking the respondents to recall past experiences; it asks them to delve deeper into the experiences to bring forth the "essences" of the experiences, which may then allow the interpretation of those events in ways previously unforeseen. Perhaps the unique hermeneutics generated from in-depth interviews will serve to illuminate how girls get turned on or off to science and how women in science persevere despite many motivational obstacles.

Ability Versus Motivation

Numerous research studies have indicated that boys in academic science courses consistently outperform girls. It is interesting to note however, that there are no scientific studies with convincing empirical documentation to claim that males hold a cognitive superiority in the science area (Beerman, Heller, & Menacher 1992; Ziegler & Heller 2000). Samuels (1999) states that the lack of achievement in science by girls is often precipitated by a lack of confidence rather than a lack of ability. She further elaborates that "through encouragement and supportive relationships with teachers, girls can develop the skills necessary to be competent and successful in any scientific endeavor" (p. x).

Not only do girls have less confidence in their perceived abilities to achieve in science academically, other studies have shown that girls have less interest in science and poorer attitudes toward science than boys (Collier, Spokane, & Bazler 1998; Erb, 1983; Holland, 1990; Trammel, Sidlik, Piburn, Baker, & Leary, 1992). It appears that the lack of academic achievement in science by girls may be explained by a combination of motivational factors such as poor attitude, lack of confidence, and disinterestedness.

According to the National Assessment of Educational Progress, NAEP, (National Center for Educational Statistics, 1995), these apparent differences in science achievement between boy and girl students begin to appear as early as age nine and peak at age seventeen. In fact, according to NAEP assessment, males outperformed females in science by an average of eleven points, (which equates to approximately one year's worth of science). Once the differences in achievement between boys and girls emerge, it compounds the motivational problem for girls, causing them to experience performance anxiety and frustration (AAUW, 1992). In fact, according to Oakes (1990), girls do not expect to succeed in tasks that are difficult or thought to require high ability. Furthermore, when girls fail, according to Baker and Leary (1995), they "internalize their failure, attributing it to themselves" (p. 6). Hence, this poor self-concept may lead to girls not selecting or persisting in advanced science courses. Ultimately, few young women relative to men choose to pursue science careers (National Science Foundation, 1996).

Several research inquiries have provided motivational reasons why girls do not fare as well as boys in scientific academic performance (American Association of University Women, 1992; Debacker & Nelson, 2000; Samuels, 1999). Likewise, the literature also offers some possible strategies for motivating girls in science (Glaton, 1981; Kahle, 1990; Samuels, 1999; Yager & Penick, 1986). I will explore these explanations and strategies in depth in the literature review section of this dissertation.

Under-Representation of Women in Science

Four studies (National Science Foundation, 1996; National Science Foundation, 1997; National Science Foundation, 1999; National Science Foundation, 2000) have shown that the presence of women in nearly all scientific career fields is seriously lacking. A recent report of the National Science Foundation (1996), indicated that "women constitute 51 percent of the United States population, and 46 percent of the U.S. labor force, but only 22 percent of scientists and engineers in the labor force" (p. 2). Statistics for the percentage of women scientists and engineers employed in business or industry are also found within the National Science Foundation's report in 2000. According to this data, far more women scientists and engineers are employed in a teaching capacity than in research and developmental capacities. In fact, men, according to the data provided, hold 83.9% of all positions in science research and development. The previously mentioned report was confirmed again in 1998 by the National Science Foundation in which it was stated that although women have made progress in science academic achievement and science participation, they are still underrepresented in science and engineering.

The serious shortage of women in science degree programs and career fields does not appear to be due to their lack of science ability but to a critical lack of appropriately motivating science experiences in early education. As explained in the previous section, women's early lack of confidence, disinterestedness, and poor self-concept undermine and hamper their science achievement. When young women fall behind in their science achievement in middle and high school, it becomes extremely difficult to enroll and succeed in science college programs because they lack the prerequisite courses and preparation. One study (Collier, Spokane, & Bazler,1998) shows that motivation influences the selection and persistence in science courses and programs that leads to degrees and careers in science. Collier et al. (1998) found evidence of an "understructure" (attitudes, activities, preference) to science career choice that begins in the elementary school years. They further elaborate, "girls have poor attitudes toward science, participate in fewer science activities, and are less likely to prefer science careers" (p. 38).

Consequences of the Lack of Appropriate Motivation

When women are not encouraged with early and ongoing motivational science experiences that appeal to their interests, they are unlikely to become scientists. Hence, science and humanity suffer the irreplaceable loss of their talents, which account for one half of the potential workforce, and their scientific contributions, which could offer solutions to many human afflictions. Furthermore, when women are not motivated to become scientists, their views and interests become under-represented in the sciences.

There are many implications for this under-representation such as the inequitable application of science to male-centered interests. For example, women have been excluded as subjects and objects of medical research until the late 1980s (Schiebinger, 1999). Traditionally, what has been discovered concerning the health issues of men has been extrapolated to women. Diagnoses resulted from studies of men; methods of treatment have been designed for men; drug trials have mostly been conducted on men. Women, according to Schiebinger (1999) have often suffered and died needlessly because no one had bothered to address their particular health issues. In fact, when women--with their differing social formations and political affiliations and life experiences--are brought into science, the issues they see as problematic and worthy of research will most likely be significantly different in nature than those problems men seek to answer (Harding, 1991).

Another negative implication of the under-representation of women's views and interests is the limiting of science methods by men's historical preferences for control and conquest (Harding, 1991). When men outnumber women in science, the preferred research methods of men become the accepted norm for science in general. This has considerable implications for how scientists work together and do research since male and female scientists often approach their work differently (Harding, 1991; Pattatucci, 1998). Furthermore, the inclusion of women's views and interests could help to shift male-dominated science methods to more balanced science methods that emphasize both controlled analysis and holistic understanding, hypothesis testing and hypothesis generation, detached objectivity and intuitive subjectivity, and individual competition and team collaboration (Eger, 1993; Keller, 1983).

Therefore, it is imperative that more women become motivated to pursue degree programs and career fields in science for the benefit of humanity and science itself. The removal of motivational barriers that block women's pursuit of science and the enhancement of motivational facilitators that encourage women's pursuit of science appear to be important keys to the equitable representation of women and their interests in science careers. This study seeks to better understand these motivational barriers and facilitators.

Problem Statement

The central purpose of the inquiry was to investigate the elicited stories of seven South Georgia women research scientists so that their retrospective motivational experiences with science as girls inside and outside the formal school setting might be better understood. This inquiry examined specific motivational factors and experiences that encouraged or discouraged these women to pursue careers in science.

The research questions were divided into a primary question and supporting secondary questions. The primary question addressed the collective motivational influences of three factors: science experiences, social interactions, and gender perceptions. These general factors were not fixed and independent entities but they represented interacting areas with overlapping borders. Furthermore, they were not precisely defined hypothetical variables that required rigid testing but they represented fertile areas of interest laden with rich possibilities; they invited exploration and guided the inquiry.

Primary Question:

How do female scientists interpret the encouraging and discouraging influences of science experiences, social interactions, and gender perceptions on their motivation to become scientists across three developmental periods (preschool to elementary, middle to high school, undergraduate to graduate school)?

Secondary Questions:

I. How do female scientists interpret the encouraging and discouraging influences of formal and informal science experiences (such as playing with science toys, exploring nature, experimenting, having science-related hobbies, participating in planned science activities) on their motivation to become scientists across three developmental periods?

II. How do female scientists interpret the encouraging and discouraging influences of social interactions (with parents, relatives, teachers, counselors, and others) on their motivation to become scientists across three developmental periods?

III. How do female scientists interpret the encouraging and discouraging influences of gender perceptions (such as sex role stereotyping, gender bias, gender preference) on their motivation to become scientists across three developmental periods?

Science experiences, social interactions and gender perceptions were the motivational factors chosen in this study because they appear to be the most prevalent factors mentioned in the literature that are instrumental in influencing the science career choices of girls and young women (Samuels, 1999; American Association of University

Women, 1992; Subrahmanyan & Bozonie, 1996), and also because of the personal experiences I have had as a student and teacher of science. The importance of these influences is documented in the literature review section of this study. The three developmental periods (preschool to elementary, middle school to high school and undergraduate to graduate school) were chosen because previous studies seem to indicate developmentally different types of science experiences, social interactions and gender perceptions across these general time periods (Davis, 1999; Matkins, 1996; Wasserman, 2000).

As a result of this study, new insights were gained from the hermeneutic reflection of women scientists upon past-lived experiences they felt encouraged them or deterred them in their pursuit of science careers. The interpretations gathered might ultimately add to our theoretical and empirical understanding of the motivational experiences that encourage or discourage girls and women in science. The information may also provide educators, parents and society with suggestions for new approaches toward the motivation of girls in science, which can eventually lead to more women in science careers.

CHAPTER II

LITERATURE REVIEW

The literature review is organized according to the following three motivational influences identified in the central research question: (a) gender perceptions (including the social construction of gender, cultural attributions of femininity and masculinity, gender congruent and incongruent roles, and the perceived masculinity of science); (b) science experiences (including the issue of boys having more experience with science, motivating girls through positive self-expectancy, and motivating girls with serious fun); and (c) social interactions (including the motivation of girls with female role models, the notion of making science meaningful to girls via collaboration and connection, the necessity of changing teacher and counselor behavior, and the roles of parents in motivating their daughters in science).

Gender Perceptions

One of the most difficult issues to address is the elimination of the masculine socialization of science. This is quite an undertaking as it ultimately asks us to address and alter the socialization of gender. So at this point I would like to briefly investigate what has become known as the "social construction of gender" which also involves the perceived masculinity of science and the fact that boys typically have more experience with science. Then, I will investigate other factors reported in the literature concerning the motivation of girls in science.

The Social Construction of Gender

Numerous validations of the belief that gender is socially constructed are found within the literature (see, for examples, Aldrich, 1978; Belenky, Clinchy, Goldberger, & Tarule, 1986; Bem, 1993; Chodorow, 1978; Danet, 1996; Eccles, 1987; Eccles & Jacobs, 1986; Eisenhart & Finkel, 1998; Freeman, 1984; Gilligan, 1982; Harding, 1986; Harding, 1991; Lorber, 1994; Maccoby & Jacklin, 1974; and Oakley, 1972). Lorber (1994) maintains that gender has become so routine that "questioning its taken-for-granted assumptions and presuppositions is like thinking about whether the sun will come up" (p. 13). She further elaborates that gender has become so ubiquitous in our society that we presuppose that it is an innate part of our biological idiosyncrasy. Most people find it difficult at best to believe that gender "is constantly created and re-created out of human interaction, out of social life, and is the texture and order of that social life" as Lorber states (p. 13). Judith Butler (1990) disputes that gender is not an "interior state" but rather it is a performance that each of us replays over and over again. Furthermore, Aldrich (1978) makes it clear that the stereotyping of gender begins in infancy and proceeds through childhood, adolescence and adulthood. The social construction of gender takes place in the home, the school and in the broader culture such as the mass media. Hence, gender is a social construction that develops over time and is distinguished from sex, which is biologically determined before birth (Vetterling-Braggin, 1982). This constructive process also has a psychological component that enables individuals to overcome social stereotyping and to personally choose how they develop their gender identity (Lorber, 1994).

According to Lorber, it is clear that once a child's sex is evident, "others treat those in one gender differently from those in the other, and the children respond to the different treatment by feeling different and behaving differently" (p. 14). In fact, parents do such a thorough job of educating their children in gender distinction that by the end of the first year children of both sexes correctly identify themselves with their individual genders (Danet, 1996). Furthermore, Oakley (1972) maintains that gender in personality not only emerges very early in cultural learning, but that gender differentiation increases with age. She further maintains that this indicates "people are aware of the opposition between masculinity and femininity and the need to conform to one ideal or another in socially visible ways" (p. 52).

It is clear that as boys and girls grow older, they have different experiences. This dichotomy of experiences arises out of the adherence to socially constructed gender attitudes and behaviors. Children ascertain their gender roles beginning with their parents who impress these roles upon them, either consciously or unconsciously.

Ultimately, the psychological implications of the social construction of gender on women are indeed clear. According to Bem (1993):

> Change a woman's position in the social structure, and her motivation and ability will quickly change as well. The political implication should also be clear: if women are ever to have political and economic equality, what needs to change is not the psyche—or even the socialization—of the individual; what needs to change is the androcentric social structure that operates systematically and in the here and now to preserve male power. (p. 135)

The Cultural Attributions of Femininity and Masculinity

According to Bem (1974), "in general, masculinity has been associated with an instrumental association, a cognitive focus on 'getting the job done'; and femininity has been associated with an expressive orientation, an affective concern for the welfare of others" (p. 156). The Bem Sex-Role Inventory (BSRI) lists personality characteristics of individuals who are "masculine" and those who are "feminine" (1974). The BSRI was "founded on a conception of the sex-typed person as someone who has internalized society's sex-typed standards of desirable behavior for men and women" (p. 155). Elsewhere, Bem (1988) defines sex typing as "the process by which a society transmutes male and female into masculine and feminine" (p. 354).

According to the BSRI, a "masculine" individual acts as a leader, is aggressive, ambitious, analytical, assertive, dominant, competitive, independent, self-reliant, self-sufficient, and is a risk-taker. The same scale describes a "feminine" person as affectionate, cheerful, compassionate, gentle, shy, sympathetic, warm, soft spoken, and yielding. Although Bem (1988) identifies masculine (instrumental) and feminine (expressive) characteristics, she does not promote a unilinear, bipolar model of gender identity (with masculinity and femininity as bipolar opposites). Rather she contends that gender identity is multidimensional with four combinations of hi-lo masculinity and hi-lo femininity resulting in sex-typed masculine, sex-typed feminine, androgynous, and undifferentiated personalities.

Gender Congruent and Incongruent Roles

Bem (1983) states that children develop "masculinity" and "femininity" at a very early age. She further maintains, "by the time they are four or five, for example, girls and boys have typically come to prefer activities defined by the culture as appropriate for their sex and also to prefer same-sex peers" (p. 598). Fennema & Peterson (1985) claim that the process of aligning one's behavior with the associated perceived social expectations (gender-role congruency) is the single most derisive factor involved in the disassociation of girls from science.

Several theories seek to address the sex-typing phenomenon. The social learning theory according to Bem (1983) "locates the source of sex typing in the sex-differentiated practices of the socializing community" (p. 600). In other words, the social learning theory attributes sex typing to society's practice of rewarding children for sex-appropriate behaviors and punishing them for sex-inappropriate behaviors (Bem, 1983).

In contrast to the social learning theory, the cognitive development theory places the responsibility of sex-role socialization upon the individual child (Bem, 1983). According to Bem, "cognitive developmental theory postulates that, because of the child's need for cognitive consistency, self-categorization as female or male motivates her or him to value that which is seen as similar to the self in terms of gender" (p. 601).

Features of both the cognitive development and social learning theories are combined in the gender schema theory. In fact, Bem (1983) states "gender schema theory proposes that sex typing derives in large measure from gender--schematic processing, from a generalized readiness on the part of the child to encode and organize information--including information about the self--according to the culture's definitions of maleness and femaleness" (p. 603). Gender schema theory further assumes that sex typing is a "learned phenomenon," thus it is neither inevitable nor unmodifiable (p. 603).

The Perceived Masculinity of Science

Science appears to be very much a part of this ascribing of roles. Therefore, the gender gap in science may better be understood in terms of its perceived "masculinity." Rossiter, (1982) describes the cultural stereotype of science as tough, rigorous, rational, impersonal, competitive and unemotional--those characteristics embroiled with issues of men's gender identities. Haynes (1989) examined images and stereotypes of scientists in literature and concluded that many of the characteristics associated with scientists are also considered masculine traits as indicated on the BSRI scale. Haynes found the stereotypical view of the scientist in literature to be cold, unresponsive, rational, unemotional, aggressive, competitive, and adventurous. Keller (1983) believes that the "active, if not 'masculine' in the proprietary sense, is nevertheless unduly permeated by an attitude of objectivizing, controlling, manipulating, 'dominating'; and this attitude is indeed part of a commitment of scientists to the masculinity of their profession" (as cited in Eger, p. 18, 1993).

Mead and Metraux (1957) conducted a study in which they analyzed a sample of essays written by high school students across the United States on their opinions of scientists. From their analysis, Mead and Metraux were able to construct a composite picture of a typical scientist as seen through the eyes of the high school students participating in the study. The shared image provided by the informants is that of a man who wears a white coat and works in a laboratory. Mead and Metraux further discovered that the image of a science career conflicted with contemporary values, that it divided boys and girls. They stated the following:

> Girls reject science, both as a possible form of work for themselves, concerned with things rather than people, with nonliving things (laboratory animals, not live animals; parts of anatomy, not living children), and for their husbands, because it will separate them, give their husbands absorbing interests which they do not share, and involve them in various kinds of danger. (p. 387)

The year was 1957, that Mead and Metraux conducted their classical study; surely by today, the images held by youngsters of scientists have changed. Let us jump forward to the year 1991. Mason, Kahle and Gardner (1991) conducted a study in which they asked children to draw a picture of a scientist. They report that both boys and girls of all school ages still have stereotypic perceptions of scientists as men. Baker and Leary (1995) studied the beliefs of girls concerning science classes, careers and scientists and found that most of their beliefs were gender stereotyped. According to Kelly (1985), the perception of science as a masculine dominion repels girls from displaying an interest in it or perhaps from pursuing science related careers. Because most girls are verbally and actively taught that certain pastimes are feminine while others are masculine, they tend to gravitate toward activities that will grant them approval and praise, namely those activities and behaviors that have been imputed to be feminine (Bem, 1974, 1983, 1988, 1993; Haynes, 1989).

Not only does the male-dominated science identity strongly influence the activities and choices of girls in the pre-college years (Baker & Leary, 1995), but it also has a conspicuous role in the career decisions of college women. According to Seymour and Hewitt (1997), college women considering science careers often become discouraged from ultimately pursuing those careers because they view their future selves as scientists as "different" from the traditional scientist. In other words, these women feared future struggles that the negative stereotypical images of the traditional scientist might present in their own lives as future scientists. Packard and Wong (1999) further explored this clashing of present and future selves among college women considering science careers and found it to be detrimental to the completion of degrees in science for many women. Hence, the perceived masculinity of science is injurious to both young girls just beginning to show interest in science and young women already enrolled in science courses and seriously considering science careers.

Science Experiences

Boys Have More Experience with Science

Science has traditionally been deemed a male field. In fact, Hammrich (1997) gives examples of indirect and direct science experiences contributing to such gender differences as "playing with scientific toys and games, participating in science activities at home, and parental stereotypic behavioral expectations" (p. 22). Adamson, Foster, Roark and Reed (1998) state, "there is growing evidence that science-related experiences outside the classroom are gender related and that they may occur before clear differences in achievement are evident" (p. 846). They further elaborate that as boys and girls engage in different activities at the elementary level they begin to develop certain skills. For example they state that as "boys gravitate toward group activities that involve making inferences about the motion of balls or computer images, they may have more opportunity to fine-tune and enjoy scientific reasoning" (p. 847). Samuels (1999) maintains that boys often have had more play experiences with concrete phenomena and thus have "an easier time extrapolating abstract conclusions" (p. 12).

Furthermore, Bae and Smith (1996) found that in the middle school years "boys were more likely than girls to have talked to a scientist or attended a computer club, or to have used a computer for a significant amount of time during the week, or to have a computer or microscope at home" (p. 5). They also state that by the tenth grade "boys are more likely than girls to have conducted their own science experiments" (p. 5). The American Association of University Women (1992) report that by third grade, 51 percent of boys and 37 percent of girls had used microscopes, while by eleventh grade 49 percent of males and 17 percent of females had used an electricity meter. In the younger child, typical "boy toys" such as blocks, encourage visual spatialization and mental rotation, resulting in the better spatial ability test scores of boys than girls (Valian, 1999). One final example involves a study conducted on college physics students' abilities to judge the relative velocity of objects moving on a computer screen. The higher achievement of male students over female students was attributed to the greater experience male students had with video games (Law, Pellegrino, & Hunt, 1993).

The social construction of gender has negative effects when it leads to sex-role stereotyping that does not allow for individual differences. The aforementioned studies are but a few that show the negative effects that the social construction of gender has upon the science motivation and achievement of girls.

Motivating Girls in Science with Positive Self-Expectancy

Numerous studies have shown that boys are significantly more confident concerning their perceived abilities to engage in and be successful in science, while girls consistently present lower perceived abilities in science (Beyer & Bowden, 1997; DeBacker & Nelson, 2000; Ryckman & Peckham, 1987). Dweck and Bush (as cited in

Jones & Smart, 1995) studied the attributions of males and females toward success and failure in academics and concluded that girls tend to correlate failure with lack of ability or talent while boys cited lack of effort as a reason for failure. In fact, Ryckman and Peckham (1987) found that girls are much more likely than boys to attribute success in science to external factors such as luck or simplistic problems. Ziegler and Heller (2000) also corroborate these findings when they state, "girls attribute their successes in mathematics, natural sciences and technology to external factors, such as luck or easiness of the problems, significantly more often than boys do" (p. 218). Perhaps girls' misplaced attributions of success may result from the tendency of teachers and parents to "disable" girls by jumping in to "help" when girls struggle with science. On the other hand, teachers and parents often provide boys with guiding questions in science so that they might "figure it out for themselves."

According to Beyer and Bowden (1997), when female science students attribute their successes to ability, they tend to succeed; when they attribute their failures to lack of ability, they tend to fail. Girls therefore, display an attributional style that makes them vulnerable to failure. Other studies have shown that highly talented girls often attribute failure to lack of talent and will often give up much sooner than males after having experienced failure (Dweck & Repucci, 1973 (as cited in Zeagler & Heller, 2000); Nicholls, 1975). This pattern of behavior has been referred to as "learned helplessness" in the literature (Diener & Dweck, 1978, 1980 (as cited in Zeagler & Heller, 2000); Rholes, Blackwell, Jordan, & Walters, 1980).

Dweck (1986) describes learned helplessness as a condition in which, because of the attribution of failure to lack of ability, individuals begin to see success as an impossible attainment. The term learned helplessness means that people learn to be helpless; they are not born helpless. Helplessness is learned from experiencing repeated painful failures that seemed to be beyond people's control and perhaps were. They did not learn to be helpless because they were defective people or passive victims. They learned it from parents and teachers who perhaps because of gender bias or gender stereotyping attributed their failure to a lack of ability. Hence they both learned and were taught to be helpless. They learned to adapt to painful situations that seemed or were beyond their control by not trying. They learned to protect their self-worth from the pain of failure by not participating in high-risk situations. Apathy becomes a silent excuse to protect their self-worth from the pain of failure. They were taught to be helpless by parents and teachers who were either over-critical and under-helping or over-protective and over-helping (Peterson, Maier, & Seligman, 1993).

What is important is that learned helplessness can be unlearned as they are taught to develop learned optimism. By using attribution retraining they can be taught to attribute their failure to controllable factors such as lack of effort or lack of effective learning strategies or lack of background information. Also, they can be taught to attribute their success to controllable factors such as extra effort, effective learning strategies, and appropriate background information (DeBacker & Nelson, 2000).

It is also extremely important to address the social conditions that result in learned helplessness in girls in science. Attitudes and practices of parents, science educators and significant others must change so that girls are guided and encouraged to work through difficult scientific problems on their own rather than be allowed and persuaded to relinquish these problems to others to do the work for them.

Often, the lack of confidence displayed by girls arises out of the stereotypical belief held by many parents, teachers, male, and female scientists that science is a masculine domain (Debacker & Nelson, 2000). In fact, girls and many parents often perceive success in science as threatening to the feminine self-image of the girls (Skolnick, Langbort, & Day, 1982). According to the AAUW report (1992), during adolescence, boys begin to associate self-esteem with accomplishments while girls correlate self-esteem with beauty. Skolnick, Langbort and Day found that the American society (men and women) believes that either a female is born beautiful or that she is not. Girls and society often associate beauty with success. They often also associate intelligence with genetics; therefore girls "begin to attribute their success to luck and not to skill," specifically in math and science (p. 21). It is also possible, according to Brown and Gilligan (1992) that this lack of perceived ability in science is just one additional factor that culminates in the general overall lack of confidence girls are reported to experience during adolescence. Therefore, it is imperative that teachers provide sustained support to girls so that they might be, as Rop (1997-1998) says, "encouraged to experience the intellectual freedom they need to succeed in school science and to consider making science their life's work" (p. 3).

The American Association for the Advancement of Science (AAAS) reported in 1989 that science anxiety is particularly significant for girls. The report noted that "Because the scientific and engineering professions have been predominantly male and white, female and minority students could easily get the impression that these fields are beyond them or are otherwise unsuited to them" (p. 4). In fact, according to the AAAS report, girls often mistakenly believe that boys are more adept at using science tools.

Therefore, not only must teachers instill confidence in girls' abilities to use science equipment, they must also actively work to dispel the mistaken notion that boys are naturally more proficient at using science instruments.

When girls are confident in their perceived scientific academic achievement, when they are provided with new study skills and new methods of concentration or comprehension, they are much more likely to acquire necessary science skills (Samuels, 1999). As the attainment of science skills increases for girls, the likelihood that they will rise to the challenges of science also increases (Samuels, 1999). This optimal challenge in which perceived skills match the demands of the task may then lead to what is considered a very motivating "flow" experience.

Csikszentmihalyi, Rathunde and Whalen (1993) describe "flow" as the feeling that emerges when one is so involved in an activity, so intensely concentrating on an activity, that he or she becomes unaware of extraneous things they would normally notice. Boyer and Lamoreaux (1994) describe a person experiencing flow as having lost all sense of time and becoming "one with the activity" (p. 3). They further elaborate, "the person in flow attains a higher order of complexity by attempting tasks of increasing difficulty and training to meet new challenges" (p. 4). Csikszentmihalyi et al. (1993) maintain that the optimal challenge of flow is a highly enjoyable experience that is intrinsically motivating. However, when students are over-challenged they become frustrated and when they are under-challenged they become bored. Therefore, there is a social connection to the individual experience of flow. The flow experience in science can be socially set up by the teacher who provides science activities that are optimally challenging. If the teacher makes science too challenging, it becomes a source of frustration and anxiety. If the teacher makes science too easy or under-challenging, then it becomes boring.

When girls' skill levels are well matched with the challenge of doing science, they are likely to experience the joy of flow. This optimal challenge of flow is similar to the connected knowing that Barbara McClintock experienced when she forgot herself and became totally and empathetically involved with the genetic study of corn. Root-Bernstein (1996) provides an excellent description of the flow experience of forgetting self when he quotes Barbara McClintock:

> I found that the more I worked with [chromosomes], the bigger and bigger [they] got, and when I was really working with them I wasn't outside, I was down there. I was part of the system.... I actually felt as if I were right down there and these were my friends. As you look at these things they become part of you. And you forget yourself. The main thing about it is, you forget yourself. (p. 68)

Samuels (1999) suggests that science educators select clear guidelines of expectations so that girls may reduce feelings of anxiety and build positive self-expectancy. According to Samuels, as long and short term goals are specified and met, girls experience a sense of accomplishment that "bolsters their self-esteem and propels them toward the overall goal: a successful science education" (p. 31).

Motivating Girls with Serious Fun

Collier, Spokane, and Bazler (1998) suggest that attitudes play an instrumental role in whether or not girls prefer science to other subject areas in school. Furthermore, Collier et al. found that "girls were less likely than boys to see science as a fun puzzle to be solved" and more often than not, "girls showed less interest than boys" in science (p.

37). They further elaborate, "science as a fun puzzle to be solved seems to be the factor most closely allied with personal involvement with science" (p. 44). In fact, many studies have shown that girls will be motivated to achieve in science when science is made interesting to them (see, for examples, Glaton, 1981; Kahle, 1990; Samuels, 1999; Yager & Penick, 1986). In fact, the Association for Women in Science (AWIS) surveyed a large number of female students of science and found that 47% cited science being enjoyable and interesting as the most important factor in their decisions to study science (Didion, 1995).

Elizabeth A. Wood (1973), Fellow of the American Physical Society and a past president of the American Crystallographic Association stated that the reason she is a scientist is because

> It was just more fun than anything else I was exposed to in school or college....I became a scientist because I enjoyed doing science and liked the people who also enjoyed it....The excitement of some of my discoveries keeps me up half the night or gets me up before four in the morning to watch a meteor shower. (p. 242)

She further elaborated that

> the arts and sciences both depend on the joy of discovery for the stimulation of the participant, the joy that comes from attaining a result unforeseen when the work was begun; a result achieved, often through the surmounting of technical difficulty. (p. 243)

Other studies have shown that girls prefer inquiry-oriented instruction in all disciplines (see Glaton, 1981; Kahle, 1990; Yager & Penick, 1986). The importance thus lies in finding ways to interest girls in science through gender-specific interventions. Samuels stresses that courses should be "designed to encourage independent thinking, problem solving, and scientific inquiry" to best motivate female students in science (p. 5).

Each of these preceding goals of fun and inquiry orientation can easily be met with "serious-fun science." In fact, those characteristics very adequately describe serious-fun science itself. Serious-fun is the simultaneous integration of seriousness and fun as an ideal motivational experience. This balanced motivational experience that incorporates seriousness and playfulness has been described as "serious play" by some, (see, for examples, Mann, 1996; Rathunde, 1991a, 1991b, 1992; Rathunde & Csitszentmihalyi, 1993; and Wasserman, 1990, 1992), "play as progress" (Rieber, Smith, & Noah, 1998) and "serious fun" by others (Rea, 1994, 1995, 1997; Rea, Millican & Watson, 2000). Rea, Millican, and Watson (2000) state that serious fun "combines the spontaneous fun of interesting activities with the focused seriousness of meaningful accomplishments" (p. 23). Rea (1995) coined the phrase to represent "play with a purpose" (p. 22) and Mann (1996) defines serious play as "fun but purposeful" (p. 49). The distinguishing characteristics of serious fun according to Rea, Millican, and Watson (2000) is that "it is experienced-based instruction that provides opportunities for students to playfully experience learning, seriously reflect on their learning experience, and thereby construct a personal understanding of the subject matter" (p. 25). Rieber and Matzko (2001) describe this serious type of play as "play that involves an intense, mindful, and personally satisfying activity in which a person is almost on "auto-pilot" as he or she engages in the activity" (p. 15). Furthermore, according to Dewey (1933), the ideal learning condition is one that is "playful and serious at the same time" (p. 286).

There is also a social component to the individual experience of serious fun. Teachers who adopt a participatory style of leadership in which they provide high support for fun challenges in science and high expectations for serious mastery in science learning create the balanced social conditions of serious fun motivation. A participatory style of leadership may optimally promote the motivational development of young female science students because it enhances both their enjoyment and mastery of science. Teachers who adopt a directive leadership style in which they provide low support for fun challenges in science but high expectations for serious mastery in science create the social conditions for a serious type of motivation. When taken to the extreme, the directive style becomes an authoritarian type of leadership, which may discourage the developing motivation of young female science students. Teachers who adopt a supportive style of leadership in which they provide high support for fun challenges in science but low expectations for serious mastery in science create the social conditions for a fun type of motivation (Rea, 1995, 2001). When taken to the extreme, the supportive style becomes a permissive type of leadership, which may undermine the developing motivation of young female science students.

There are many ways in which serious fun seems to be beneficial to girls' success in science achievement in light of the motivational research findings previously mentioned. Serious fun lends itself quite well to cooperative and collaborative learning environments, which studies have shown are conducive to the success of girls in science (American Association of University Women, 1992; Belenky, Clinchy, Goldberger, & Tarule, 1986). Many serious fun-activities involve collective brainstorming and collaborative efforts among two or more people. Because parental influence has been reported to be the overwhelming influential factor upon career choices for girls (Hammrich, 1997; Jordan, 1999; New England Consortium for Undergraduate Science Education, 1996; Samuels, 1999), it is important for parents to adopt a participatory style of leadership and provide numerous early serious-fun science experiences for their daughters. By providing these early serious-fun experiences, more parents may see their daughters attracted to science courses in school and consequently choosing science as a career field.

Certainly early enjoyable scientific activities can spark interest and pique curiosity for girls. Nokes (1998), a biological and agricultural engineer describes her curious and playful scientific investigations as a young girl. At the age of seven, she "designed" a water-powered car and presented it to her father, who explained to her that she had violated the first law of thermodynamics since she had not provided an external energy source. She later recalled dissecting an ear of corn to determine how the kernels were attached to the ear. She credits her early playful investigations with science as part of the reason why she went into the field of scientific research as an adult.

Furthermore, Wood (1973), a female fellow of the American Physical Society, and a past president of the American Crystallographic Association explained why she became a scientist: "It was just more fun than anything else I was exposed to in school or college" (p. 242). She further states, "I became a scientist because I enjoyed doing science and liked the people who also enjoyed it...and the excitement of some of my discoveries keeps me up half the night..." (p. 242).

Collier et al. (1998) mention the importance of getting girls involved in extracurricular science activities. They found that those girls participating in extracurricular science activities "were more positive toward science and science careers" (p. 39). For example, Bartsch, Snow, and Bell (1998) speak of an extracurricular science program called Florida Education in Geology and Ecology: FLEDGE-ling Camp for Girls. All participants in this program were given exit surveys and follow-up interviews following the completion of the program that indicated "the girls learned most from the field and hands-on activities that were undertaken, and that these were also identified as the most enjoyable by the girls" (p. 321). They further elaborate "some of the best evidence for the effectiveness of the program has come from parents who have relayed stories of their child's newfound interests in science and their eagerness to share their insights with family members and peers" (p. 330).

Baker, Lindsey, and Blair (1999) describe another extracurricular summer program called Girl's Summer Lab (GSL) in which middle school girls participated in science activities three days a week for ten weeks. Activities included searching for fossils, working at an authentic dinosaur dig site, working with chemicals, and collecting and analyzing data via computer. Following the completion of GSL, all of the participants "were extremely positive about what they had learned" (p. 86). One girl described her feelings following completion of GSL as being "Happy, excited. Because its been really fun and I've learned more than I did in a whole year of Earth science" (p. 86).

Another area the literature mentions is the necessity of providing large-motor activities as a means of motivating younger girls in the science area. Serious fun of course can be rendered through this type of free play. A good example is the manipulation of slinkies to learn about waves (wavelength, amplitude, troughs, crests, etc.). The use of swings to demonstrate pendulum motion is another example, as well as the use of toy cars in races to study motion and speed. All of these activities constitute serious fun and allow for and enhance large motor skills.

Samuels (1999) reports that many girls express distaste for science because they feel it has no meaning for their own personal lives or for the lives of other humans. Therefore, it is imperative that science educators stress those aspects of science that display serious usefulness for the improvement of the quality of human life (Rosser, 1993). Many serious-fun hands-on activities can illuminate the usefulness and importance of science and bring science to a personal level. For example, when studying the inheritance of traits, I often pair two students together, one playing the role of mother and the other as father. Their job is to construct a picture of their "child" by combining their traits (a toss of a coin adds an element of chance) while adhering to the principles of dominance and recessiveness. This activity makes the serious topic of genetics more personally relevant while also making it fun.

Another example of a serious-fun activity that is personally relevant is the use of a lab activity to portray the speed with which a virus can spread among a population (Rea, Millican, & Watson, 2000). Every student is given a numbered test tube filled with a solution. All solutions are acidic except one, which is basic. The person who receives the basic solution represents the "infected" individual. All of the solutions look alike, whether acidic or basic, so the students do not know who has the "disease." All students are instructed to exchange fluids with one another with pipettes to simulate the exchange of body fluids. This is done three different times, each time with a different individual. After all exchanges have been completed, the test tubes are collected and brought to the front where I then place a couple of drops of phenolphthalein in each tube. Phenolphthalein is an indicator that turns bright pink in the presence of a base. Thus, the test tubes turn bright pink if they have been "infected" and turn yellow if they have not. This is an activity that makes a distant scientific concept seem personally relevant and seriously useful while at the same time actively fun.

Social Interactions

Motivating Girls in Science with Female Role Models

There are specific methods of deconstructing the stereotypical view of the scientist as male that can be employed by educators and parents so that girls will feel less threatened by science and science careers. Many studies stress the importance of providing female science role models to young girl students (see, for examples, Association of American Colleges, 1982; Blake, 1993; Bleier, 1984; Evans, Whigham, & Wang, 1995; Hammrich, 1997; Irarte-Gross, 1998; Kahle & Meece, 1994; Kennedy & Parks, 2000; Meyer, 1998; and Owens 1998). Patttacucci (1998) states, "Visible women in science represent concrete examples to those aspiring for science careers that it is possible for women to succeed" (p. 70). She further elaborates that "visible women in science can often provide sufficient incentive for a person struggling to persevere in her own career endeavor against what seem to be insurmountable odds" (p. 70). Lima (1998) mentions another avenue by which young women in science can succeed with the help of a mentor. She states that mentors provide "introduction and access to outside contacts in the scientific community" and "the student gains legitimacy by attaching herself to the mentor's reputation" (p. 87). Furthermore, the first national Women in Science Summit held in 1994 recommended the necessity of effective mentoring systems to the success of women in science (Didion, 195).

Female scientists who mentor younger women interested in science can have a profound effect on the science careers of the younger women under their guidance. Gaines (1998), a practicing woman scientist, credits a female mentor at the National Institute of Environmental Health Sciences with opening the doors of science to her. Gaines states that her mentor believed in her, supported her and empowered her with the courage to pursue her dream. What stood out in Gaines' mind as outstanding about her mentor was that she "graciously nurtured my development as a scientist while simultaneously tolerating lack of support and often blatant discrimination from our supervisor" (a male scientist) (p. 74). She went on to say that "My mentor's steadfastness to endure in the face of hardship and barriers to success enabled her to overcome obstacles and fueled a determination to open doors for other women" (p. 75).

Subrahmanyan and Bozonie (1996) address the issue of female role models in the context of science textbook selection. They stress that "it is essential in science that the famous scientists described in the textbooks are both male and female" because when girls read about women scientists they may become encouraged that they too can become scientists (p. 7). Likewise, Subrahmanyan and Bozonie emphasize the urgency teachers must adopt toward becoming knowledgeable about gender representation in science textbooks so that girls will see that not only have women historically been greatly involved in science, but contemporary women are active in science as well.

Samuels (1999) provides several possibilities for providing female role models from the scientific disciplines for girl students. Her list of possibilities includes incorporating examples of women scientists into classroom lectures, discussions and activities. She especially stresses the significance of portraying women scientists who are also mothers and/or wives so that girls might realize that it is possible to enjoy a career in science while having a family life. Samuels also suggests decorating the classroom with photographs of female as well as male scientists, "assigning students to research female scientists, selecting female teacher assistants whenever possible, and supporting the hiring and retention of female faculty" (p. 42).

Sanders (1994) emphasizes the need to bring female guest speakers into the science classroom who are actively engaged in research in a field of science, are working in a technical or medical field, or are even women college students majoring in some type of science. Bringing female scientists into the classroom as role models for girl students is not always an easy task, especially for teachers in rural, isolated areas. Rop (1997-1998) mentions the alternative possibility of creating electronic mentoring relationships between girl science students and female scientists. Samuels also maintains that the mentors do not necessarily have to be women actively engaged in research science but rather can be "older women students, teachers, or volunteers from the community" (p. 42).

The need for female role models continues into the university and post-graduate levels. Olsen (1998) mentions the importance of the existence of peer groups such as the American Chemical Society Women Chemist's Committee and the Association of Women in Science as another support structure for women in science careers. As a female professor of chemistry, she stresses the need for female professors of science to stand among other women as living examples of successful women in science.

Making Science Meaningful to Girls via Collaboration and Connection

Eisenhart and Finkel (1998) conducted a study that indicated when girls are involved in the types of science activities that already interest them; they do not have "to choose between commitment to success in science and involvement in other activities that are important to them" (p. 238). They further contend that girls are more successful at "using and learning science in the context of socially relevant activities" (p. 239). What Eisenhart and Finkel advocate then is the deconstruction of the current science curriculum so that girls' interests in socially relevant activities are addressed and eventually their chances of achievement in science might greatly improve. In fact, Martin (1985, 1994) maintains that like gender, science curriculum is also socially constructed and it is constructed in such a way that it privileges those who find success in a distanced, dispassionate, and conventional method of school science. This basic method serves to discourage many women and minorities from pursuing science education and science careers.

Candice Pert (1997) is a research scientist with a Ph. D. in biophysics at Georgetown University Medical Center in Washington, D.C. Pert recognizes the importance of an atmosphere of collaboration and connection, and she tries to create that type of environment in her labs. She related:

> In my own lab, I consciously tried to develop a nurturing, even maternal mode of management, motivating people by praise rather than criticism, by team spirit rather than competition with each other....I strived to create an atmosphere in my lab that would allow for more collaboration, opening up doors for different labs to

> work together on joint projects instead of viscously competing with one another to win funding and glory. (p. 123)

The Foundation of Science Program deviates from traditional science teaching methods. Teachers at a mid-western public high school developed the project. Students became partners with community members as they evaluated the water quality found in a local stream. The project required participating students to not only monitor the water quality but also collect and analyze organisms found to inhabit the creek, observe the various habitats within the creek area, and provide a series of written reports that were presented to the local environmental agency, and the findings were ultimately presented by the students on a local cable television station. The students involved in this project were consistently "made aware, by their teachers and through the involvement and interest in their work by members of the community, of the relevance of their work to themselves and to others in the community" (p. 242). This prolonged yet engaging activity involved mainly girls who were interviewed at the onset of the project and then again at the culmination of the project. Emergent themes indicated a complete turn around in attitudes toward science, from hating it to actually finding it exciting and easier to understand. FOS is an example of a program that Eisenhart and Finkel (1998) demonstrate "connects students to the community and to other people, and to science in ways that are distinctly different from those of conventional school science" (p. 244). This type of approach seems to be instrumental in motivating girls to succeed in science.

Belenky, Clinchy, Goldberger, and Tarule (1986) suggest that girls are more likely to involve their individual experiences and perceptions with others in a collaborative and cooperative scientific effort. The American Association of University

Women's (AAUW) report (1998) also states that cooperative learning "is designed to eliminate the negative effects of classroom competition while promoting a cooperative spirit and increasing heterogeneous and cross-race relationships" (p. 126).

In the Belenky et al. (1986) study, it was determined that girls are more likely to experience successful learning in science when they are permitted to empathetically enter into the concept to be investigated, a phenomenon they describe as "connected knowing." "Connected knowing," according to Baker and Leary (1995), emphasizes "the importance of connections and relationships for women's ways of knowing" (p. 5). Baker and Leary (1995) further elaborate that

> a woman who takes the epistemological position of constructed knowledge is the woman who can construct her own knowledge from both objective and subjective experiences. Knowing is based on connections with people, ideas, objects, and the written word. Connections and relationships give rise to a moral component in attitudes, judgements and behaviors. Thus, decisions take place in context and are evaluated in terms of their effects on others. (p. 5)

Gilligan (1982) conducted research on the moral development of women, which provided insight into the correlation between women's affinity for connectedness and career choice. She found that women often do not consider personal interest or competency in a field when making a career choice, rather they envision how that career choice will impact the relationships within their personal lives. Hence, according to Packard and Wong (1997), "many women experience feelings of conflict when envisioning themselves in a future science career because of the perceived impact that it will have on the relationships in their personal life" (p. 4). Packard and Wong (1997) also found that many women college science students well on their way to science careers will often get out of the science track because they envision themselves futuristically as working in an isolated environment, too busy for their families and consumed by their work. According to Packard and Wong (1997), "for many students this may present a strong clash of identity if they feel they are too different from the images of this career" (p. 5).

Pattatucci (1998) mentions several detrimental effects that isolation has upon women in science including "impairment of self-confidence, stigma, and exclusion from access to informal networks of professional communication"(p. 203). She further elaborates, "informal associations are essential for professional growth, career enhancement and the scientific process" (p. 203). Ultimately, the need for relationships and a sense of connection with others plays a leading role in the career choices of many women. Therefore, we must endeavor to situate a sense of connectedness within science fields so that girls and women feel comfortable pursuing science courses, science related activities, and possibly science careers.

Changing Teacher and Counselor Behavior

Subrahmanyan and Bozonie (1996) advocate that teachers work from an "equitable" rather than an "equal" framework. Therefore, the science teacher should opt for a more proactive approach to motivate girls, even if it results in unequal treatment between boys and girls.

Samuels (1999) states that science teachers must first be aware of gender stereotypes and then must constantly work at not reinforcing them. She goes on to say that this can be done by providing students a choice of activities that are free from sex role stereotypes and by encouraging them to choose activities that interest them, whether or not the activities conform to what society thinks is gender appropriate. Teachers must also always try to make valid efforts at encouraging girls' involvement in class discussions and finding examples of both male and female scientists (being certain to mention both first and last names so students do not assume they are men) within each discipline.

Many studies have shown that teachers interact differently with male and female students to the females' disadvantage (see, for examples, Greenfield, 1997; Iriarte-Gross, 1998; Peltz, 1990). As Subrahnanyan and Bozonie state, "Boys get more attention, they get more praise and encouragement to perform, and they are more often challenged with higher order questions" (p. 4). Teachers should make authentic efforts to call on girls more often, and encourage them to get involved in class activities and discussions.

Spear (1987) conducted a study that indicated that because "low teacher expectations exist, female students are more likely to develop the feeling that they either do not belong in science or cannot achieve at science," and as a result, many talented young women leave science education (as cited in Mayberry, Welling, Phillips, Radeloff, & Rees, 1999, p. 4). It is imperative therefore, that teachers and counselors develop high expectations especially in association with the academic achievement of female students of science.

Teachers should also monitor the language they use in the classroom with students to be certain it is non-sexist. It is imperative that science teachers avoid use of the male pronoun to refer to both men and women, and try to use the term humankind rather than mankind (Samuels, 1999).

Davis (1999) interviewed three women scientists and found that "teachers greatly impacted the formation of their self-image and career choice" (p. 138). She further elaborated that the women scientists she interviewed "believed that their teachers assisted them as students entering scientific careers and changed their lives" (p. 138). Stanton-Salazar, Vasquez, and Mehan (1995), refer to the instrumental role of educators as "institutional agents" who should provide resources, channels and other forms of support to women interested in science and should guide these women toward pathways around career and educational obstacles. Hence, teachers must always be door openers rather than gatekeepers toward women pursuing science careers.

Guidance counselors must also be careful to encourage girls who are interested in science to pursue science-related careers. Davis (1999) conducted another study that indicated the influential roles played by guidance counselors as additional door openers to science careers for young women.

It is clear that teacher behavior influences student performance. Therefore, in the case of girls, science teachers should make every effort to provide them with a "safe" and inviting classroom atmosphere, one in which they are comfortable engaging in discussions, answering questions, and taking part in activities.

The Role of Parents in Motivating their Daughters in Science

Numerous researchers have conducted studies that show parents, more than anyone or anything else, have the greatest influence on their daughter's lives and choices (See, for examples, Hammrich, 1997; Jordan, 1999; New England Consortium for Undergraduate Science Education, 1996; and Samuels, 1999).

Wasserman (2000) presents a series of interviews with all 86 living female members of the National Academy of Sciences. In one interview, Margaret Kidwell, a geneticist and population and evolutionary biologist replied in this manner when asked about the early influences in her life that led to her career as a scientist:

> I think my family background had a big influence. I grew up on a farm in England and I was the eldest of two girls, and there weren't any boys. I just loved farming and helped my father a lot…I developed a lot of independence and self-confidence and learned how to work in a whole range of activities, including driving a tractor by the time I was 10 years old. (p. 104

Ruth Patrick, a distinguished limnologist had this to say when Wasserman asked her to relate the contributing factors to her ultimate success as a scientist:

> One was my father, who, from the time I was about six years old, encouraged me in the study of the natural sciences. Every Sunday afternoon he would take my sister and me with our little baskets and bottles out for an expedition. An expedition was going to the woods, where we would collect the flowers and the ferns and the mushrooms and the worms and the snails and all living things that little girls would be interested in or should be interested in… He had four microscopes, and he would put out the appropriate one for what we were going to examine. He would make the slides and tell us what the things were: the protozoa, the nematodes, and the different kinds of algae. (pp. 37-38)

Physicist Mary K. Gallard also credits her parents with contributing to her success as scientist when she states:

> I think family is part of it. I grew up at a time when it was very rare and unusual to go into science. My family was an academic family. My mother had been a teacher and a girl's counselor. She did not have a real career, but she always worked, more or less. My father never treated boys differently from girls. (p. 128)

And finally (although there are many more examples) Wasserman also interviewed Pamela Matson, a biogeochemist who likewise credited her parents for her scientific success:

> They gave me self-confidence through my whole childhood and young adulthood. My parents were supportive without pushing anything... I decided that I liked biology when I was very young. My grandmother was my mentor. She used to take me out walking in the forests of Wisconsin, and we would pick spring flowers. I loved spring flowers, and I always wanted to know about them and why they grew in certain places. By the time I got into high school I knew I wanted to be a biologist. (p. 164)

Parents may also have a negative impact on the scientific achievement of their daughters. A British study indicated that parents expect less from their daughters academically, than they do from their sons, and this difference is noticeable as early as the first grade (Entwisle & Baker, 1983). According to Pattatucci (1998), "Parents often subtly, or perhaps not so subtly, channel their sons toward, and their daughters away from, academic study and activities that would encourage interest and potential success in scientific-oriented endeavors" (p. 3).

CHAPTER III

CONCEPTUAL FRAMEWORK OF INQUIRY: HERMENEUTIC PHENOMENOLOGY

According to Van Manen, (1990) "qualitative research (*qualis* means 'whatness') asks the *ti esten* question: What is it? What is this phenomenon in its whatness?" (p. 33). Denzin and Lincoln (1990) state, "qualitative researchers stress the socially constructed nature of reality, the ultimate relationship between the researcher and what is studied, and the situational constraints that shape inquiry" (p. 8). They further elaborate that qualitative researchers "seek answers to questions that stress how social experience is created and given meaning" (p. 8). My study seeks to hermeneutically interpret the phenomenologically lived motivational experiences of female scientists within the social-historical context of their educational development.

Marshall and Rossman (1999) state that the purpose of phenomenological interviewing is "to describe the meaning of a concept or phenomenon that several individuals share" (p. 112). The particular type of interview used in this study focused on the past experiences of the informants. But before the interviews began, as a phenomenological researcher, I first wrote a full description and interpretation of my own past experiences regarding gender perception, science experiences, and social interactions across the three developmental periods already mentioned. Marshall and Rossman refer to this initial phase of the inquiry as *epoche.* They state, "the purpose of this self-examination is for the researcher to gain clarity from her own preconceptions" (p.113). Patton (1990) describes the second phase (known as *phenomenological reduction*) as the phase in which the essence of the phenomenon is identified. At this point, the researcher identifies emerging themes that describe the "texture of the experience" (Creswell, 1998, p. 150). Creswell next identifies the final stage as *structural synthesis*. In this stage, "all possible meanings and divergent perspectives" (p. 150) are explored and ultimately a picture of the essence and deep structure of the phenomenon emerges.

Phenomenology: Conceptual Framework

For several reasons, I chose to approach my research study from a hermeneutic phenomenological world-view. Nietzsche once said, "Whoever is searching for the human being first must find the lantern" (Buytendijk, 1947, p. 185). Nietzsche was referring to the Greek philosopher Diogenes' fruitless quest to find a real human being in broad daylight with a lantern. When Diogenes explained to curious bystanders that he was looking for real humans, they laughed and pointed to themselves, at which point he chased them and shouted that he only wanted **real** human beings (Van Manen, 1990). According to Van Manen, Diogenes' actions brought some people to reflect upon the following questions: "What is the nature of human beings? And what does it mean to ask this question?" (p. 5).

According to Van Manen, research from a phenomenological point of view "questions the way we experience the world, to want to know the world in which we live as human beings" (p. 5). Therefore, "the act of researching – questioning – theorizing is the intentional act of attaching ourselves to the world, to become more fully part of it, or better, to become the world" (p. 5).

Brief Historical Development of the Philosophy of Phenomenology

According to Kerry and Armour (2000), phenomenology arose as a specific philosophical approach out of the works of German philosopher Edmund Husserl (1859-1935). Husserl based this new philosophy on his belief that humans should be characterized as "open and engaged beings capable of developing personal meaning in the process of actively manifesting themselves" (Meier, 1988, p. 92). Kerry and Armour (2000) state that "phenomenologists advocated a presuppositionless approach, whereby nothing is taken for granted, and going back to the things is essential" (p. 3). Koch (1995) further describes phenomenology as "the study of phenomena as they appear through the consciousness" (p. 828). This immediate conscious experience of things is not based on the intervening suppositions of pre-established formal theories. Hence, phenomenologcial studies do not attempt to validate formal theories but rather seek to explore experience.

The phrase "lived experience" was coined by Husserl. He believed that one must revisit previous taken-for-granted experiences, reevaluate them, and thus illuminate the "structures of the consciousness (essences)," ultimately critically evaluating the purposes the structures hold in making sense of it all (Koch, 1995, p. 828).

Husserl specifically described his new philosophy of phenomenology as transcendental phenomenology because he sought an intuitive understanding of the essence of the phenomenal world that transcended or was independent of the context and the biases of the observer. In order to achieve subjective transcendence, Husserl believed that observers needed to "bracket" or suspend (also called reduction) their subjective biases that might interfere with a pure understanding of the phenomena (Kerry & Armour, 2000). This transcendental view of the essence of phenomena is fixed; it does not allow for the social construction of the phenomenal world, which includes the development of career and gender identities. This inherent limitation of transcendental phenomenology is offset, however, by Heidegger's creative combining of hermeneutics with phenomenology.

According to Koch (1995), Heidegger, a pupil of Husserl, reacted against the transcendental nature of the essence of phenomena. He believed that the essence of phenomena could not and should not completely transcend the context of the phenomena or the observer's subjective biases. In other words, he did not think that "bracketing" or suspending initial biases was possible or completely desirable. Rather than trying to transcend our personal biases and the context of the phenomena, he proposed that we "interpret" the essence of the phenomena in light of the context of the phenomena and that our personal biases are a part of that context (Koch, 1995).

In other words, he added hermeneutics to phenomenology and "hermeneutical phenomenology" was born (also called existential phenomenology). However, by adding hermeneutics to phenomenology he changed the original meaning of hermeneutics. Originally, hermeneutics was a process of interpreting the hidden meaning of a text such as the Bible (Van Manen, 1990). This was an "epistemological" process of coming to know or uncover the hidden meaning of the text. Heidegger expanded the meaning of the interpreted text to include the phenomenal world (the whole world of subjective experience, not just trying to understand books). The phenomenal world of experience is a text in need of interpretation. So hermeneutics is more than an epistemological (knowledge) process of knowing the essence of a phenomena; it is an ontological (being) process of encountering and constructing the phenomenal world. Furthermore, when we interpret the text of the phenomenal world, we reconstruct our identity and our way of being in the world (Van Manen, 1995).

Hence, interpretation is more than a way of knowing – it is a mode of being. Our interpretations of our personal stories are more than head knowledge, they constitute our being or our identities. We are who we interpret ourselves to be; we are defined by our personal stories. The interpretations of our stories open up new possibilities for being in the world because they redefine our identities. Furthermore, the social-historical context plays an essential part in the interpretation or construction of our identities.

Hermeneutics

According to Van Manen (1990), "hermeneutics is the theory and practice of interpretation" (p. 179). Abrams (1993) stated "the aim of hermeneutics is to establish a general theory of 'understanding' as opposed to explanation" (p. 91). For Heidegger (1962) the notion of hermeneutic understanding was the ability to understand one's own possibilities for existence in the world. Furthermore, Eger (1993) also stresses that understanding the meaning of a text is not a "fixed target," or pre-existing, rather it "emerges from the interpretation"; it is a constructed path (p. 7). Herein lies the importance of identifying the forestructures or preunderstandings belonging to the interpreter of a text. Eger states that forestructures "cannot just be cleared away but must themselves become a focus of inquiry…not so much to purge them as to understand their effect" (p. 7).

The process of interpretation and understanding is a hermeneutic circle according to Heidegger (1962). Heidegger states, "Any interpretation which is to contribute to understanding, must already have understood what is to be interpreted" (p. 194). In other words, you cannot understand the parts of the text without understanding the whole. Likewise, you cannot understand the whole of the context without understanding the parts of the text. Thus, to interpret the essence of a text, one must examine the context and history of the text (what led up to the formation of the text), and to understand the historical context, one must understand the meaning of the present text. So the process of understanding is circular and continuous; it is also creative and constructive.

The Hermeneutical Circle

Eger (1993) provided an excellent description of the hermeneutic circle when he stated:

> Start with some original "projection" or "preconception" for the text as a whole – a guess, a hunch, a prejudice carried over from previous readings – use that to make sense of the smaller parts of the text, and then see whether all these partial meanings, taken together, reinforce the original projection in a consistent way. It is important to note that although preconceptions may be deliberate, often they are unconsciously or "tacitly" adopted. This is likely to be so especially when it seems that the individual parts are clear enough, and no special assumptions need be made. In any case, one usually finds that the parts so interpreted *do not* in fact add up harmoniously; some discrepancy remains. Using this "remainder" to correct the original projection, we start the cycle over again, and then again, and continue in this way, in a series of back-and-forth movements between the part and the whole. (p. 6)

Eger (1993) further elaborates that with each reiteration of the cycle, convergence increases. In other words, the changes should be decreasing and the circle should be shrinking as the cycle repeats itself time and time again. Eventually according to Eger (1993), "in the classic view, the *true* meaning of the text is being approached as, step by step, we purge our interpretations of all spurious and subjective factors" (p. 6). It is important to stress that the hermeneutic circle may not shrink to the same point for different interpreters. In fact various interpreters may arrive at decidedly different points as they interpret an identical text. Therefore, according to Eger (1993), it is possible that "multiple interpretations can coexist, and no test can really decide among them" because in the process, the interpreter becomes a part of the interpretation (p. 10).

This process of interpretation is a creative circular process (hermeneutical circle) of understanding the meaning of the phenomena or the text (scientists' stories) in light of the social-historical context and also understanding this context in light of the text. In other words, the textual parts must be interpreted in terms of the contextual whole and the contextual whole must be interpreted in terms of the textual parts. The text is co-constituted (or co-constructed) by the context and the context is co-constituted (or co-constructed) by the text.

The important point is how we enter into this hermeneutic circle of interpretation. As I understand it, we (researchers) need to seek an empathetic interpretation of the text by placing ourselves within the context instead of trying to bracket ourselves out of it. According to Van Manen (1995), we are a part of this context but at the same time we must not impose our interpretations on the respondent. We must seek an "authentic encounter" (be honest about our perceptions) with the text and personally identify with the lives of the female scientists instead of pretending to be detached and totally objective.

We become a part of the hermeneutical circle of interpretation and become co-interpreters or co-constructors of the storied text. This text constitutes a record of the motivational development of the career and gender identities of the scientists and our selves (researchers). As we co-interpret the stories of the female scientists, we co-interpret our own story. As we discover how the female scientists developed their identities, we discover our own identity.

The hermeneutic circle of interpretation is the most challenging part of hermeneutic phenomenology to understand and implement. Very few writers clearly explain how to creatively enter into this circle of interpretation. Gadamer (1976) likens this to a "fusion of horizons." The researcher and respondent must achieve a fusion of their interpretations of the text in a way that enriches and leads to new discoveries about their identities that surprises both. This co-interpretation of the text should reveal new possibilities for becoming and being in the world.

Gadamer (1975) maintains that the researcher's pre-conceptions (forestructures) make up his or her "horizon," which he defines as "the range of vision that includes everything that can be seen from a particular vantage point" (p. 269). The researcher's horizon includes the range and limits of his or her visibility (Eger, 1993). The text also has a "horizon" according to Eger (1993) that contains a limit to the meanings that can arise from it. The interplay between the researcher's horizon and the text's horizon plays an instrumental role in understanding the text. According to Eger (1993), both the horizons of the researcher and the text must overlap to some degree so that the projections belonging to the researcher "fall within the realm of the text's potential meanings," which allows the text to speak to the researcher, expanding his or her field of vision, "to a point where the two horizons are said to have fused" (p. 14). Gadamer (1975) calls this "fusion of horizons" the point where insightful understanding takes place. The "fusion of horizons" takes place when the interpreter meaningfully interacts with the text, or engages in "dialogue" with the text (Eger, 1993).

By engaging in dialogue with text, the researcher acknowledges the potentiality of a "thing" as text with characteristics that make it have meaning and allows it to "speak" (Eger, 1993). Eger also states that the same holds true for other "things" not of human creation, such as trees, stars or molecules. As an example of the interaction between a researcher and a thing, Eger mentions geneticist Barbara McClintock's work with corn. In her research, McClintock emphasizes the importance of listening to the material to "hear what the material has to say to you" and "to let it come to you" (as cited in Eger, 1993, p. 16).

There is also danger in the researcher imposing his or her forestructures upon the text or "thing" being investigated. As an illustration of the imposement of forestructures, McClintock, when speaking of other geneticists who ignored her work, stated

> [Anything else it tells them] they don't really recognize as there, or they think it's a mistake and throw it out...*if you'd only just let the material tell you.* (Keller, 1983, p. 179)

According to Eger (1993), in the above passage, McClintock points out that there is no dialogue taking place between the scientists and nature, rather "dialogue between the scientist and nature turns into a *monologue*, the scientists speaks, nature hardly murmurs" (p. 16). McClintock further elaborates, "the work is done because one wants to impose an answer on it.... They have the answer ready, and they [know what they] want the material to tell them" (Keller, 1983, p. 179). These scientists are merely trying to confirm their pre-established hypotheses (hypothesis-testing); they are not open to discovering new, more useful hypotheses (hypotheses-generation).

It is also important to note that hermeneutics helps phenomenology to avoid the limitations of transcendental subjectivism by including the social-historical context of the respondent and the researcher. Furthermore, phenomenology helps hermeneutics to avoid the limitation of merely interpreting written books by expanding the meaning of the text to include lived experience.

Merleau-Ponty (1962) described phenomenology as "the study of essences" (p. viii). Van Manen (1990) states that what Merleau-Ponty meant by his definition is that "phenomenology always asks the question of what is the nature or meaning of something" (p.184). According to Van Manen (1990), the work of phenomenology "does not produce empirical or theoretical observations or accounts. Instead, it offers accounts of experienced space, time, body, and human relation as we live them" (p. 184). Thus, phenomenology seeks to find meaning in human experiences.

Van Manen (1990) stresses the need to not associate essence with mystification. He states, " the term 'essence' may be understood as a linguistic construction, a description of a phenomenon" (p. 39). To linguistically capture the essence of a phenomenon, the lived experience must be presented to the reader in such a way that he or she is able to comprehend the experience in a new light. Van Manen describes the phenomenological inquiry as similar to "an artistic endeavor, a creative attempt to somehow capture a certain phenomenon of life in a linguistic description that is both holistic and analytical, evocative and precise, unique and universal, powerful and sensitive" (p. 39). Thus, a phenomenological inquiry questions "the essential nature of a lived experience: a certain way of being in the world" (p. 39).

Willis (1991) states that the nature of the phenomenological inquiry allows for delving into the primary perceptions associated with human experiences. Willis goes on to say that not only does phenomenological inquiry require the researcher to explore the individual life-world perceptions of the participants, but it also requires the researcher to examine and present her or his own life world perceptions.

Hermeneutic Phenomenology

Once the phenomenological descriptions are put forth, they are subject to interpretation and thus the inquiry becomes hermeneutical (Willis, 1991). In fact, Willis maintains that phenomenology and hermeneutics go hand in hand – once lived experiences are considered, then they immediately begin to be interpreted. Furthermore, Schleiermacher (1977) stressed that without hermeneutics, the possibility of misunderstanding the lived experiences increases.

Phenomenology is not factual in nature; instead it seeks to ask, "What is the nature of the phenomenon as meaningfully experienced?" (Van Manen, 1990, p. 40). Therefore, it is not enough to simply relive and retell past experiences regarding a particular event or phenomenon. Rather, the phenomenological inquirer must explore the past experience in such a way that "the essential aspects, the meaning structures of this experience as lived through, are brought back, as it were, and in such a way that we recognize this description as a possible experience, which means as a possible interpretation of that experience" (Van Manen, p. 41). Furthermore, Hein and Austin (2001) state, "hermeneutic phenomenological research results are themselves texts, descriptions offered as insights, not as replicable results of structural analysis. The researcher aims to create a rich, deep account of a particular phenomenon, an uncovering rather than an accurate analysis of participants' descriptions" (p. 9).

Research from a hermeneutical phenomenological stance is unique in that it does not allow the researcher to separate and set aside his or her personal experiences, perspectives and assumptions. Rather, the hermeneutical phenomenological researcher must acknowledge his or her experiences, theoretical commitments and presuppositions, making them explicit in the study (Hein & Austin, 2001).

The Hermeneutic Circle and Women in Science

In first sharing their lived motivational experiences with the researcher in this study, the women participants developed understandings of the historical steps they took that ultimately led to careers in science. As the women read the transcripts of their stories and further reflected upon their experiences with the researcher, their understandings and interpretations of the events evolved. Eventually, following the hermeneutic circle, the participants revisited their initial reflections to see if they held the same meanings at the end of the study as they held at the beginning of the study. The participants also revisited or reconstructed early motivational experiences and reflected on what those experiences meant to them as children and to them at the time of the interviews. Many of the participants came to discover through the interview process that these early motivational experiences were more important to their becoming scientists than they had previously realized. They also began to reevaluate or reinterpret their current identities as female scientists in light of their past motivational experiences and in turn they began to reinterpret their past motivational experiences in light of who they have become (this is the hermeneutic circle). The process of reinterpretation or reevaluation is critical, for according to the French philosopher Roland Barthes (1977), if one does not revisit or reread, one is condemned to read the same story everywhere. In other words, without interpretation of the text, the text becomes relativistic; anything at all can be read into the text (Hoy, 1982).

The journey toward becoming a scientist--as made by each of the participants in this study--is a process of the social construction of the identities of the participants, both as scientists and as women. Making sense of the journeys of the individual women scientists in this study involved the dynamic process of exploring what each motivational step of the journeys meant to the conscious and unconscious goals of becoming scientists.

The hermeneutic circle presents itself in this study as the lived experiences of seven women scientists, which are explored and interpreted in terms of a historical journey or record. As the participants shared their lived experiences with the researcher, the participants reconstructed their journeys. As the women scientists worked together with the researcher to construct interpretations of the lived experiences, they became co-constructors in the understanding of how the journeys to science careers are navigated. To understand the relevant steps of the journeys taken by the women scientists (from girlhood to present), the researcher and participants explored the greater historical contexts (the previous relevant experiences of the women scientists) along with the meanings of their present lives as women scientists. This is a part of the hermeneutic circle. It is important to note that this circle is not a vicious one, but rather according to Heidegger (1962), "In the circles is hidden a positive possibility of the most primordial kind of knowing" (p. 195). For according to the hermeneutic circle, life and early experiences are continually being interpreted and reinterpreted in light of new developments and the new developments are continually being interpreted in light of the history of early experiences. This hermeneutical circular interpretation involves both forward and backward causation or what amounts to a constructive circular causation (Hoy, 1982).

CHAPTER IV

METHODOLOGY DERIVED FROM HERMENEUTICAL PHENOMENOLOGY

Hein and Austin (2001) maintain that phenomenological research does not require the use of a specific method. Phenomenological inquiries allow the researcher to adapt a research method to " his or her own specific skills and talents, and to the nature of the research question and data collected" (p. 3). They further elaborate that the chosen research method "should be viewed as providing only a general guideline--one that the researcher then modifies to meet the particular needs of the study" (p. 3).

Participant Selection Criteria

I chose to interview (in-depth) seven women who hold doctorates in the hard sciences of biology, chemistry or physics and are employed either full time as research scientists, or half time in research and half time with either business or faculty positions. These women were chosen because they are typically involved in conducting formal research in the hard sciences. The women interviewed were located in south Georgia (since this the area in which I live) at two area universities. All of the participants are actively involved in science research (i.e., they are currently working on a scientific problem in which data is systematically collected and evaluated).

Data Collection Methods and Instruments

Semi-Structured Interview

The primary method employed in my study for collecting empirical materials is the semi-structured interview. According to Van Manen (1990), in a hermeneutical phenomenological inquiry, the interview serves to provide a means by which spoken material can be gathered and explored and serves as tangible resource for grasping a deeper "understanding of a human phenomenon" (p. 66). It also serves as a means by which the researcher can develop a conversational relationship with the respondent. I used a tape recorder to record my informants' recollections of their lived experiences. All interviews were transcribed for analysis.

Interview Questions

Specific interview questions were derived from the central research question about the women's motivations to become scientists and its three subdivisions: science experiences, social interactions, and gender perceptions (see appendix A for an organized list of specific questions).

The primary research question was as follows: How do female scientists interpret the encouraging and discouraging influences of science experiences, social interaction, and gender perceptions on their motivation to become scientists across three developmental periods (preschool to elementary, middle to high school, and undergraduate to graduate school)? This primary question was subdivided into secondary questions by the motivational influences of science experiences, social interactions and gender perceptions:

I. How do female scientists interpret the encouraging and discouraging influences of formal and informal science experiences (such as playing with science toys, exploring nature, experimenting, having science-related hobbies, participating in planned science activities) on their motivation to become scientists across three developmental periods?

II. How do female scientists interpret the encouraging and discouraging influences of social interactions (with parents, relatives, teachers, counselors and others) on their motivation to become scientists across three developmental periods?

III. How do female scientists interpret the encouraging and discouraging influences of gender perceptions (such as sex role stereotyping, gender bias, gender preference) on their motivation to become scientists across three developmental periods?

Forestructures

According to the tenets of contemporary hermeneutical philosophy, researchers are obligated to make explicit any forestructures (preunderstandings) they hold pertaining to the phenomenon under investigation (Geanellos, 1998). Preunderstanding is a probe for beginning the research for a more complete understanding; it is the researcher's initial beliefs and preliminary understandings of how he or she thinks the research questions might be answered prior to conducting the research. The success of the research is measured by how much we have expanded and refined our preunderstandings (Eger, 1993).

Failure to address forestructures places the researcher at risk of uncovering his or her own truths rather than the truths of the participants in the study (Geanellos, 1998). In fact, Gadamer stressed the importance of proclaiming forestructures when he stated "it is always part of understanding that the view that has to be understood must assert itself against the power of those tendencies of meaning that dominate the interpreter" (as cited in Geanellos, 1998, p. 238). The exposition of the researcher's preunderstandings helps to safeguard against unconsciously imposing the researcher's view on the participants. It also allows the reader to understand the researcher's standpoint on the research questions. Furthermore, Heidegger (1962) believed that it is not possible for researchers to enter into the hermeneutic circle without first identifying and explicitly proclaiming personal forestructures held concerning the investigated phenomenon. According to Geanellos (1998), forestructures consist of:

> (i) forehaving, background practices from the lifeworld which make interpretation possible;
>
> (ii) foresight, background practices that carry with them a point of view from which an interpretation is made;
>
> (iii) foreconception, background practices that create expectations about what might be anticipated in an interpretation. (p. 241)

It is extremely important to a hermeneutic inquiry that the researcher become conscious of any pre-understandings he or she holds concerning the phenomenon to be explored before the investigation commences. Gadamer (1987) states that all "textual interpretation must begin then with the interpreter's reflection of the pre-conceptions which result from the hermeneutic situation in which he (or she) finds him (or her) self" (p. 130). Eger (1993) stated, "no longer may preconceptions be regarded as something merely negative, since in effect they are part of the 'seeing' (interpreting) apparatus without which nothing at all can be seen" (p. 8).

Researcher's Forestructures

In order to become aware of the ways in which I might influence information-gathering in this study, I will now attempt to identify and make explicit the forestructures (pre-understandings) I hold with regard to the motivational influences that I believe encourage or discourage women to pursue a science career. These forestructures were made explicit by reflectively answering the same interview questions given to the participants (this self interview can be found in appendix E). These questions allow me to address my preunderstandings concerning the three motivational influences that composed the primary research question: gender perception, science experiences, and social interaction. The identification of the relevant forestructures also allow me to not only situate myself within the phenomenon being studied, but it also sanctions the examination of my own life world perceptions so that I might relate them to the life world perceptions of the participants of the study.

I chose the three motivational influences of gender perception, social interaction and science experience based on my literature review and based on my personal, educational and teaching experiences. From my own experiences and from my literature review, I found that the motivational influences of the general categories of gender perception, social interaction, and science experience seem to include all of the subcategories of encouraging and discouraging factors affecting women's selection of science careers.

In appendix E, I expound upon how I interpret the influence of gender perception, social interaction, and science experiences on my motivation to pursue science and become a science teacher. I further identify some of the important themes (as exemplified by pivotal experiences, crystallizing moments, encouraging or discouraging experiences) of my own experiences and explain how they have shaped who I am and what I believe is important about science motivation.

By conducting this personal interview, I gained many important insights about my preconceptions and personal beliefs concerning how these three motivational factors affected my pursuit of science. Several themes emerged (from my personal interview) within the three categories of science experience, gender perceptions and social interactions.

One of the emergent themes from my own experiences with science was "an interest in nature and the outdoors" as exemplified by the enjoyment I experienced camping, fishing and caring for the animals on our family farm. "The stimulation of hands-on experiences and physical demonstrations" provided by my third grade teacher and my high school and college science instructors was another theme that emerged from my self-interview. "Experimenting with science" was an additional theme identified from my self-interview within the category of formal and informal science experiences. The earliest experiences I had with science were those early informal "experiments" that I performed with household materials in our family's bathroom. Experimenting with those chemical reactions piqued my interest in science and motivated me to read more about science. Certainly, I would consider these experiences as serious-fun experiences since they exemplify the simultaneous integration of seriousness and fun as described by Rea, Millican and Watson (2000). Therefore, from my own experiences, I agree with the numerous studies that have shown that girls will be motivated to succeed in science when science is made interesting to them (see, for examples, Glaton, 1981; Kahle, 1990; Samuels, 1999; Yager & Penick, 1986).

In fact, as a science educator with ten years of high school science teaching experience, I feel confident in stating that girls can become excited about science if science is made intriguing to them and if they are encouraged to participate in and excel in science. Teachers must foster science confidence in their female students and dispel anxiety by providing noncompetitive, collaborative, yet stimulating learning environments. In fact, I credit my high school biology teacher with getting me excited about science through the fun and interesting science experiences he provided for his students both in the classroom setting and outside in the surrounding woods and fields of rural Kentucky. Those moments spent engaged in serious science fun in his biology class were instrumental in my decision to major in biology in college.

Another theme emerged from my personal interview within the category of gender perception: "discouragement by others who perceived science as a masculine activity." When my brother received the chemistry set that I wanted for Christmas, I experienced the consequences of being forced to accept the cultural attributions associated with femininity as assigned to girls by society. Clearly, my mother wanted me to assume the attributions associated with femininity, which did not include the masculine traits often linked with science and scientists. Because I was discouraged at an early age from pursuing the traditionally masculine endeavor of science, I experienced frustration and disappointment. I was taught that my interest in science conflicted with the contemporary values society uses to divide boys and girls. Another example of "discouragement by others who perceived science as a masculine activity" emerged within the category of gender perception when I experienced the frustration of attempting to assume a position incongruent with the roles ascribed to my gender when I was denied a job as a health environmentalist because of my sex. That incident left me feeling angry, frustrated and oppressed. That was the first time I had experienced economic oppression because of my sex. It was a disheartening and depressing event.

I now realize that gender issues have negatively influenced my science career aspirations throughout almost every developmental and educational stage of my life. For this reason, I maintain that one of the most destructive barriers faced by women and girls aspiring to careers in science, is the perceived masculinity of science and science careers. Therefore, it is imperative that educators and parents provide equitable science motivation for both boys and girls. As previously stated, the science teacher should opt for a more proactive approach to motivate girls, even if it results in unequal treatment between boys and girls.

Also within the category of gender perception, the following theme emerged: "confliction between my goals to have a family and pursue a science career." When I became pregnant I abandoned my quest to become a medical doctor because I did not believe that I could care for a baby and successfully pursue the rigorous coursework necessary to achieve a medical degree. No one encouraged me to continue with my studies and no one was available to offer childcare assistance. The sense of loss that I experienced as a result of the conflict between family goals and science career pursuits was injurious to my motivation to become a doctor. My self-confidence also eroded, and I felt like a complete failure.

My self-interview also provided a strong theme related to social interactions in science: "encouragement by significant others who believed in my science talents." The encouragement I received from my father in science in my later childhood and adolescence and as a college student and from several teachers from third grade through college was instrumental in my decision to select and persevere in a science discipline. When I reflect upon the past experiences of my life that were most influential toward my career choice, the interactions with people in science are the most significant experiences that come to mind. Many of my first experiences with science took place because someone cared enough to provide them for me and took the time and initiative to encourage me in an area traditionally viewed as incongruent to my gender. I will never forget the personal encouragement my high school biology teacher, Mr. Scott, provided to me when I expressed to him an interest in pursuing a career in science. He had no doubts that I could be successful majoring in biology in college; his confidence in my abilities served to motivate me and encourage me to continue with my studies in science. Hence, as stated elsewhere in this paper, teachers can be door openers or gate-keepers to girls interested in pursuing science careers. Fortunately, my high school science teacher was an extraordinary science door opener.

Another theme that emerged from my personal interview was also related to social interactions in science: "the importance of female science role models." There was an obvious lack of women in science in my life who could have acted as role models. But the female physics and astronomy professor at my university was one woman with whom I identified with positively as a role model in science. She was a living, accessible example of a woman successful in science research. She was also a caring and approachable teacher. When I met her and interacted with her, I realized that I could also succeed as a woman in the sciences.

"The significance of individual mentors in science" was an additional theme that emerged within the social interactions category. Some of the most encouraging moments

I experienced in science were those moments I spent as a co-researcher with some of my professors at my university. Collaborating with an experienced scientist on an individual basis made me realize that I was acquiring the science skills and the knowledge base necessary to succeed as a scientist conducting research. Many of those experiences, such as using an electron microscope to take pictures of microscopic structures and then developing and enlarging those photographs provided me with a sense of accomplishment and pride in my scientific abilities. To this day, I use some of those photographs when I teach the cell's structure to my biology students. They are always impressed that I took them and developed them myself.

Data Collection Procedures

Three of the women participants were located through university web sites, the other four were referred to me by the first three women. I initially contacted the women through email correspondence. In this initial correspondence, I included the information found in the cover letter in Appendix C. Upon agreement of participation in the study, the interview questions in Appendix E were emailed to the women so that they might have time to think back to childhood, as some of the questions required them to do. Each participant also received a pre-interview information request form (Appendix F) via email. The purpose of this form was to gather preliminary information regarding job title, job description, vita (if possible), marital status, etc. By collecting this data prior to the initial interviews, time was saved.

The exact time and locations of the interviews were negotiated between the participants and the researcher; all of the interviews took place in the offices of the women participants. Marshall and Rossman (1999) stress the importance of the interview site being one in which “there is a high probability that a rich mix of the processes, people, programs, interactions, and structures of interest are present” (p. 69). Each participant signed a consent form (Appendix D) and all the participants were provided pseudonyms to protect their privacy. The lengths of the initial interviews were approximately one and one half to two hours. All interviews were audio taped and field notes were taken.

The women participants ranged in age from thirty years to approximately seventy years old (the oldest woman scientist did not wish to reveal her age). Six of the seven women had Ph.D.’s in some branch of chemistry while the seventh held a Ph.D. in microbiology. All of the women live and work in southeast Georgia, however, only two of the participants grew up in that area. Three women were raised in Pennsylvania, one in Ohio, and one in Michigan. Three of the women scientists participating in this study were married; four were single or divorced.

The semi-structured interview format is open-ended although some of the specific questions were planned in advance. The specific interview questions were designed to stimulate serious reflection on the part of the participants, not merely recollection of facts. Participants were prompted and allowed to tell fully developed personal stories about what encouraged or discouraged them to become scientists. According to Hein and Austin (2001), phenomenological research “involves the use of disciplined reflection, which represents a formalized version of the general human capacity to reflect on experience” (p. 15). As the interviews progressed, new questions were formulated based on the personalities of the participants, the experiences they offered, and time constraints.

All interviews were taped and notes were taken regarding the settings and the demeanor of the participants. Following the completion of the interviews, the tapes were transcribed. A copy of the initial interview was given to each participant by email for clarification and verification and also for revision and elaboration. Following the review of the initially transcribed interviews by both researcher and participants, a follow-up interview took place with each respondent via email. The purpose of the follow-up interviews was the clarification and verification of issues; they also allowed further interpretation and revisions and amplification of the meaning of the script. It is imperative that what was said by all informants in the initial interviews is consistent with what I recorded, as this is one indication of trustworthiness of the data.

Levels of Data Interpretation

The initial level of interpretation actually begins with the process of *conducting the interviews*. During this initial level of interpretation, the researcher and participant arrive at a mutual understanding (intersubjectivity) of what motivated the participant to become a scientist. According to Cohen, Kahn & Steeves (2000), the researcher then reads and re-reads the data several times; this is often known as "immersing oneself in the data" (p. 76). Further interpretation occurs as the respondent reviews and clarifies the interview transcripts. After the interpretive revision of the transcript, the researcher begins the second level of interpretation, which is the *thematic interpretation of all the transcripts* (Hein & Austin, 2001). Because the nature of my study lies within the subjective end of the continuum, I did not make use of a highly structuralized and categorized approach at data organization and interpretation. I read and re-read all finalized transcripts and searched for the emergence of categories of meaning. Guba

(1978) states, "as categories of meanings emerge, the researcher searches for those that have internal convergence and external divergence" (as cited in Marshall & Rossman, 1999, p. 154). Marshall and Rossman further elaborate that "Here, the researcher does not search for the exhaustive and mutually exclusive categories of the statistician but, instead, identifies the salient, grounded categories of meaning held by participants in the setting" (p. 154). Included in this analysis phase, was a period in which the data was reduced. Cohen et al. (2000) state,

> This step in data analysis involves some decision making on the part of the researcher concerning what is relevant and what is not....The researcher can re-organize the interviews to place together discussions of the same topic, eliminate digressions that are clearly off track, and simplify the spoken language of the informants without changing the unique character of it. (p. 76)

Hein (Hein & Austin, 2001) described her search for themes in a hermeneutic phenomenological analysis of an interview transcript. She read the complete text numerous times and then by "looking at words, phrases, sentences, blocks of dialogue, and the transcripts as a whole," she began to identify themes or constituents (p. 12).

Once the work of generating categories and themes from the collected data has been initially completed, the researcher then begins to *code those categories and themes*. Codes are used to mark passages in the data that has been gathered and categorized. I elected to use a color-coding process in which different colored hi-lighter pens were used to underline passages in the transcripts and field notes. According to Marshall and Rossman (1999), it is possible that as the process of coding continues, the researcher "challenges the understanding, searches for negative instances of the patterns, and incorporates these into larger constructs, as necessary" (p. 157).

In the last stage of interpretation, it is no longer necessary to include the participants, because once the information has been recorded and finally revised, the interpretation shifts from the participants to the researcher. The researcher attempts to then thematically organize the data in a way that is personally meaningful. Blending his or her forestructures with the script, the researcher creates a meaningful fusion of horizons. This fusion of horizons took place in this particular study in Chapter VI, where interpretations across individual women scientists took place.

The hermeneutical aspect of an inquiry is difficult to elicit. According to Hein and Austin (2001), "In phenomenological research, interpretation does not focus solely on the literal or explicit meaning of the words used by the participant. It goes beyond the surface linguistic and logical properties of the transcript to reveal implicit (or latent) meanings" (p. 14). According to Hein and Austin (2001), "meaning, as expressed in the researcher's description of the phenomenon, can be viewed as emerging from three principal sources: (a) the participant's meaning, (b) the researcher's meaning, and (c) intersubjective (or shared) meaning" (p. 14). It is also extremely significant that the inquirer now also critically challenge the patterns that seemed to have readily emerged and look for alternative explanations for their existence (Marshall & Rossman, 1999). At this point, I offered an argument as to why the interpretations arrived at by myself and the participants were the most plausible and meaningful explanations to me and what the implications of these interpretations might be for past and future research (Marshall & Rossman, 1999).

CHAPTER V

INTERPRETATION OF MOTIVATIONAL THEMES WITHIN WOMEN SCIENTISTS

Introduction

The purpose of this chapter is to provide a realistic context and background information for holistically understanding each interview. This holistic contextualization of individualized interviews of each of the women scientists who participated in this study also sets the stage for the thematic analysis of interviews across the participants that takes place in Chapter VI. In this chapter, readers are able to see the themes within the realistic context of an individual before the themes are abstracted across the group in the final chapter. Therefore, in this section I have provided organized narrative summaries of the stories offered by the seven women scientists participating in this study. The organized narrative summaries are structured according to the three categories of motivational themes: science-related experiences, science-related social interactions, and science-related gender perceptions that emerged from the motivational experiences shared by the respondents.

In this chapter, I will also attempt a blending of horizons between myself, as researcher, and each of the women scientists' stories so that a better understanding of the text might be reached. As Eger (1993) states, the "fusion of horizons" takes place when the interpreter meaningfully interacts with the text, or engages in "dialogue" with the text. The blending of horizons between researcher and text is characteristic of the hermeneutic phenomenological inquiry.

Dr. Scott

I was more than a little nervous when I met with my first participant, Dr. Julie Scott (pseudonym). Our appointment was set for 4:30 on a Monday afternoon and I had left early from my teaching job to drive to the university where she teaches from Jesup, Georgia where I live and teach at Wayne County High School. I pulled into the parking lot of the building that houses her office with about fifteen minutes to spare. In two tote bags, I had two audio tape recorders, a clipboard with the interview questions, extra batteries and tapes, and a gift for Dr. Scott. Her office was located on the second floor of a very old administrative building that adjoins the chemistry building on her university's campus. I remember the floorboards creaking as I made my way down the back hall toward her office. Numerous window-air conditioners were humming and I worried about the noise interfering with the tape-recording. Her door was open and I peeked in and knocked at the same time. Dr. Scott was sitting amidst a plethora of books, documents, and student paperwork earnestly writing in a very small cubicle that served as an office. She struck me as a very stunning young woman in a natural way with long, dark hair, a slim build, and a pretty smile. I introduced myself and she cleared a space for me to sit while I went about setting up my equipment and locating an electrical outlet for one of the recorders. She admitted to me that she had not read the questions that I had emailed her ahead of time and I realized that it would probably be more difficult for her to remember incidents from childhood right off the top of her head. Although I had already explained to her the nature of my research project via email, I reiterated the gist of what I was trying to accomplish and thanked her again for agreeing to participate. She seemed a little nervous too and I worried that I would not be able to get her to talk as much as I hoped. With the recorders on and my pen and paper at hand, we began the interview.

Biographical Information of Dr. Scott

Dr. Scott is an Assistant Professor of Chemistry at a medium sized state university in southeast Georgia. Her research interests are computer molecular modeling and lipid fluorescence. She obtained her B.S. degree in chemistry from Kutztown University in Pennsylvania and then she received her Ph.D. in chemistry from the University of Pennsylvania in Philadelphia.

Dr. Scott grew up in rural Pennsylvania where she attended elementary and high school. She spent a lot of time as a child visiting her maternal grandparents, who lived on a farm just a few miles away. Her father was a middle school band director and her mother did substitute teaching and was the organist at her church. She has one brother who is 21 months older than she is and she also has an additional younger sister and brother.

Science-Related Experiences of Dr. Scott

I asked Dr. Scott if she could recall some personal experiences with science in early childhood that may have motivated her to pursue science. She remembered one of the first science projects she had to do in elementary school was to collect leaves in the fall and classify them. They also rubbed a crayon over the leaves which were under pieces of paper to make impressions of them. She stated several times how much fun that particular activity was for her. When I asked what it was about it that she really liked, she said that it was probably the art, "That you could actually get the pattern to come out and it looked really neat." Then I asked if that experience helped her in any way with deciding to become a scientist. She replied:

> Well, if it did anything, it made me realize that I didn't want to classify things like that. Because I mean it's fun to look at stuff but it's more fun to watch it instead of naming it (pause) to just watch it, see what it does. (personal communication, J. Scott, October 22, 2001)

She also enjoyed "messing around" outside. Her mother's parents lived on a farm about a half-hour away from where they were and they had lots of farm animals and cats and dogs. She liked going over there because she enjoyed being around and interacting with the farm animals. She also enjoyed playing hide-and-seek and kickball outdoors in the summer. I identified with Dr. Scott's positive experiences with nature as I grew up on a farm and spent much of my time exploring and investigating the plant and animal life found within 100 acres of pastures and woodlands where I lived in rural Kentucky.

One Christmas she asked for a filing cabinet to keep her "stuff" in. And she also used to get the nature cards monthly through the mail that had pictures of different plants and animals and other organisms on them. She enjoyed reading about the different living things portrayed on the cards each month.

When asked what those experiences mean to her as she reflects upon them today she stated, "Well, I feel like I had a lot of opportunities outdoors. And I still love the outdoors. A lot of children I think today, don't get outside. They don't get to mess around and investigate things outside" (personal communication, J. Scott, October 22, 2001).

She also remembered the fun she had in ninth grade biology class and the success she enjoyed in biology and chemistry in high school. So the fact that she did well and understood what was going on in those science classes motivated her and encouraged her to continue doing well. I asked her how important it was that science experiences were made to be fun in junior high and high school and she replied, "Oh, that's the attraction…if it's fun, then you can learn something from it." Certainly the experiences I had in high school biology that were fun experiences are those that most motivated me to learn and later recall what I had learned.

As an example of a fun learning experience, Dr. Scott mentioned "messing around" with slide rules in high school chemistry. She had fun with the slide rule and she was good at it so she began helping others in her class. She also recalled several fun physics labs in high school including rolling balls down inclined planes to calculate speed and velocity. And in biology she recalled dissection as a enjoyable experience. So Julie enjoyed science when it was fun and when it interested her.

Science-Related Social Interactions of Dr. Scott

Dr. Scott could not recall any teachers who were particularly motivating in elementary school but she did like her high school biology teacher. She described him as "pretty laid back, and he was perceived by the kids in the class as a cool man." She went on to say that all of her teachers in middle school and high school were encouraging to her because she made good grades in all of the subjects. In high school, she worked with projectors and video cameras and often videotaped the basketball games for the school. So, as a college freshman, she had intended on majoring in telecommunications but all of the classes were full so she just took the required general education classes. It was not until the summer following her freshman year, when she was out in California visiting her uncles that she decided to be a physics major. Her cousin had graduated with a degree in physics and she really liked him because he seemed so relaxed and open and knowledgeable about how things worked, so when she got back to school she decided to try physics. But before she could take physics, she had to take chemistry and calculus. So she took chemistry and did really well in it and enjoyed it. She especially enjoyed the fun chemistry labs and she stated that those experiences were very important to her because "I didn't decide on science until I walked in the door of the college and dropped and added everything." What we next discussed was what was fun about the chemistry experiments to her and she mentioned the qualitative analysis ones in which you get color changes. She went on to say that she teaches in a similar way, saying, "I try to make it fun every time I walk in there." As a high school teacher, I also attempt to make learning fun as much as possible in the science courses that I teach. Countless former students have returned to me over the years to tell me how much they learned in my classes because of the way I incorporated fun into the lessons that I taught.

She did not have a good experience with her high school guidance counselor, however. She recalled:

> We had a very horrible guidance counselor at the high school level. I mean she was, she was about 65 years old, never married, never had any children. And like I said, I grew up in rural Pennsylvania and everybody was trying to go to Penn State. And if she didn't think you had good enough SAT's to get into Penn State, then you were going to apply to these other little schools, you know. And we really had (pause) I had very little option of what I was going to do if I wanted to go to college. She was like, well try this small college or try this school, you know. She gave me two options and handed me the forms and said, "Here, fill

> these out." You know (pause) and that was it. And it was like, okay, well I guess I'm going to try one of these schools. (personal communication, J. Scott, October 22, 2001)

Ironically, she got accepted into both of the schools she applied to. But the one she attended, Kutztown University, she attended because she was invited to be a part of the cross-country running team.

Dr. Scott's parents encouraged her to do whatever she wanted to do. They never told her she could not do anything. When asked which parent she identified with the most, she stated that she identified with her father because "he was mechanically inclined." It was his ability to build and interpret things that she was most interested in.

Julie remembered a group of friends in high school who were in all the same math and science classes and studied together. She had a male friend who she particularly liked to study with and they would "push each other," and in the yearbook they were each voted "most studious." He ended up also being a chemist who teaches in Pennsylvania.

In undergraduate school, she also partnered up with a young man who was in a lot of the same science classes she was in and she remembered studying quite a lot with him. So her peers were important to her as a support network and as a sounding board.

Even today, in her position as Assistant Professor of Chemistry, she still networks with others, particularly the other women in her department when she becomes discouraged. In fact, that is her primary method of dealing with discouragement she faces as a part of her job today. She stated, "There's some comfort in discussing it and having somebody say 'They're wrong.'"

Julie did not remember anyone trying to discourage her in her endeavors to become a scientist. In fact, she stated:

> If anyone ever told me that I couldn't do something, I probably didn't hear them....Maybe I have selective hearing or something but when I think about how I got to where I am, a lot of times I think I had a really smooth ride. (personal communication, J. Scott, October 22, 2001)

During her junior year of undergraduate school, a female chemist became a part of their faculty and she became Julie's advisor. Dr. Scott felt that she was very fortunate to have been given to this woman to be advised. She was excited about this woman at the time and she told me, "There's a woman who was teaching science, the first one I ever met, that was teaching chemistry!" She went on to say:

> she was very instrumental I think. Because when I went in to get advising, she was like, "Well, why don't you apply to graduate school?"....She helped me to write the letters and looked over the applications and stuff like that. So she was very (pause) I mean if you really think about women in science, the mentors really help people and that was part of why I'm here now. To try to give back some of that to my students now. It was really important for me to see that, you know, here's a woman doing what she wants to do. (personal communication, J. Scott, October 22, 2001)

Dr. Scott also credits this woman as having been her favorite teacher. She felt as though because this teacher was a woman, her mannerisms reflected her own mannerisms, she identified with her and was motivated by her more than any other teachers she had. She remembered the unusual way in which this teacher would swing her arms around in class and how she would move around the class and she liked the fact that it was okay for this woman to be who she was because it was her class and she was in charge of it. She went on to say that the other thing about this particular teacher was that she stayed at Kutztown University only two years:

> and she decided to go back to medical school.... So also in my mind it was like, gosh, she's doing whatever she wants. She has the smarts and she can do whatever she wants and she was doing it. (personal communication, J. Scott, October 22, 2001)

Science-Related Gender Perceptions of Dr. Scott

When asked if her gender made it harder or easier for her to become a scientist, Dr. Scott answered:

> I think if it was harder, it was harder at the undergraduate level. Because by the time I got to graduate school, I fell into what I think of as a lucky situation because I went into a graduate group that was almost all female. (personal communication, J. Scott, October 22, 2001)

Her comments made me wonder and then ask her if she had been in a minority as far as gender was concerned at the undergraduate level. She stated that yes she was, because there were only two girls in the group.

Dr. Scott also felt that her gender hampered her in some ways in her pursuit to become a scientist. She said,

> You see it more when you get to bigger meetings and stuff because the guys just have a different way of networking than women do. And you have to kind of figure out on your own how that is. The way they interact with each

> other....They're much more (pause) and it's not like they're shocking or anything, it's just the way they're used to interacting with each other is different than the way we're (pause), we don't want to say anything, step on anybody's toes or anything. And they don't care what they say...they just go out and say it and it works! And we don't do that kind of thing because we're just (pause) I don't know. The way we were raised and whatever. So that gets...you've got to be a little more aggressive. Especially when you go out to meetings and stuff. If you want to talk to somebody about science, just walk up to them and ask them something; it's just something that we're not used to doing. (personal communication, J. Scott, October 22, 2001)

She went on to say that women can learn to interact the way men do: "It's not necessarily something you have but you can learn."

When asked if she had ever experienced conflict between her self-image as a woman and her motivation to become a scientist, she felt as though she did in the beginning. When she was going through undergraduate and graduate school in the 80s the women scientists she had access to were older women who acted like "science nuns," a term she learned from a book she read entitled Molecules of Emotion by Candace Pert. These older women of science often acted "aggressive and...wear their hair in a bun or something, and I identified with them when I was reading that book. That these women existed, and they had to act very masculine to get where they were" (personal communication, J. Scott, October 22, 2001). She felt fortunate that times have changed and women her age do not necessarily have to do that. And she said she realized in graduate school when she was in this predominantly female group that "we were just going to do it our way and who was going to stop us?"

When asked if she had ever experienced conflict between her motivation to become a scientist and significant relationships with men, she recalled when she was married (she is now divorced) that there was "somewhat of an intellectual battle there." Her ex-husband was also a scientist, so that was helpful, but she said, "I always had the feeling that he was more intelligent than I was. I've since changed that opinion (laughing). I always had a little bit of an inferiority (pause) with that (pause) that he was smarter than I was" (personal communication, J. Scott, October 22, 2001). I asked why she thought she felt that way and she stated, "I think some of it was his pedigree. I wasn't the valedictorian of my class; he was. I went to a state school; he went to Notre Dame. That kind of thing."

Dr. Scott did not report any incidences of being discriminated against or being stereotyped as a woman in science.

I sent the transcribed interview back to Dr. Scott via email for possible changes she might want to make and for clarification purposes. I also asked her if by participating in the interview and reliving some of those experiences through the study it caused her to think of those motivational experiences in becoming a scientist in a different light. She replied, "Yes, it is good to reflect now and then about why you are in a position you are in." I then asked her if she had thought about it much before and she said that she had. In fact, she mentioned:

> I have been to several women in science symposia and meeting groups where this has been analyzed....In fact, I was actually a speaker at one in 1999. Where I used

to work, we hosted a symposia for some organization of Georgia Professional Women and my colleague, Jennifer Davis and I co-chaired a woman in science symposia entitled, "Women Meeting Science's Challenges in the 20th Century. (personal communication, J. Scott, November 20, 2001)

My last follow-up question asked her to reflect upon what reliving and sharing her motivational stories as a participant in this interview meant to her. She replied that "it is good to reflect, because it reinforces why you are where you are and why you are doing what you are doing, which is reassuring. If it's not, then one ought to change jobs or something."

Dr. Townsend

I was fortunate to have scheduled three interviews with women chemists on the same day at the same medium sized state university in southeast Georgia. So I took a personal day from my job and drove up to the university early in the morning to make my 8:00 am appointment with Dr. Jenny Townsend (pseudonym). Her office was located in a suite of offices on the third floor of the university's chemistry building.

Dr. Townsend's door was open and she was typing on her computer when I arrived. I was surprised to see how young she looked, probably in her late twenties I thought. She was well dressed, made up and had long blonde hair. She made me feel immediately welcome and I was relieved to sense that she was a talker and I felt that I would most likely not have any difficulty eliciting information from her. We spoke for a few minutes about a couple of students of hers who were former students of mine at the high school level. I was pleased that she had made an attempt to find out more about who I was and had gone to the trouble to ask her students from Jesup if they knew me. This gave us a connection, and I felt more comfortable interviewing her because of that. She had also taken the time to read the questions beforehand and had given them some thought. We had to rearrange a couple of her electrical cords to accommodate my recorder but we soon got the interview under way.

Biographical Information of Dr. Townsend

Dr. Townsend is in her second year as an Assistant Professor of Chemistry at a southeast Georgia university. She teaches two chemistry classes and also does research in bioinorganic chemistry. She attended undergraduate school at the same school where she is now employed and attended graduate school at the University of Alabama in Tuscaloosa. Following a two-year stint as teacher and general laboratory coordinator at Washington and Lee University in Virginia, Dr. Townsend taught for one year at the University of Georgia. She is thirty years old.

Jenny Townsend was an only child who grew up here in south Georgia. Her mother and father ran a Western Auto store in a small southern Georgia town while she was growing up and then later, when she was nineteen years old, they both became high school teachers. Her mother taught math and her father taught history and then eventually he became an educational administrator.

Science-Related Experiences of Dr. Townsend

Several generative themes appeared within the area of science-related experiences in the story Dr. Townsend related to me. When asked about any early experiences with science that motivated her, she was very quick to mention a chemistry set that she had received for Christmas while she was in the second grade. Her mother claims that she begged and begged for that chemistry set until she finally got it, although Jenny has no recollection of pleading for it. She said that it came with lots of different chemicals, equipment and instructions to make several things. She became animated and excited when she described the activities that she engaged in as a result of receiving that chemistry set: "I used that stuff up! I made hand lotion. I made all sorts of things. I even did something to our cat. I put something on the cat and she lost her hair" (personal communication, J. Townsend, November 5, 2001). It was clear to me that those experiences were fun learning experiences that she engaged in because of her own intrinsic curiosity about science. Later in the interview, she credited the experiences with the chemistry set as a defining moment in her decision to become a scientist.

Dr. Townsend also mentioned science enrichment classes in elementary school as a source of science-related activities. These classes were opportunities for the "brighter" students to separate from the other students and engage in special activities, most of which revolved around science. She mentioned several projects that she remembered as motivational toward her interest in science including making a model of the solar system to scale, studying lunar rocks and preparing a presentation to give to the class about a particular dinosaur. When asked how she felt when she was engaging in the enrichment activities in science she replied, "I remember it being fun and interesting." And when asked to reflect back upon the importance of those early science experiences, she stated:

> I think they were very important. I really think those enrichment classes did a lot for me. Because I had that experience from first grade until fourth grade....And so I think that those sort of shaped how I saw science. (personal communication, J. Townsend, November 5, 2001)

Dr. Townsend also recalled the enjoyment she experienced in her high school science courses. She remembered, "doing a lot of cool things." In high school chemistry for example, she recalled making aspirin and soap. What seemed to be particularly meaningful to her was that she enjoyed the formulation of a product. In other words, she enjoyed actually making something. "You know, we weren't just working some math problems. We actually added two things together and got something completely new" (personal communication, J. Townsend, November 5, 2001). In high school physics class, she enjoyed learning about how things worked. She recalled using toy cars to study velocity and force. And in biology, she remembered the fun she had with her lab partner dissecting a fetal pig saying, "...that was really neat to me...we actually dissected more than we needed to" (personal communication, J. Townsend, November 5, 2001). Maybe because science was made interesting to Dr. Townsend, she could state, "I loved science all the way through school."

Science-Related Social Interactions of Dr. Townsend

Within the category of social interactions, several people were instrumental in her motivation to become a scientist. Dr. Townsend credited her parents with getting her the chemistry set that sparked that first interest in science at a very early age. Her elementary enrichment teacher further fanned the flame of interest in science with the science-related activities she provided. Dr. Townsend remembered how that teacher kept her interested in science through the years by doing things such as bringing in all these "models and rocks and whatnot when we were talking about the moon dust and what the astronauts were doing" (personal communication, J. Townsend, November, 2001). She stated that her high school chemistry teacher, Mrs. Whiten, was probably the one who encouraged her the most. She credited those experiences in the eleventh grade in Mrs. Whitten's chemistry class as yet another defining moment in her decision to become a scientist. Dr. Townsend recalled discussing her future plans in science with her chemistry teacher and she further remembered the encouragement Mrs. Whiten provided when she expressed the desire to major in chemistry in college. Dr. Townsend stated,

> I remember talking to her about what kinds of jobs I could get if I decided to be a chemistry major. And she told me about some of the different opportunities and lab work and she tried to open my eyes to the rigor involved in being a science major. (personal communication, J. Townsend, November, 2001).

The interest Mrs. Whiten had in Jenny did not end with her high school career. She continued to have contact with her through Jenny's mother and through Jenny herself when they ran into each other a few times over the years. In fact, Dr. Townsend remembered seeing Mrs. Whiten again during her senior year of graduate school and when she told her what she was doing, she recalled that

> she was so excited when she found out that I had actually gone to graduate school. She said she knew I would be good at that and she was just so excited. She wanted me to send her a note when I graduated to let her know how I was doing. It was great seeing her because she seemed so excited and wanted to know all about my research. (personal communication, J. Townsend, November, 2001)

Jenny graduated high school and then attended college not far from where she grew up. She remembered Dr. Harvey (pseudonym), the professor of her biochemistry course as being particularly encouraging. She stated that at the undergraduate level he encouraged her when she was disappointed that she was making more B's than A's in chemistry. He told her that she did not have to be perfect to be a chemist. Dr. Harvey was the first male scientist in Jenny's life who took an interest in her and encouraged her.

Dr. Townsend also recounted a discouraging experience with a male professor at the undergraduate level. At that time, Jenny was considering becoming a doctor. She related to me that,

> He pretty much told me that there was no way that I could be an MD if I wanted to be, that my grades just weren't up to par. I felt like he was telling me, 'You can't.' And then I talked to him about graduate school, and he was sort of lukewarm about that. He didn't urge me on. He said, 'Well, if that's what you want to do, you'll probably get in somewhere.' (personal communication, J. Townsend, November 5, 2001)

When I asked her why she thought he responded that way, she stated, "If you want to know the truth, I think it's because that person's a little bit of a male chauvinist and he still is today." As I listened to Dr. Townsend recount that exchange of conversation between the male professor and she, I sensed a feeling of resentment that she felt towards him because of what he had said to her as an undergraduate student that still lingers today. In fact she further elaborated that, "I showed him because I'm working down the hall from him now." It also seemed evident that although this particular male professor meant to discourage Jenny from becoming a medical doctor or from attending graduate school, his words of discouragement fortunately had the opposite effect. They motivated her to prove to him and to herself that she could succeed, that she could be successful in science at the graduate level.

Jenny's friends in undergraduate school had a difficult time understanding her desire to become a scientist. She shared a house with six other women who were pursuing degrees in early childhood education and nursing and thus their class schedules were much less demanding than hers. She recalled that they could never understand why she was always working at the chemistry lab at night and studying and why she could not go out with them and have fun. Their constant questioning of her motives and goals eventually led to self-doubt. She began asking herself, "Yeah, why am I doing this? They're going out all the time and I'm stuck in the basement of this chemistry building. What am I doing here?"

However, Jenny did have a male friend who was in almost every science class that she was in during undergraduate school. They were often lab partners and studied together. Their friendship served as a source of encouragement and comfort to Jenny as she recounted:

> We were the ones who, when all of our friends were out doing other things, were here in the basement of this chemistry building working. He just helped me to not get discouraged in a couple of classes, because he was always a little bit smarter than I was and he would help me with certain things...We would always work together. (personal communication, J. Townsend, November 5, 2001)

In graduate school, Jenny met up with other students with similar goals to her own and she eventually formed a friendship with two other women that proved to be a much needed support network. Dr. Townsend recounted:

> We would go to lunch together. We would talk about issues in the department....Anytime you were having a problem you could go out with these

> girls. And if they didn't have the answer, at least you got to tell somebody what was going on. (personal communication, J. Townsend, November 5, 2001)

Jenny experienced another type of negativity in the form of discouragement in graduate school when she perceived in a particular class that certain professors thought the male members of the class to be on a higher intellectual level than the female members of the class were. Therefore, she felt she had to work harder than they did to prove herself. She stated:

> I always felt that I had to do much, much better than anyone else, than any man, to get the same recognition....I do feel that the whole time I was there I was just struggling to make sure that people knew that yes, I'm as good as they are and I'm better than some of them. (personal communication, J. Townsend, November 5, 2001)

When Dr. Townsend was in the process of relating this particular incident to me, she seemed to be reliving the frustration of that experience as her tone of voice increased and her body language indicated agitation. It was clear to me that the retelling of this experience was enough to bring back some of the negative feelings she had at the time the incident took place. This particular example of negative social interaction also falls into the category of gender influences. Several other experiences recounted in this study also overlapped among two or more of the three broad categories of themes.

Several times in the interview Dr. Townsend mentioned the significance of the encouragement provided by her parents, particularly her mother, and her grandparents. Both of her parents encouraged her in general to do well throughout her school career, but her mother appeared to be the source of the most significant influence and encouragement during the troubling transition from undergraduate to graduate school and during her more difficult years at graduate school. Dr. Townsend suffered a detrimental motivational blow when the professor in undergraduate school did not encourage her to apply to graduate school. She began to doubt her abilities in science and spoke to her mother about the situation, who encouraged her to apply to graduate school anyway and to do what she wanted to do. She remembered her mother saying, "Well, if that's what you want, why don't you see if you can try and get into graduate school? If you can't, then you can think of something else" (personal communication, J. Townsend, November 5, 2001). Dr. Townsend felt that her mother really wanted her to go to graduate school because "she knew that I wanted to do something different." Numerous times throughout the interview Dr. Townsend would mention the positive implication of her mother's interest and encouragement on her achievements. Her mother's confidence in her was apparent when she remembered her mother making statements such as, "I think you could be good at this. I think you should do this." When asked which of her parents was more encouraging, she answered that her mother both encouraged and motivated her more than her father.

Dr. Townsend also benefited from the encouragement of her grandfather to do well in school. She stated, "He is really, really, really big on school....He was particularly encouraging. He'd say, 'Go to school. Yeah! Go to school!' (personal communication, J. Townsend, November 5, 2001). She further elaborated that both her grandmother and grandfather are extremely proud to tell everyone they know that they have a doctor in the family. Dr. Townsend smiled as she told me this and I could see that their pride in her was pleasing to her.

Not all of her family members were always encouraging however. Her other grandmother's confusion and misunderstanding of Jenny's long years of study and lack of marriage was a source of consternation for Jenny. Dr. Townsend stated that this grandmother would continually ask her to explain what she was doing, why she was still in school, and why she was not married. She lamented that the questions about marriage became particularly intense at the end of graduate school when she began looking for jobs. She stated that, "At that time my grandparents were asking me, 'Jenny, are you going to get married now?', because I was twenty-five then and I guess they thought twenty-five was the magic age to do all that girl stuff" (personal communication, J. Townsend, November 5, 2001). And once again, Jenny began to experience self-doubt and began asking herself why she was doing what she was doing and should she really be doing what she was doing.

Science-Related Gender Perceptions of Dr. Townsend

The final category of exploration in the interview with Dr. Townsend revolved around gender influences. When asked if she thought her gender made it easier or harder to become a scientist, she stated that, "Sometimes I think it was a little bit harder..." and then went on to recount the experience in graduate school in which she felt that she always had to push herself a little bit further than the male members of a class to be perceived by the professors to be as intelligent as they were. When asked how she dealt with this type of discouragement she related that her female friends were a source of comfort and also acted as a sounding board when problematic issues arose that needed to be discussed.

When asked if she had ever experienced any conflict between her image as a woman and her motivation to become a scientist, Dr. Townsend asked me if self-image was referring to femininity, and I confirmed that it did. She told me that in undergraduate school she began dating a man and that relationship became serious and marriage was considered until she opted to leave Georgia and attend graduate school at the University of Alabama. The relationship was sporadic after that but did not end until she accepted a position at Washington and Lee University in Virginia. So to answer my question, Dr. Townsend did indicate that she had indeed experienced conflict between her image as a woman and her motivation to become a scientist, especially when her grandparents began earnestly questioning her about marriage at the end of her graduate school career. As stated before in this interview, their queries caused Jenny to question her goals and doubt herself. Even at the time of the interview, she stated:

> As I've gotten further in my career, sometimes I wonder, looking back, did I sacrifice relationships with people because I had to move because I wanted to have a better job and to further my career? Did I have to make some of those sacrifices or not? ....So there were times when I wondered how different my life would have been if I'd decided to be just a travel agent (pause) how different would my life have been on a personal level. (personal communication, J. Townsend, November 5, 2001)

I sensed a note of wistfulness or sadness when she was wondering what she might have missed as a result of her career aspirations and so I asked her about relationships she might have now with other men. She stated that she usually does not maintain significant relationships with men for long because they seem to be threatened by the fact that she holds a Ph.D. in chemistry. She mentioned a man she dated for a time in Virginia who made her feel like she was "walking on eggshells part of the time." She went on to say, "I didn't want to appear too smart, or too aggressive, or whatever. And finally I just got tired." About current relationships, she stated:

> I've dated a couple of men when I first came here, and they just think it's such a big deal. And it's really sad to say, but I really don't date anyone for that long who has those problems because you can't live the rest of your life not being yourself. (personal communication, J. Townsend, November 5, 2001)

The final question of the interview was if she had ever been discriminated against or stereotyped as a woman in science. Dr. Townsend felt that she probably was as an undergraduate and a sorority member when she felt she was not taken seriously by many of the male professors including the male science professor who discouraged her from attending graduate school or medical school. She stated that "They probably thought, 'Oh well, she's just a little sorority girl. She's out all the time.' Which sometimes was true." It is interesting that Dr. Townsend, in retrospect, tended to validate their actions because she was a sorority member. She also went on to say that, "...the person that I talked to about what I wanted to do with my life, when he started saying all the things I couldn't do, I think it was partly based on what he saw." Again, she attempted to explain his actions, making them seem appropriate. She further elaborated that, "...he kept trying to talk to me about being a high school chemistry teacher. He never pointed me anywhere else. He would say, 'You could always teach.' And I think it was because I was a woman" (personal communication, J. Townsend, November 5, 2001).

Dr. Adams

Dr. Missi Adams' office is located across the hall from Dr. Scott's office in the same old building. Her door was open when I approached, and she was sitting in her chair with her feet propped up on her desk. She appeared to be in her thirties, was nicely dressed in slacks and a blouse and was wearing makeup. Her hair was stylishly cut; she was tall and slim. I introduced myself and I immediately got the feeling that she was comfortable and in control and calm, which was reassuring to me. After a few moments of conversation, we began the interview.

Biographical Information of Dr. Adams

Dr. Adams is an Associate Professor of Chemistry at a medium sized state university in southeast Georgia. She was raised in Pennsylvania where she attended elementary through high school. Dr. Adams obtained her B.S. degree in chemistry from a private college in New York called Canisius College and then her Ph.D. in chemistry from State University of New York in Buffalo. She is divorced and is 36 years old.

Dr. Adams has one sister, who is eighteen months her senior. Her parents were blue-collar workers; her mother was a laborer at a sewing factory and her father made airplane and spacecraft gauges at U.S. Gauge, Ametek Division. Neither of her parents had attended college; Dr. Adams was a first generation college student.

Science Experiences of Dr. Adams

When asked about early childhood experiences she may have had with science, Dr. Adams first recalled an experience in first grade. Her teacher had created several "stations" (learning centers) pertaining to various land biomes including the tundra, grassland and wetland. Each station contained information about the plants and animals that inhabited that particular biome. Dr. Adams enjoyed exploring the stations and learning about the biomes. She stated, "I thought it was terrific and I really enjoyed it." After that, she tended to gravitate toward science in school. She recalled liking all of the subjects in school, but she really liked science after the experience with the biomes in first grade.

She also mentioned that she enjoyed playing informally with Barbie dolls, like many little girls do. But in her mind, the Barbies she played with were always surgeons. In fact, she stated that, "As long as I can remember that's what I thought I was going to be." She also recalled enjoying the outdoors as a child and helping her parents in the family garden.

In high school, Missi enjoyed dissection, calling that adventure "the highlight of the science experience" and "phenomenal." In her high school biology class, the students dissected frogs, worms, and fetal pigs. I asked her what she liked about dissection and she replied, "The worms and the frogs were fun because you got to cut stuff up. The pig is the closest anatomically to a human. And so it was absolutely fascinating to see how you were set up on the inside." Dr. Adams also remembered the fun she had engaging in dissection: "…we just wanted to see everything and so when you were done cutting things out, if you wanted to cut out extra stuff, that was fine with her. As long as you did it properly and diagrammed it" (personal communication, M. Adams, November 5, 2001).

Science-Related Social Interactions of Dr. Adams

I next asked Dr. Adams if there were any particular teachers who motivated her to pursue science. She mentioned Mrs. Michener, her ninth-grade biology teacher who provided the dissection experiences. Dr. Adams stated, "She was great at teaching....She was just a neat lady" and she appreciated the opportunities Mrs. Michener provided when she did the dissection labs saying, "It was a big risk for her. You turn young kids loose with scalpels, it's not necessarily a good idea. She took a huge risk." And she also mentioned a professor in undergraduate school, Dr. Cross, who taught her Introduction to Chemistry class. In undergraduate school, she started out as a pre-allied health major but after taking Dr. Cross's course, she decided to switch to chemistry. She said, "He was fantastic. And he was the reason I changed to chemistry....And he was so good. I was just like, 'That's it. I want to be a chemist!'" When asked what her most encouraging science experience might be, she again credited Dr. Cross's class, mentioning that

> He was a black man. And I think maybe his experiences made him sensitive to gender/race issues....He didn't put any barriers up to females so he was really encouraging. And he made it really fun. He related everything to real life. That certainly sparked my interest in studying chemistry. (personal communication, M. Adams, November 5, 2001)

Dr. Adam's parents wanted both she and her sister to do well in school but they never encouraged either of them to go to college. She stated that her childhood was turbulent and that her parents "were so busy hating each other that they didn't really have a whole lot left to give either my sister or me." Her parents were not the type of parents who visit colleges with their children or help them prepare for the SAT. In fact, she stated that "My whole career happened half-assed and by accident...everything that happened, happened despite my parents, not because of them." Her father barely finished high school and her mother did not finish at all. So college was perceived as "frivolous."

When she made it known to her parents that she wanted to be a doctor, their response was devastating. Once she told them, she said she "had to wait fifteen minutes for them to get done rolling around the floor. There were tears in their eyes from laughing so hard....They thought it was a hoot. Didn't give it any credence whatsoever" (personal communication, M. Adams, November 5, 2001).

She felt as though her parents did not take her seriously, but they realized she meant to pursue her education when she decided to leave Pennsylvania and attend college in New York. Missi had married just out of high school, and when she decided to go to college in New York, her husband was supportive and agreed to accompany her. But her parents became upset with her and the decision that she had made. The criticism began to take on a stronger tone as they asked her who she thought she was to "drag her husband away from his family" and that he "was a wonderful man to put up with what I was expecting from him." According to Missi, they would have been perfectly happy if she had stayed in Pennsylvania and continued working as a secretary, which is what she did as she worked her way through school. She felt as though the notion of her going to college was very threatening to her parents. Her mother felt that Missi should be taking care of her husband instead of wasting time going to college and would often call her from Pennsylvania and tell her that. When I asked why she thought her mother behaved that way she stated:

> I think she wanted me to do well because it would give her bragging rights. But I don't think she wanted me to do well because it made her feel like she had failed. Because she hadn't done well. So it was really hard for her because she didn't know how to process having a daughter that was doing things that she hadn't

done. On the one hand I think she was proud, and on the other I think she was very, very threatened....It was just constant mixed messages of go get 'em, but don't go too far. (M. Adams, personal communication, November 5, 2001)

Other family members were also discouraging, especially when she decided to apply to graduate school. She remembered her ex brother-in-law, who she remains friends with today, saying, "When are you going to get a real job? When are you going out into the real world?" Missi felt that her family thought graduate school was a "cop out", a "way to avoid having to work."

I realized as I heard Dr. Adams describe the struggles she faced as a result of the lack of encouragement provided by her family, that she deeply resented their actions. It seemed though that because of the struggles she faced, because of the opposition of her family, she grew stronger and more independent. She learned to be a fighter and that came across in the conversation we had. I respected her for that and I admired her determination and her strength to succeed. I identified with Missi more than any of the other participants in my study because I felt that we had traveled similar paths in our lives and we had fought similar battles and were stronger for those tough times.

Other people in her life were supportive. Missi mentioned a group of ten friends in undergraduate school who stuck together and helped each other along. She recalled that, "We were all in it together and it was rigorous and it was tough and it was hell, and you know, we carried each other at different times. That was an incredibly wonderful experience" (personal communication, M. Adams, November 5, 2001).

Missi's graduate school experience was more competitive, she did have some support from team members and others she collaborated with, but for the most part, she was on her own.

Dr. Adams had an advisor in graduate school who had both a negative and a positive impact on her. He was incredibly hard on her. He verbally abused her by telling her she was stupid, asking her if she was a f-ing idiot, lying to her and about her. She felt as though "he was trying to see how much you could take." Later, she believed that his method of training was "to break you down the first two years and then start to build you up after that." She even decided to quit graduate school after her first semester but was persuaded to try another six months. It is interesting that despite the abuse from her advisor, she said that she "would never have worked for anybody else." She told me, "Even after everything I went through with him, I think he was an awesome advisor and I think he did make me into a good scientist…"

I was curious to know what sustained her motivation to pursue her science career when her family was against her, when the work was so demanding that she often spent the night in the lab, when she spent so much time away from her husband. Her biggest motivator was fear of failure. "Plain and simple. I was not going to fail. It was never an option. I refused. I was not going to give my family the right to say 'I told you so'" (personal communication, M. Adams, November 5, 2001). Her fear of failure was mentioned several times throughout the interview. I knew that feeling. I knew the determination and the drive. And I knew that those characteristics most likely helped to shape her into the independent and successful woman she is.

Her second biggest motivator was her husband. She said that she could never have done it without him:

> There is absolutely no doubt in my mind. I dedicated my thesis to him even though our marriage was falling apart. Because I know that if he had not been there (pause) I mean, he took care of the household, he took care of the grocery shopping, he took care of everything from the time I started going back to school.... You know, I'd be in the lab literally sleeping on a lawn chair overnight and he'd bring me McDonald's. (personal communication, M. Adams, November 5, 2001)

Their marriage did eventually fall apart after she accepted the position she now holds.

Science-Related Gender Perceptions of Dr. Adams

I asked Dr. Adams if she felt her gender had made it harder or easier for her to become a scientist and she replied that overall, she did not think it made any difference. She did believe however, that:

> there is overt sexism and covert sexism that will always exist by a certain type of man. And I think you have to fight that. And I think that one of the best ways to fight that is to play up the female. Men are such simple creatures and you can manipulate them so easily. And the women who have the most difficulty fighting sexism are the ones who try to be men. While they are criticizing you or coming down on you for being a woman, using the fact that you are a woman can completely disarm them. (M. Adams, personal communication, November 5, 2001)

These series of statements intrigued me and I wanted to continue along that line with the questioning so I asked her how a woman might disarm a man with her womanhood. I was surprised at her response because it seemed contradictory to some of the other things she had been saying. She said a woman could do that by flirting with men. She went on to say, "You can charm them. The smartest thing a woman can do is let men think they came up with the idea. I mean they're so easy to manipulate." For example, she stated that she had a male member of her committee who was very demanding. She perceived that:

> He found women scientists, or women graduate students entertaining. And so you'd play that. You know, you'd say 'Hi Dr. Bruckenstein. How are you doing?' It's not like in a real sexual way, it's just that if you come across aggressive and manly and try to compensate for their sexism by being more anti-female, I think you're doing yourself a disservice. The bottom line is, when it comes time to take an oral exam in front of a committee of all men, you're either going to know the material or not. And if you present it in a way that's not threatening, with a smile, or a softer voice, they won't be so threatened. They're threatened by your strength. And they're threatened by you treading on their territory. And so if you tread lightly, even though you have the knowledge, it's less threatening to them. (personal communication, M. Adams, November 5, 2001)

I was distressed about her feelings here. At the time, I was thinking that this is what we do not want, this is why science needs to change. Here is an example of a woman in science who is changing her behavior to accommodate the beliefs of males in the field of science. Women scientists should not have to tread lightly, because science should not be male territory, it should be human territory.

Dr. Adams did stress that:

> Now I would never, in a million years suggest that dealing with it intelligently would mean wearing short skirts and low cut tops and bending over in front of guys. That's not what I'm talking about. I'm talking about having to wade through the waters gingerly. And personally, I find that revolting. I find it absolutely physically sickening, that we have to deal with that. But having tried it both ways, that's definitely the better approach. (personal communication, M. Adams, November 5, 2001)

I realized what she was saying. And I was saddened to see that women scientists are trying to fit into a socially and culturally constructed historically scientifically masculine world. We are becoming somewhat more successful as a society in motivating girls to pursue science. But once they become scientists, once they immerse themselves in the scientific world, the very nature of science, the fact that it is perceived to be a masculine field, is a deterrent. That is the biggest issue facing women in the scientific community.

Dr. Adams did not feel as though she had experienced conflict between her self-image as a woman and her motivation to become a scientist. But she did mention several other women scientists she knew who seemed to have difficulty in that area. One of them was a woman who she described as being one of the best scientists in the country. In fact she was head of the National Science Foundation's Chemistry Division until recently. She described her as a stunning woman who dressed like a man:

> If you didn't know she was married, you'd think she was a lesbian because of the way she looks. And I hate to make that stereotype, but very short hair…not a stitch of makeup. And that's how she got the focus off of her being a woman, by not looking like one. I think that's unfortunate. (personal communication, M. Adams, November 5, 2001)

Dr. Adams also mentioned that in the science department where she works, only two of the six women scientists wear make up. She said she does not know what the origin of that is but that she thinks it is sad and believes "you don't have to give up being feminine to be a scientist."

When asked if she experiences conflict now between her role as a scientist and significant relationships with men, she was adamant that it was indeed quite a problem. She feels that "it's almost hopeless." She recounted an experience she had with a particular man she had just met. They were going out to lunch and everything was going well (at least she thought it was at the time). They talked about their jobs and lives and Missi enjoyed him and was interested in him and wanted to see him again. But he never called her. She finally asked her former brother-in-law what he thought she might have done wrong. He was appalled to find out that she had told this guy what she did for a living. She remembered him saying, "Tell him you're a barmaid. Tell him you're a waitress. Tell him anything. Don't tell him you have a Ph.D. in chemistry." When she asked why he stated, "Missi, he's a guy!" Dr. Adams could not believe what a big deal people make out of the fact that she has this degree. It is obvious that the intimidation others display upon learning about her advanced degree, is extremely frustrating to her.

She felt that men do that more than anyone and it is a huge factor in the lack of success in her relationships with men. I asked her how she deals with it and she stated:

> The few who make it so much a part of their identity are going to continue to enforce that stereotype, unfortunately. And the best thing I can do is be down to earth and be me. Not make it a part of who I am. And it's not going to work with men because they are always going to be intimidated by it, unless they have a Ph.D. as well. (personal communication, M. Adams, November 5, 2001)

My final question was had she ever been discriminated against or stereotyped as a woman in science. She recalled an experience she had at a conference as a graduate student when she was at a bar with the rest of the group who had traveled with her to attend the conference. The man who happened to have been sitting next to her asked her what she did for a living and he was very surprised when she told him she did laser fluorescence spectroscopy. She was dressed in a nice dress and had taken great care with her appearance for that occasion. He said she did not "look like a chemist." And she replied, "What's a chemist supposed to look like?" She laughed and said, "Now there's a stereotype. Because I don't have my pencil pocket protector and a calculator on my belt? What does that mean? That you can't be fashionable and take pride in your appearance?"

Dr. Nix

It was the day before Thanksgiving when I arrived to interview Dr. Delana Nix at her office on the college campus where she teaches at a small university in southeast Georgia. It was a very good time to have scheduled the interview since she was required to be there but no classes were being taught. She was sitting at her computer trying to locate something in an email someone had sent to her, so while she was doing that I set my equipment and we chatted. Dr. Nix was youthful in appearance. She had shoulder-length curly brown hair and was dressed informally in jeans and a sweater. Her office held numerous photographs of her young daughter and wedding pictures of her and her husband. Dr. Nix had read the interview questions I had emailed her and had taken some notes about what she wanted to say.

Biographical Information of Dr. Nix

Dr. Nix is an Assistant Professor of Analytical Chemistry at a small college in southeast Georgia. She is married, has a four-year-old daughter and is thirty years old. She attended elementary through high school in a suburb of Pittsburgh, Pennsylvania. She attended undergraduate school at the University of Pennsylvania and graduate school at the University of South Carolina, where she obtained a Ph.D. in chemistry. Delana has one sister who is five years younger than she is. Her father was a steel mill worker, a plumber, and sometimes worked in construction. Neither of her parents ever attended college.

Science-Related Experiences of Dr. Nix

We started with the question about early childhood science experiences that were motivational to her. She was quick to point out that she had thought of two experiences but she was not sure if they had influenced her in science. She remembered going to a science museum at Carnegie Mellon with her father. She was sitting on his shoulders so she could see and she still remembered seeing the "dinosaurs and all the cool things they had there." The other experience she recalled was playing with a friend's microscope set. She stated, "I remember that we thought it was the coolest thing to look at our own urine under the microscope. I remember peeing on something and looking at that and thinking it was cool" (personal communication, D. Nix, November 21, 2001). As far as formal science experiences in school, she said that the science they did was "everyday science," nothing special that she could recall.

Delana always did well in school. She especially excelled in math in the early years. In fact, when she was in the fourth grade, she tested and placed in sixth grade math so they moved her to the sixth grade math class. But the problem was that when she got to the fifth and sixth grades, she had to re-take the same sixth grade math since there was no other place for her to go. So she ended up taking the same math for three years.

Delana enjoyed reading so she did not play outdoors a lot except ball occasionally with the other neighborhood children. When she was in the third grade, her family got a swimming pool. She recalled:

> I guess my first real chemistry thing was when my Dad taught me how to test the water in the pool. For the chlorine it had to be a certain color yellow and for the pH it had to be a certain color red. And if it wasn't, you had to add something. (personal communication, D. Nix, November 21, 2001)

One of the main reasons Dr. Nix preferred science to other subjects in school was because she had so many negative experiences in areas other than science. So it was not necessarily that she had positive experiences in science in the elementary years, but that the experiences she had with science were not negative. In middle school, science seemed easy to her and she excelled at it, while she had to work at other subjects such as home economics and industrial arts. And in seventh grade she tested into algebra so she was excited to finally get out of the boring general math classes. But until she was in the ninth grade, she was bored with most of the classes she took in school.

In high school she was placed into a college-prep. curriculum, which gave her more freedom to choose from a variety of subjects. She took advanced classes in English, algebra two, and geometry. In the sciences, she started out with advanced physical science, then moved on to chemistry, biology, organic chemistry, anatomy and physiology and physics, often taking two science classes at a time. She recalled visiting an amusement park as part of her high school physics course where she "got to see how the rides were related to physics." The variety of courses available at the high school level and the activities associated with them made school much more interesting to her than it had been.

Dr. Nix remembered that in her high school chemistry class they "made aspirin and some other cool things." She was also part of a team of students who were chosen to participate in a Science Olympiad where they had to construct a life-sized vehicle that they would actually have to roll down a ramp and compete against the times of other vehicles. She was the one chosen to drive the car her team built because she was the only girl on the team and weighed the least. She stated:

> Ours went so fast that it went all the way down the ramp and hit the wall on the other side of the gym and bounced off and cracked the front of it. We got a prize and thought that was pretty cool. (personal communication, D. Nix, November 21, 2001)

Delana admitted to having always been competitive. She posited that:

> I was a very competitive person so when we would go and do something like that and win, or when I got pulled out of class to do something important or different,

> that was meaningful to me because it proved that I was where I belonged. (personal communication, D. Nix, November 21, 2001)

The notion of competitiveness reappeared numerous times throughout the interview as a means of science motivation. She enjoyed "beating other people." When I asked what she gained from those competitive experiences in science, she said, "I guess you gain some confidence." Self-confidence was something she always struggled with and said she still struggles with it today.

Later in the interview, I asked Dr. Nix what those early experiences with science meant to her today. She did not believe they had a great deal of significance. She said:

> There are a lot of other issues in your life. There are a lot of other diversion pathways. They're part of the puzzle. They make you what you are but I don't know how much importance they have now. I think they influence you with what you do with your own child. What kind of encouragement I'm going to provide for my own child. What kind of toys I'm going to buy her. (personal communication, D. Nix, November 21, 2001)

In high school, she decided she wanted to be a doctor and was pre-med. all the way through undergraduate school. She was told that to be accepted into medical school, you had to have more than just good grades. You needed to have done something that "would stand out." So she volunteered at a large university hospital and did paperwork for a transplant surgeon. She stated, "I got to read patient files and learn stuff about it and I really thought it was great." So the next year she volunteered again but it was on the trauma floor of the hospital. Although she had watched real-life trauma television shows, the real thing was startling to her:

> I realized how different it was in person versus what you saw on television or what you saw on paper or what you studied in a book. It was different. People were crying and were upset. It was so much more emotional than I had expected. (personal communication, D. Nix, November 21, 2001)

At that point, Delana knew she was not cut out to be a doctor. For a period of time, she coasted along on "auto-pilot" until she decided to go to graduate school.

Science-Related Social Interactions of Dr. Nix

When asked if any teachers were particularly motivating to her in elementary school, she could not think of any. But at the high school level, she remembered her chemistry teacher as being positive and encouraging towards her. He was interested in her future plans and would ask where she wanted to go to school. Often he would get her out of other classes to help grade papers and do other things for him. She enjoyed the attention he offered her and liked being singled out.

Her undergraduate advisor was also encouraging and a positive influence. He was quick to write recommendation letters for her and she credited him as being the most encouraging person to her in undergraduate school.

At the undergraduate level, she was assigned to work with a particular professor who passed her off on to a graduate student who ended up getting pregnant and was told to leave. Delana remembered, "she was finishing up and trying to leave and she didn't really have any time to try and help me." So after that she decided to go to graduate school, but she was not very confident about her decision. Once she got to graduate school, she recalled a particular class in which the professor required the student who scored the highest on his exams to wear a "1960s bright yellow and purple stained tie" for the day. Delana got the honor for the first test and was embarrassed about it but the next time she got to wear it, she was excited about it. So she was still competitive and enjoyed being recognized for making the highest grade on exams.

Her graduate school advisor was a very positive influence on her. She recalled that he was always encouraging her to try new things in her research. She further stated that, "He never really treated me any differently than anyone else. He wasn't harder on me or he wasn't softer on me."

In graduate school, she also remembered joining a brand new research group with a professor new to the university. Because the professor was new, she recalled:

> We really had a lot of responsibility to set everything up, get everything going and figure out things for ourselves. So that was very challenging, but it was fun too, because you got to see how everything went together. You didn't just come into a lab and have someone teach you something. So because of that, as new students came in below us, you ended up having to teach them everything. (personal communication, D. Nix, November 21, 2001)

So Delana benefited from a situation in which she was in on the ground floor of the creation of a working laboratory, which made the research more relevant to her as she got to be a part of the entire process, from the procurement of lab equipment, to the layout of the lab, to the beginnings of the research.

Also in that lab environment in graduate school Delana became proficient at mentoring new students. She remembered how she was passed off in undergraduate school to the girl who had no time for her, so she was careful to take extra care with the students assigned to her. And "Because of that, my advisor gave me all the undergraduates," stated Delana. So she enjoyed mentoring and training undergraduate students during her years at graduate school.

Her original dissertation committee consisted of four men. One of those men made some "highly inappropriate" comments to her during a conference after having too much to drink. The comments were sexual in nature and concerned her husband. Delana was so upset by what happened, that she had him removed from her committee. She replaced him with the only available female professor of science who "was one of the most encouraging people there that worked with me and talked with me about stuff and helped me figure out what to do." Once she got on the committee, "things turned around a lot from that point. Because she was a lot more helpful to me and a lot more interested in what I did…" (personal communication, D. Nix, November 21, 2001). So this female professor served as a role model and mentor to Delana while she worked on her dissertation.

I next asked Dr. Nix if she had a group of friends in the undergraduate and graduate years that banded together and got each other through. She mentioned that there were two other girls she was friends with who were in all of the same classes. They did their homework together and they discussed things together and even competed against one another for the best grades.

From there we moved on to the role her parents played in her life. I asked her if they encouraged her once she told them she wanted to be a doctor. She said:

> I have probably the most uninvolved parents in the universe….They really didn't have any frame of reference. They just went to work and came home. They had a

> lot of personal problems; they're divorced now....They didn't have any way of knowing. (personal communication, D. Nix, November 21, 2001)

Despite her parents' lack of knowledge of higher education, Delana persevered on her own, taking out student loans and working her way through school. She did mention that she was close to both of her grandmothers. One of them was stricken with a stroke and lived on for fifteen years afterwards with a myriad of medical problems, and the other one had Alzheimer's disease. It was their medical problems that influenced her to want to become a doctor. She stated, "I thought there were things I could do that could be helpful to their situations if I were a doctor." So there was not a lot of family support for Delana in her quest to pursue a college education.

Science-Related Gender Perceptions of Dr. Nix

When asked if she thought her gender made it harder or easier for her to become a scientist, she felt like it could make it harder. She posited, "You have to be willing to work in places that are all men and not be offended and not be upset by that" (personal communication, D. Nix, November 21, 2001). I was very interested in this comment. It made me wonder if scientists can ever just be scientists, instead of men scientists and women scientists. Will society's cultural expectations for femininity and masculinity ever go away? Will those expectations ever stop defining who we are and how we are supposed to behave? Along this same line, Dr. Nix recalled her experience as the only female member of her graduate research group. She was around men so much that she recalled:

> I found myself developing sailor mouth or an attitude where I wanted to fit in with them. If they would swear, I would swear. If they wanted to talk about nasty

> things or look at pornography on the internet, I would say, 'Oh, that's cool.' I would try to act like one of the guys...I didn't want to be the complainer. Because I didn't want them to hate me or say, 'She's just a chick.' Or 'She's annoying.' Or 'She's a pain in the butt.' So they didn't really act that way but there was this kind of guy thing going on. So I tried to fit in. (personal communication, D. Nix, November 21, 2001)

Furthermore, Delana described her field as "a guy type of field." She went on to say that "we were working with lasers. We had to build things, circuits and so on. Most women do things with biochemistry or things where women are a little more predominant."

Next I asked Dr. Nix if she had ever experienced any conflict between her self-image as a woman and her motivation to become a scientist. She replied that yes, she probably had. She went on to say:

> When I think about the way I dressed, wearing a lab coat and especially during my post-doc; for a year I would only pull my hair back and wear jeans with holes and looked kind of miserable. So that kind of self-image. (personal communication, D.Nix, November 21, 2001)

The day that I came to interview her she was also informally dressed in jeans and a sweater. But she believes that the way she dresses is just who she is rather than a reflection of her job.

Dr. Nix also experienced conflict between her goals to pursue science as a career and the relationship with her husband. They were married right after she graduated from undergraduate school so she was married during her graduate school years and beyond.

She feels that there is an ongoing conflict between her husband and herself concerning careers. She told me:

> I think sometimes there was an assumption that I thought my career was more important....So there is this ongoing issue, we don't fight about it or anything. But that my career is more important, that his career is a side issue. (personal communication, D. Nix, November 2001)

Her husband has not yet completed his bachelor's degree and works for his father.

She also reported experiencing conflict between her job as a scientist and her family life, especially during the time in which she was a post-doc working in Washington D.C. Her position required her to make an hour long commute each day into the city, and she had to leave her newborn daughter at home with her husband. She related that, "That was really conflicting for me, the fact that he was home with her and I wasn't." She also felt some degree of guilt that she did not always want to stay home with her daughter either. The position she holds now does not create as much conflict since she lives close to the university and her daughter is older and in daycare.

My final question was had she ever been discriminated against or stereotyped as a woman in science. She replied that it was possible. It seems that as a post-doc, she worked for a man who was a federal employee and as her tenure came to an end and she came up for permanent hire, his boss decided not to hire her. According to Dr. Nix, she believed that she followed all of the perceived guidelines (not written anywhere) to get permanently hired but was still not hired because she was a woman. There was another female post-doc who was in the same situation. A meeting was held and the results were that Delana and the other woman had to do three additional things to get hired, get her own money to pay herself, finish her publication, and publish some other material. She stated, “The perception by me and by the other woman was that the rules had changed for us for whatever reason.” Her immediate male boss quit that same day and eventually a sexual discrimination lawsuit was filed by the other woman involved. The lawsuit has not yet been settled so we did not discuss anymore of the particulars. But as a result of that situation, she lost the job that she thought she was going to have and she did various other jobs including substitute teaching until she was hired a year later at the college where she now teaches. She remembered that time as a disheartening period in which she goofed off and roamed around from one thing to another.

Dr. Black

While I was interviewing Dr. Townsend, another woman stepped in and said hello and introduced herself as Dr. Pam Black. She was one of the women I had initially tried to contact via email for a possible interview but had not heard back from. When I told her who I was and what I was doing, she invited me over to her office after I finished with Dr. Townsend to interview her. I was ecstatic! Now I would get to interview four women scientists in one day. Although she did not get to read the questions ahead of time, I decided to go ahead and conduct the interview. When I arrived at her office, the first thing I noticed about Pam was how happy she seemed. She almost never stopped smiling. It was obvious she enjoyed her life and her work and I was eager to begin the interview to learn more about her.

Biographical Information of Dr. Black

Dr. Pam Black is a 38-year-old Assistant Professor of Chemistry at a medium sized state university in southeast Georgia. Her research interest area is bio-organic chemistry. She grew up in Michigan and attended Michigan State University and the University of Michigan, Dearborn to obtain her B.S. degree. She received her Ph.D. in chemistry from Purdue University in Indiana.

Dr. Black has a twin sister and a brother who is two years older than she is as well as a sister who is three years her senior. Most of her time growing up was spent with her twin sister until she left home to attend college. Her father was employed by Michigan Bell and her mother was a homemaker.

Science-Related Experiences of Dr. Black

When asked to recall early childhood experiences with science, she first remembered the fact that she lived in a rural area with forty acres of woods full of trails and a creek that ran through it. She and her sister spent countless hours roaming the woods, playing and exploring in the creek and collecting organisms in jars from the water. At first she remembered that whatever they collected would always die. She said, "We would try to figure out why it would die. So I guess we were doing experiments when we were very little before we even knew it." Dr. Black said that both she and her sister "were always interested in nature and that kind of stuff…We just did all sorts of experiments back there without even knowing what we were doing" (personal communication, P. Black, November 5, 2001).

Later in the interview I again asked her to reconsider the experiences she had outdoors in the woods and see if she could recall how they made her feel. She remembered,

> They made me curious. That was the biggest thing. Just the whole (pause) like why do leaves change? Why is the sky blue? They made me curious I guess, more

> than anything. They spawned my curiosity. (personal communication, P. Black, November 5, 2001)

I then asked if those early experiences contributed to her becoming a scientist and she replied that they did because they spawned her curiosity.

Toward the end of the interview session I asked her what those experiences mean to her now, as she looks back at them. She answered:

> Totally. Totally. I just think to myself (pause) this is one of those staggering questions that give me chills down my spine. Where would I be had I been raised in the city? Had I been raised in a forty story high rise? I don't know the answer to that. That's kind of scary. But everything that has happened to me, everything that I have done has led me to this chair. But how do I know if I had been raised in a forty story high rise, that I wouldn't be happy doing something else? I don't know. That's one of the hard questions. But yeah, oh yeah, definitely. (personal communication, P. Black, November 5, 2001)

I then asked about her science experiences in the middle to high school years and she immediately remembered an ecology class she took in high school in which they would go out to a wood lot behind the school, divide it into quadrants, and count the number of trees, types of trees, and measure the tree trunks in each quadrant. The teacher had all of the data for the past ten years pertaining to that wood lot and they would compare their findings with the previously established data. She really enjoyed that particular experience. She also recalled having to make a solar system to scale, complete with clay planets. These types of hands-on activities were meaningful to her because "we actually did things." And in a horticulture class they grew plants.

In undergraduate school (she started out in a medical technology program) she recalled that she and the other students drew each other's blood and did both red and white cell counts in a hematology class. She also took a parasitology class in which they looked at various different slides of parasites including ringworm and other fungi that grows in the human body. Those activities were "cool" to her. But her favorite class was chemistry, especially organic chemistry. When asked what it was she loved about organic chemistry, she said it just "made sense" to her. She recounted, "I just got it. I could put it in a little compartment and call it when I needed it. It just made sense to me."

Pam worked for a few years as a medical technician, but she was not happy with her job and decided to go back and get a chemistry degree. So she enrolled at the University of Michigan's Dearborn campus and took all upper level chemistry courses. Her goal was to attend graduate school and get a Ph.D. in chemistry.

Until graduate school, all of Dr. Black's experiences with science had been positive ones. In graduate school, she was assigned to a research group whose research did not spark her interest. So as time passed, she became increasingly discontented and discouraged. Likewise, her professor became more and more discouraged with her. She had looked at the other research groups in the department and nothing they were doing interested her either. She explained to me:

> I didn't want to switch groups and I didn't want to really stay in that group and I probably would have considered not staying in graduate school at that point, just because what I was doing wasn't interesting. I just wasn't passionate about it. (personal communication, P. Black, November 5, 2001)

Her professor became more and more upset with her performance and began giving her negative evaluations but although she wanted to improve, she could not because the research just was not interesting to her.

Fortunately, a new female assistant professor was hired at Purdue whose research was interesting to Pam so she switched to her group. Dr. Black recalled that from that point on, "I loved every single thing that I did." The research that this new professor was doing was much more applied. It was "right there, you could actually see it" described Dr. Black. The fact that it was a more practical type of research sparked her interest because that is the type of person she is. She stated:

> We were actually synthesizing compounds that we would send off to drug companies and they would test....the drug companies would change it a little bit here and a little bit there to try to get it to behave more like they wanted it to behave. (personal communication, P. Black, November 5, 2001)

Science-Related Social Interactions of Dr. Black

From there we moved on to influences people had on her motivation to become a scientist. Her earliest recollections involved a teacher in elementary school who explained to her why the leaves turned colors in the fall. And she remembered being fascinated with the explanation that teacher provided. She was always curious about nature. In high school she remembered two exemplary science teachers that she was fortunate to have. She recalled, "Both of them just absolutely positively loved what they did. And they had so much excitement and energy for their discipline that you couldn't help but be drawn into that" (personal communication, P. Black, November 5, 2001).

Those were the same teachers who taught the ecology and horticulture classes she enjoyed so much. I later asked her what she thought she may have gained from the experiences provided by those two particular teachers and she said it was probably passion. She recalled that they

> absolutely positively loved every single minute of what they did. And I realized that that's what I wanted out of my job. I wanted to be able to love every single minute of my job. (personal communication, P. Black, November 5, 2001)

Dr. Black also remembered her admiration for and identification with her grandfather who was an engineer with the Ford Motor Company. She told me these feelings she had about him:

> His mind was very cut and dry. And I think I admired him, my Mom's father, more than anybody on earth. And it was just because he had such a systematic mind. And that's really how scientists are. It's very systematic. You look for patterns. And so I think there was an influence there.(personal communication, P. Black, November 5, 2001)

Dr. Black also credited both of her parents for always encouraging her in everything she attempted. She especially appreciated the fact that neither of her parents ever told her she could not do something because of her gender. She stated,

> My Mom never pushed my brother to be a mechanic and us to be housewives. Or, 'You can't do that because that is too hard for you.' My Mom never, ever told us that. And truthfully, they have four kids, and the three daughters are more highly educated than my brother is. So the early influences had to be both my grandparents and my Mom and Dad really making us believe that we could do

> anything we wanted to. Not ever saying, 'You can't do that because you're a girl.' Never did I hear that. (personal communication, P. Black, November 5, 2001)

Her parents were also supportive of her at her most discouraging moments in graduate school when she was involved in research that did not interest her. It was a difficult time for her at that point in other ways because she was further away from home than she had ever been before. So she would travel home frequently on weekends and her parents would listen to her "rant and rave about everything that was negative. And there was a lot of positives but they didn't hear any of that, of course."

I asked her how her parents responded to her when she "ranted and raved" and she said that at first they would only listen and ask a question every now and again. She figured that they knew all she needed was someone to listen to her. But her father died before she finished graduate school and her Mom wanted to try to fix things when she came home upset. So she finally had to tell her to stop talking and just listen.

During undergraduate school she remembered the parasitology professor as having been a positive influence on her. She stated,

> If there was one person that I would have wanted to be like after graduation, it would have been him. Probably because he was so practical. He was teaching about all these parasites and then the next semester he would go and try to cure all these parasitic diseases....So I could see the practicality of what he was doing right there. Because he would actually teach it and go do it. (personal communication, P. Black, November 5, 2001)

She also stated that she had "really excellent" organic chemistry teachers. Her inorganic chemistry teacher was the one she credits for having convinced her to attend graduate school. He provided her with information about graduate school and told her it would probably be free. When asked in the follow-up interview how the interest he showed in her made her feel, she stated, "Like I would be successful at it. Like it was just out there waiting for me. It was an enabling feeling—I could do it" (personal communication, P. Black, January 10, 2002).

She also remembered a friend in undergraduate school having a positive effect on her. This woman was a pre-med. major and Pam described her as being "so intelligent." She went on to say,

> I wanted to be like her. She was like my role model. She probably did it without even knowing she was encouraging me. It was more like a challenge. I could be as good as she was. (personal communication, P. Black, November 5, 2001)

In graduate school, her Ph.D. advisor was also very motivational to Pam. She described this woman as being "totally encouraging." Dr. Black's relationship with her was so significant that she still maintains it today. In fact, this woman recently gave her Barbara McClintock's book entitled Feeling for the Organism. She read the book and identified with what Barbara McClintock had to go through as a female scientist and was encouraged by her story.

When asked which of her parents encouraged her the most, she said it was probably her Dad. Dr. Black said:

> Because he knew more about life than my Mom. My Mom didn't know anything. She didn't have a perspective. Not that she's dumb, because my Mom is bright. She just didn't have a perspective. My Dad had a perspective….I guess he had a better perspective on the way the world really was than my Mom did. He went out

everyday to work and he had a better perspective than she did. (personal communication, P. Black, November 5, 2001)

Not all of her family members were always encouraging to Pam as she pursued a career in science. Her older sister went to college and majored in business and would point out how much more money she was going to make than Pam would in teaching. She even told her, "Those who can, do. Those who can't, teach." In retrospect, Dr. Black believed her sister was jealous of her science interest. I asked her how those comments made her feel and she stated that the more discouraging her older sister became, the less she would listen to her. She knew what she wanted to do and no one was going to discourage her from obtaining her goals.

Science-Related Gender Perceptions of Dr. Black

When asked if she believed her gender made it harder or easier for her to become a scientist, she thought that it had no bearing at all. At Purdue, her classes were easily made up of half women, and she saw no evidence of bias toward males or against females. She did later state however, that she felt she was encouraged more in science because she was a woman, especially in graduate school. She believed that if she had been male, she may not have been accepted at Purdue, "because their requirements for females might be lower than males." But in the end, she knew she was not "hanging on by the skin of her teeth," because she received numerous awards in graduate school. She feels that she "percolated and rose to the top and stayed there."

Dr. Black did feel as though she has experienced conflict between her self-image as a woman and her desire to become a scientist. It was difficult for her to watch her brother marry and have a family and both of her sisters marry while she was still in graduate school. Her friends were also marrying and having children during that time period. She remembered those times as “rough” times but they never made her want to quit. In fact she stated, “It probably made me want to try harder.”

Dr. Black also experienced conflict between her science career and significant relationships with men. She was very adamant about this being a problem. She stated:

> It takes a very secure man to be involved with somebody whose got a higher degree than them, number one. And I have found that. And the whole fact that graduate school and being a scientist is so time consuming that there’s not a lot of time for that part. But yes, there is major conflict there. I think the biggest one is the whole security thing. A lot of men can’t handle it, being involved with a person with a higher degree. (personal communication, P. Black, November 5, 2001)

But she made it clear that in no way did the conflict between her motivation to become a scientist and significant relationships with men ever affect her desire to become a scientist. She went on to relate a personal story about her mother’s new husband who has a degree in engineering. They have been married for four years now. And Dr. Black said,

> He always feels this need to explain everything to me....He wanted me to know that he was smart. And he knew how things worked. And I finally figured that out and it didn’t bother me anymore. But he used to just drive me crazy. Every time I was there for a holiday or whatever, he’d constantly be explaining stuff to me. It would be stuff I already knew, a lot of it. (personal communication, P. Black, November 5, 2001)

My final question was whether or not she had ever been stereotyped or discriminated against as a woman in science. She responded that she probably had been by her students. Recently some parents of a few of her students called her boss and complained that she was not a good professor. She said that several of the women in the department have had that happen, but none of the men had. She went on to say:
"I don't know what students think because it's a female standing up there. If I do something wrong (pause) if a man does the exact same thing wrong it's more easily tolerated." I then asked her if that experience had affected her motivation for teaching. She replied that yes, it had. She stated,

> I try really hard not to make mistakes because of that. I'm constantly aware of my image to the students. I try not to be too ditzy…I try not to be too much of a stereotypical woman because I know that women are not taken as seriously as men. So I'm constantly aware of that….I'm constantly aware of my image. (personal communication, P. Black, November 5, 2001)

Dr. Jones

Dr. Wendy Jones' (pseudonym) office is located adjacent to Dr. Townsend's office. She was out in the hall when I arrived and showed me into her cubicle. Dr. Jones was a heavy-set woman and she was sporting what I have often heard called a "go-to-hell" hat, into which her hair was situated. She was wearing a floor length skirt, a blouse that did not particularly match the skirt, and no makeup. She was gregarious and charming and I was immediately drawn to her uniqueness. As I set up my equipment, she offered me a bottle of water and we began the interview.

Biographical Information of Dr. Jones

Dr. Wendy Jones is an Assistant Professor of Chemistry at a medium sized university in southeast Georgia. She is 49 years old, married and has three daughters.

Wendy grew up in Ohio and attended elementary and high school there as well. She has two older brothers. Her parents were in education; her father taught high school history and her mother was an elementary school teacher. Immediately following high school graduation, Wendy married. She did not go to college until nineteen years had passed and she had three children. So Wendy was not a traditional college student. She attended Western Kentucky University as an undergraduate and lived in the Bowling Green, Kentucky area. I was excited to hear this as Western Kentucky University was my alma mater, and it is not very often that I run into someone here in south Georgia who attended school there.

Science-Related Experiences of Dr. Jones

We began the interview as the others had begun, with science experiences in childhood. Her earliest memory was asking for an erector set like her brothers had. She "begged and pleaded" for this toy and she stated, " And my parents, in their usual mode, were very reticent to get it for me because they asked me over and over again if I would play with it." She further elaborated that "And of course by the time they got around to getting it for me, I had already picked up on the fact that it was probably not a cool thing for a girl to do." In the end, they did buy her the erector set. I realized while she was speaking that she was the oldest of the women I had interviewed to date and those societal gender expectations were much more prevalent when she was a child than they probably were for some of the others. She also remembered the enjoyment she experienced playing basketball and baseball with her brothers. She later stated:

> There was a limit, I guess because of the times, how much my mother would let me play ball with my brothers.... I pretty much played with my brother's toys. And I was very much into ball. In fact, when I was in Junior High, I was better than all of the varsity players on the basketball team...We had no girls' team then. I had no idea then. But I surely do now. (personal communication, W. Jones, November 5, 2001)

I asked in the follow-up interview what she meant by that last statement, and she explained that she now realizes how important those early experiences were. She also hung out with her brothers outside killing grasshoppers and dissecting plants to see what was inside of them. She lived in a rural area and loved being outside exploring nature.

When asked about positive experiences in school in science, she remembered a sixth grade teacher who took the time to perform meaningful science demonstrations for the class. She enjoyed the time he lit hydrogen gas and still remembers the popping sound it made. She also remembered doing some siphoning in that class. She particularly enjoyed that class because "He did activities. Not just demonstrations, he did that but he also involved the students as much as possible."

In undergraduate school, she excelled in mathematics and eventually took physical chemistry and was also highly successful in that subject. She explained that physical chemistry is very much applied mathematics, which explains her affinity for it. She did enjoy her undergraduate math classes. The experiences in those classes made her realize that she was very good at math and that realization was a positive influence on her. In retrospect she posited, "It's interesting that even though I was an older student, I didn't realize until later, the bearing that did have on me. I can look back on it now and see much more clearly than I did then." She further contemplated whether or not she would have made the same decisions if she had not had those positive experiences in science.

Science-Related Social Interactions of Dr. Jones

Dr. Jones' father was helpful to her as she attempted to complete several science fair projects. He procured the necessary chemicals for one project, and he also helped her with another science fair project in which she constructed a telegraph. Her telegraph was quite elaborate. It was mounted on a large sheet of plywood and had miniature houses, streets, and telephone poles strung with wire. She remembered how her father helped her initially and then encouraged her to complete it on her own.

Another science project she completed involved growing mold. Her older brother helped her grow the mold and then project its image on a piece of paper so it could be drawn. So it seems that Wendy was supported and encouraged by her family as she proceeded with her interest in science.

She did have a negative experience in high school when a guidance counselor took the top six members of her graduating class in for advisement. Three of them were boys and three of them were girls, including Wendy. She stated:

> They gave us this long list of careers that you could go into and the guys were counseled to go into physical engineering. And the girls were counseled to go into nursing, medical technology, or teaching. None of which interested me. And primarily that's why I didn't go to college. Because what they were offering was

> not interesting to me so I just didn't go. And there wasn't enough input from my parents. There should have been, but there wasn't. At any rate, women didn't do those things and my parents were willing to go along with that. (personal communication, W. Jones, November 5, 2001)

So basically, she just decided not to pursue a college education when the options she wanted to pursue were not offered to her. I later asked her in the follow-up interview if as she reflects on that experience it incites anger, and she stated that it had made her angry in the past but that now she tries to focus on the present and "what I can do for myself and others to prevent this from happening to other young women" (personal communication, W. Jones, January 8, 2002). I then asked her if she thought her life would have been different if she had been counseled to pursue physical engineering like the boys had been advised. She said that it was hard for her to predict but that she probably would have gone straight from high school to a university and majored in science or math.

Many of the people who influenced her or motivated her to pursue science as a career were also involved in some of the previously mentioned science experiences. She recalled once again the sixth grade science teacher she had who made science "interesting" basically by conducting a lot of experiments in front of the class and involving the students.

She also remembered a negative experience in high school with a male science teacher who taught physics and chemistry and who was also the football coach. She resented the fact that,

> His biggest goal in life was to put me with his football players in class so that they could do well and pass. And I was not a real perceptive kid but I saw through that and I didn't like it. But it went on. (personal communication, W. Jones, November 5, 2001)

After nineteen years, two marriages and three children, I wondered what made her decide to finally go to college. She related that she had become as efficient as she could as a wife and mother and was ready to try something new.

She believed that her personal and social encouragement came from her family throughout undergraduate and graduate school. She stated, "I think my mother was very favorable. My Dad too at that time." When asked which of her parents supported her more in her efforts in science, she felt that her father probably did since he was the one who helped her with so many science fair projects. And she said, "My husband was very supportive." I asked her if she could tell me a story of how he was supportive to her and she replied, "When I decided not to go into medicine, but to go into chemistry, he was the first one to tell me that I needed to go to graduate school. He's been very supportive all through the years." I then asked what he did for a living and she told me that he was an artist and he worked from their home.

She also had an aunt, her mother's sister, who was very discouraging. Dr. Jones remembered,

> She was constantly telling me that I needed to go get a job. Because my mother did some childcare for me. And I think she perceived that as being hard on my mother. But my mother seemed to be doing it willingly enough.... I remember after I got my Master's degree, Aunt Nita wrote me a card and said, 'Now I hope

In undergraduate school she had a positive experience with her college algebra and trigonometry teacher in her first semester. She recollected,

> He told me before the end of the semester that he thought very strongly that I should go into mathematics, because I was very good at it. And so that was a positive reinforcement....So that was probably the first positive thing I had. (personal communication, W. Jones, November 5, 2001)

The second person who impacted her in a positive way in science in undergraduate school was a female chemistry teacher. She related that she established a good relationship with her and, "we would sometimes sit and chat and other times talk about chemistry." Dr. Jones' interaction with this teacher was "very positively motivating." The relationship with this woman still continues today. In fact, they recently spent some time together when Dr. Jones attended a meeting in Cincinnati, where this woman now works and lives.

Also at Western Kentucky University she did a lot of work in the biology lab for the department head (she also had a degree in biology from WKU) who was male. There were several students working in the lab with her, both male and female and she perceived that environment as a "mentoring place" where "there was a lot of support there for science."

Since she was an older student who was married and had children, she did not form the peer support groups in undergraduate school that are often so helpful. She remembered that the younger students did not associate with her unless they wanted to use her. She said they would say things like, "Let's work with Wendy because she knows what she is doing and we can suck her brain dry." She was aware that she was being used but she felt that,

> Even the most uninformed, most unstudied person in the class can often give you help when you can't figure something out. So I participated in some study groups in the upper division chemistry. (personal communication, W. Jones, November 5, 2001)

In graduate school at Ohio State University, Wendy was assigned to an older male advisor. She remembered him as being "very tight-lipped and very supportive." And she felt that "he did the best for me that he could." Also at Ohio State she recalled that there were lots of women to interact with. The area of research that she went into was led by a female chemist with a Ph.D. in crystallography. Dr. Jones spoke of her as being "very good." She went on to say that this woman

> was primarily responsible for getting me involved in things like posters and presentation of my material, which was not the strong suit of my advisor, since he was older....So she was largely responsible for socializing me into that aspect of science. (personal communication, W. Jones, November 5, 2001)

In graduate school she was more accepted by the other students. She told me,

> I had friends, but not the kind of friends that I would probably do anything with outside of school because I was married and had a family. But we hung together. The last group I was with was three women.... One of those ladies actually went with me to purchase an appropriate scarf to wear with an outfit I was wearing to give a presentation. Which is something you couldn't get from a guy probably

> (laughing)....So there was a lot of positive things like that. (personal communication, W. Jones, November 5, 2001)

Science-Related Gender Perceptions of Dr. Jones

When asked if she felt her gender made it easier or harder for her to become a scientist, she felt that it had made it harder because of the social expectations for women concerning childcare and other family issues. The fact that she had a family with three daughters who she wanted to stay very involved with and also go to school was a very difficult situation for her. This statement led me to ask her to elaborate further on the conflict she was experiencing between her goals to pursue a science career and family obligations. She conveyed her feelings to me in this way:

> Being married and raising a family and trying to work both ends of the candle (pause) I think it puts really tough strains on anybody to be married and have kids, but more so on women. Because like it or not, we're still expected, in most cases, to be the ones that raise the kids, that do certain household tasks. I see that changing, but the ultimate basis hasn't really changed. (personal communication, W. Jones, November 5, 2001)

She tried to explain how she would deal with the simultaneous demands of family and school by examining and evaluating each situation that arose. She stated that if something came up that was truly a "life-threatening situation" she would definitely choose for her family. But if it was something someone else could take care of, she "opted for school."

I then asked about conflicts between her relationship with her husband and her desire to pursue a science career. She replied,

> Yeah, it was really tough. The first year or two probably wasn't so bad but when you go on and on for six years, it is very tough. And I would have to say that if it wasn't for the dedication that both of us had to hold the marriage together, we probably wouldn't have stayed together. Because if you have someone you are supposed to be having a relationship with and they're always gone, even when they're physically there they're gone mentally, it definitely has an affect on you. (personal communication, W. Jones, November 5, 2001)

I then asked her if this apparent conflict had affected her motivation to become a scientist. She replied that sometimes it probably did, but "I think the need to finish what I had started was uppermost."

When asked if she had ever been discouraged as a young girl from going into science she again recalled the counselor in high school who she feels directed her away from science because she was female. I asked how she dealt with that discouragement and she replied:

> Well, as a younger person, I think I let it affect what I did or didn't do. Living up to expectations that were told to me. But I think by the time I got to the end of my undergraduate career, that it had taken a decided change for the opposite. In that I didn't look at what one small group or what one person said and let that affect me anymore. (personal communication, W. Jones, November 5, 2001)

My final question was whether or not she had been stereotyped or discriminated against as a woman in science. She recalled an experience she had when she was trying to get into graduate school. She had sent in applications to five different graduate schools and she had heard back from all of them except the one she was most interested in attending, Vanderbilt University. She finally called them and inquired about her application and they invited her to come for a visit. She thought that was very strange and wondered why they would want her to come and visit before telling her whether or not she was accepted. So she did make the visit and apparently she was discouraged from attending graduate school there primarily because she was married and had children. Although she was eventually invited to attend school there, she decided that she would be wise to choose another school where attitudes were more encouraging towards women with families pursuing advanced degrees in science. She went on to say that the attitude was totally different at Ohio State and so that is where she attended graduate school.

Dr. Johns

I initially learned of Dr. June Johns (pseudonym) through her daughter-in-law who was in the doctoral program with me at Georgia Southern University. Marsha gave me her mother-in-law's email address and I contacted her about my project and asked her if she could participate and she agreed. So we made a date to meet on November 29, 2001 at 4:30 pm at her office on the campus of the university where she is employed. She had read the questions ahead of time and had given them some thought. Her office was a long, narrow room filled with books. Most of the books were various genetics textbooks. She cleared a space for me to set up my equipment and we chatted for a moment and then began the interview.

Biographical Information of Dr. Johns

Dr. Johns is married with three children and did not want to disclose her age but I would guess that she is near 70 years old. She grew up in southeast, Georgia and has two brothers and two sisters, who are twins. She is the youngest of the children. When she was growing up, her mother was a housewife and her father was an attorney. Her mother had taught school but quit when she married. Following graduation from high school, Dr. Johns attended the same university where she now teaches. She received two degrees, a B.S. in biology, and a B.S. in education. She then attended the University of Georgia in Athens where she obtained a Ph.D. in microbiology. Today, she teaches and conducts research in microbial genetics with the fungus Neurospora.

Science-Related Experiences of Dr. Johns

I initially asked her to tell me some stories about any early experiences she may have had that might have motivated her to become a scientist. She was quick to reply that she has never really considered herself to be a scientist, but rather a biologist or a geneticist or a microbiologist. She stated, "I grew up on a farm and of course we had lots of plants and animals and things there." She went on to say that they had several cats. And when I asked if she enjoyed playing outdoors, she stated, "That was my life. That's all I knew." I asked if it was okay with her parents if she played outdoors and got dirty and she laughed and said emphatically, "Oh yes!! That's where we were supposed to be." But she could not recall any early experience that she would consider to be influential as far as motivating her to pursue a career in science. In the elementary to ninth grade years, she said that there were not a lot of science opportunities.

In high school she took chemistry, physics and math. She particularly enjoyed math. She said, "I like math. You wouldn't know it looking in here, but I like an orderly system of things. And I liked math and chemistry and physics and I took those and enjoyed them." When asked if she could recall any particular things that she did in those classes, she related,

> No, other than taking mercury and putting it all over everything. That used to be the big thing to do; put it on rings and watches. Let the little balls run. Lots of things like that. Even in college chemistry we did all sorts of things that you wouldn't do now. Even in biology....We did a lot with blood. (personal communication, J. Johns, November 29, 2001)

Dr. Johns believed that her interest in science has probably always been there because she has always been curious, and has always loved to solve puzzles. She studied the things she enjoyed and those things were math and science. I asked her how engaging in those experiences made her feel and I realized that seemed to be quite an abstract question to her when she laughed. I told her that I knew it was abstract but she replied about how her experiences in science today make her feel. She stated,

> Well, I guess I can tell you something about the research that I do now. It's a lot of work. It's a lot of staying behind and doing the same thing over. And a lot of times things don't work. But there's that time that it DOES work. And you know you are seeing something that nobody else has seen. And it's just exciting. (personal communication, J. Johns, November 21, 2001)

I then asked her if she could recall experiences she had in undergraduate science classes and she was more successful in remembering some of those times. She remembered making media (food) for the flies they used in the genetics course she was taking. Today they use instant media, but at that time it had to be cooked. She said, "It was cornmeal and molasses and other stuff. And it smelled so good cooking late in the afternoons when it was cold outside (laughing)."

She knew immediately when they got to the genetics part of the general biology course she was taking in undergraduate school that that was what she wanted to do. Genetics was all of her favorite things put together. It was a combination of biology, math, physics, and chemistry. I asked if she liked genetics more than the other sciences because it was more structured and mathematical and she replied, "That may have been the reason. And it's not that I didn't like the other sciences. It's just as far as I'm concerned, genetics is the basis for all of this." She gestured out as she made that statement, meaning genetics is the basis for all of life, for all of the world. When asked what she thought she may have gained from her experiences with science in college she said that she just likes to study and she likes to know how things work.

The only discouraging moments that she reported on her journey to becoming a scientist were those related to the research itself, the times when problems arose and she had to start over. She recalled feeling discouraged:

> When I had a rat that I was depending on and it died (laughs). And when I worked with Neurospora and I had crosses that I made and they got contaminated. Those are setbacks that you have and you have to go on. (personal communication, J. Johns, November 29, 2001)

So most of her discouraging moments were more on the level of what was taking place in the lab. She went on to say, "You always hope everything will work, but it doesn't. And you have to learn that a lot of times that it's not going to work. And you have to use that to re-group and go from there."

I asked her to reflect back on the experiences that she had going through school and see if she could convey to me what they mean to her today. She replied, "Well, all your experiences are important to you because that's who you are. That's what makes you the person you are, the different experiences you have." So then I specifically asked about the meaning the experiences she had with science holds for her today and she said,

> Well, this is where I am. It's important. It's important to me to go to meetings. It's important to me to be associated with other people in the same field and have exchange there. All those things are important. (personal communication, J. Johns, November 29, 2001)

Science-Related Social Interactions of Dr. Johns

We then moved on in the interview to the category of social interactions as I asked her about teachers she may have had in grammar school who were positive influences on her. She said that there were several:

> Miss Lily Deal was an English teacher….And I remember that one of the things that she kept pushing at that time was that people should plant pine trees... And she got that information from places, and told us how much money the pine tree would bring in and all of that. And then there was Miss Mary Lou Carmichael in social studies. She had us do Georgia scrap books…. I didn't realize it at the time, but they saw to it that we got a lot of experiences. In college I had lots of good professors….John Cooper (pseudonym) was a very unusual person. And I had courses with him, both as an undergraduate and graduate….He brought in a lot of things, a lot of enrichment….And then in Athens I had the most wonderful major professor. And the members of my committee. We all remained friends through the years. (personal communication, J. Johns, November 29, 2001)

Since Dr. Johns was the eldest of my participants, I was interested to know how many women professors of science there were while she was a student. She said that she did have one female chemistry professor in undergraduate school. She recalled, "She was probably the only one in chemistry. I don't know of any in physics. I was probably the first in biology" (personal communication, J. Johns, November 29, 2001). In graduate school she said there were a number of female science professors including one woman who came down with a group from Yale. This woman was in the microbiology department and has since retired.

Dr. Johns told me that her parents were not a source of encouragement. She stated that she was "left to her own devices." Not that they were discouraging. When she told them what she wanted to do with her life, they were neutral about it. She did not have any friends that either discouraged or encouraged her along the way either. She was just pretty much on her own. She preferred to study by herself rather than studying with a group because, "we ended up socializing. Or someone had not prepared and we ended up spending a lot of time trying to pull them along. It just never did work." She does recall that in her undergraduate years that there were several female students in the science classes with her, although she does not think the percentages then were as high as she sees now in the courses that she teaches.

In her graduate years she said that her committee members were always very supportive and have continued to be throughout the years. She said,

> The department was an unusual department. It was an atmosphere of cooperation and learning. So that was the sort of system I was in and the department is still

> pretty much that way, which is sort of unusual. (personal communication, J. Johns, November 29, 2001)

She never recalled ever meeting up with anyone who tried to dissuade her from pursuing a career in science. And if she had, she said it would not have mattered because she would not have listened to them anyway.

Science-Related Gender Perceptions of Dr. Johns

When asked if she felt her gender made it easier or harder for her to become a scientist, she said she "never really thought it made any difference. I didn't get any special concessions and I didn't get any opposition either. I was just one of the class." I was amazed that she had never met up with any opposition, especially in the time that she was going to school and I told her that. She said maybe there had been some opposition, but if there was she did not know it. She was determined. She told me,

> I've always pretty well known what I wanted to do. And I've always pretty well known how to go about doing it and accomplishing it. And if I didn't know what I wanted to do, I certainly knew what I didn't want to do. And I could eliminate that very quickly. (personal communication, J. Johns, November 29, 2001)

Dr. Johns also reported never feeling any conflict between her self-image as a woman and her motivation to become a scientist. Nor did she report any conflict between her goals to become a scientist and her relationships with men. She told me that she married right after high school to a man who worked for a wholesale grocery company. So she attended undergraduate school as a married woman and then went off to graduate school and left him behind with three children to care for. I was very surprised at that. The children were much older at that time. She went to Athens for two consecutive summers and then returned home and taught for a year and then went back to Athens for four quarters. She drove back and forth to Athens, staying there three to four days of each week until she finished. I asked her if her husband had any problem with her being gone so much and leaving him with the children and she replied,

> Oh no. Of course the oldest one was in college by the time I went up the first summer. The second one was two years behind her, and the third one graduated high school the same year I finished my degree. But it wouldn't have mattered. He could have taken care of them, little or big. He's a good cook (laughs). (personal communication, J. Johns, November 29, 2001)

When her children were younger, her mother and mother-in-law were instrumental in caring for her youngest child. So she had a good family support network.

When asked which of her parents she identified with the most, she felt that she identified with both of them equally but in different ways. She said that she learned to sew from her mother and to cook from her father. Her father rode horses with her and her mother was involved with her in drama productions.

She believed the reason she was never discouraged or disheartened during the period in which she was working on her dissertation was because she was older and wiser than she would have been if she had started college right away. She stated,

> I knew that these things come along and not everything is going to work and you've got to stay with it. There's no need to let it get you down and bother you. There's going to be another day tomorrow. (personal communication, J. Johns, November 29, 2001)

Dr. Johns also never felt as though she had been discriminated against or stereotyped as a woman in science. I was certainly surprised with the outcome of this interview. I had thought that Dr. Johns, having grown up in times when women were often not encouraged to go to college, much less to pursue a career in science, would have reported tremendous adversity. But she seemed to have had a smoother road than all of the other much younger women interviewed for this study.

CHAPTER VI

INTERPRETATION OF MOTIVATIONAL THEMES ACROSS WOMEN SCIENTISTS

In this chapter, I will attempt to broaden and deepen our understanding of the different ways that women scientists are motivated to pursue science and further explore meaningful answers to the research questions as provided by the seven women scientists participating in this study. This exploration will further enrich our understanding of motivation with thick descriptions of motivational experiences and insightful themes that connect these motivational experiences. I will also interpret the different motivational themes across all seven women scientists and across developmental periods. In addition, I will also provide a fusion of horizons by personally sharing my understandings of and reactions to the constructed themes. Although I am not a woman scientist with a doctorate in a hard science, I do have my own understanding of how that process takes place based on my formal and informal experiences with science and also based on my in-depth study of this research.

Science-Related Experiences

Preschool Through Elementary School Developmental Period

In the category of science experiences and in the developmental period of preschool through elementary school years, all seven women scientists interviewed reported meaningful motivational experiences with science. These motivational experiences (themes) included enjoying and exploring nature and the outdoors, playful informal science experiences, fun formal science experiences, and educational success.

Enjoying and Exploring Nature and the Outdoors Motivational Theme

One of the prevailing themes that emerged across all seven of the experiences of the women was that of enjoying and exploring nature and the outdoors. These experiences ranged from exploring nearby wooded areas and streams to learning to chemically balance the family's pool water to interacting with pets and farm animals. I was not surprised that six of the seven women believed these early experiences with nature served to peak their curiosity about science. Certainly I experienced similar feelings exploring the woods and fields of the Kentucky farm where I spent a large portion of my childhood. I can still recall the curiosity and excitement I experienced when I discovered something I had never seen before (like a circle of mushrooms growing in a field, or a strange insect that blended in so well with a tree branch that it was barely visible). So I can certainly identify with the fact that those early spontaneous interactions with nature sparked scientific curiosity. I was somewhat surprised however, to find that all of the women participants had opportunities as children growing up to interact with nature; I am sure there are many children in large cities who are not as fortunate.

Dr. Scott recalled "messing around" outside. Her grandparents lived on a farm nearby and she had ample opportunity to interact with the farm animals, cats, and dogs. Dr. Adams told of the enjoyment she experienced playing outdoors as a child and helping with the family garden. Dr. Nix spoke of helping her father maintain the family pool by monitoring the pH and chlorine levels. Dr. Black particularly enjoyed experiences outside as a child because she lived in a rural area with forty acres of woods full of trails and a creek that ran through it. She remembered collecting organisms from the creek and exploring the entire area. She and her sister would try to figure out why the organisms they collected always died. In retrospect, she felt as though they were doing experiments out in the woods without realizing it. Dr. Black spent a great deal of time outdoors as a girl exploring the creek and wooded areas around her home. Dr. Black's early unstructured interaction with nature and the outdoors was so profoundly motivating that she credits those experiences with her decision to become a scientist. Dr. Jones also lived in a rural area and remembered playing outside with her older brothers, killing grasshoppers and dissecting plants to see what was inside them. And Dr. Johns grew up on a farm and the outdoors was all she knew. She had lots of cats and dogs and farm animals and her parents expected her and her siblings to play outside. She loved the outdoors and was encouraged to explore and get dirty.

Playful Science Experiences Motivational Theme

Five of the seven women scientists remembered motivational science experiences including playing with science-related toys, role-playing with science, and visiting science museums that took place in this early developmental period and were provided by their parents. I was somewhat surprised that so few of the women asked their parents for science-related toys, but only two of the women knew that they wanted to pursue science-related careers at this earliest developmental period. Like the informal interactions with nature and the outdoors, these early informal and enjoyable science experiences left lasting impressions with many of the women participants.

Dr. Scott remembered her parents getting her nature cards that came through the mail every month. She categorized them and stored them in a case as she collected them.

She recalled the enjoyment she experienced from reading about the different plants and animals portrayed on the cards each month. Dr. Townsend was fortunate enough to receive a chemistry set one Christmas during the year she was in the second grade. She made hand lotion, mixed chemicals and put them on her cat, causing the cat to lose its hair and even set the linoleum on fire in her garage. She kept referring to that chemistry set throughout the interview as a significant motivational factor in her decision to pursue science as a career. Dr. Adams played with Barbie dolls, like many little girls, but her dolls were always portrayed as surgeons in her imagination. She said they were surgeons because that is what she wanted to be when she grew up. Dr. Nix remembered her parents taking her to a science museum as a young child. She recalled sitting on her father's shoulders and looking at dinosaurs and all of the other "cool" things they had there. She also remembered playing with a friend who had a microscope. They would make slides of their own urine and look at it under the microscope, thinking how "cool" it was. Dr. Jones received an erector set one year for Christmas. Her older brothers had one and she begged and pleaded until her parents got her one too.

Fun Formal Science Experiences Motivational Theme

Four of the seven women scientists reported that their teachers in this early developmental period provided fun science experiences for them within the school setting. All four of these women remembered these early science experiences as motivational, interesting and fun. I believe that this developmental period should be one in which there are numerous opportunities for children to interact with formal yet fun science experiences in the school setting. When talking with the elementary school teachers in the county where I am employed, I have learned that most of them take very little time with science in their classes. Many of these teachers do not feel comfortable with the depth of their own scientific knowledge, therefore science is often neglected or completely left out of the curriculum. I believe that this early developmental period is a critical time in which many girls (and boys for that matter) could be turned on to science if the opportunities to investigate and explore science were provided by their teachers.

Dr. Scott remembered the fun she had in elementary school doing a science project with leaves. She had to collect various species of leaves in the fall, classify them, and rub a crayon over them on pieces of paper to make impressions of them. She particularly enjoyed the artistic part of that project. Dr. Townsend mentioned the motivational significance of enrichment classes she participated in during her elementary school years. She recalled several projects that she engaged in that revolved around science including making a model of the solar system, studying lunar rocks, and preparing a presentation to give to the class about a particular dinosaur. Dr. Adams recalled some pleasant experiences with science in the first grade when her teacher created a series of "stations" (learning centers) pertaining to various land biomes, including the tundra, grasslands, and wetlands. She said that she "thought it was terrific and enjoyed it." Dr. Jones recalled enjoying science demonstrations provided by a science teacher when she was in the sixth grade. She remembered hearing the popping noise created by hydrogen gas when the teacher lit it and she remembered two science fair projects she was involved in. One time she constructed a telegraph device, complete with miniature houses and telephone poles strung with wire and mounted on plywood. She also grew mold and projected it onto paper and traced it for another project. Both of those projects aroused her interest in science. Dr. Johns reported that there were not a lot of science opportunities for them at that age because of the state of the economy during the war and the lack of funding. Neither Dr. Nix nor Dr. Black recalled any particularly motivating science experiences in elementary school.

Educational Success Motivational Theme

Two of the women scientist participants were motivated by their own high achievement and good grades in science and other academic subjects at this earliest developmental period. One year I taught science to preschool and kindergarten students and I can still recall how excited and motivated the children became when they understood a scientific concept or were successful in completing a science project. In my own experience as an elementary school student, I remember being excited every time I made a good grade. Therefore, I wanted to continue making good grades because when I was successful, I felt good. The women participants also reported that doing well in science was encouragement in itself.

Dr. Townsend remembered being encouraged by the fact that she was good enough to be placed in enrichment classes in elementary school and that she was always pretty good in math.

Dr. Nix recalled always doing well in school, from elementary all the way through graduate school. She recalled, "I was always the person, who from the first grade, was in the top reading group….In fourth grade I placed in sixth grade math….I was always good in school" (personal communication, D. Nix, November 21, 2001).

Personal Meanings of Early Science Experiences

When asked if they could relate the meanings these early science experiences had for them, all of the women reported that the experiences were profoundly significant in their decisions to become scientists. Dr. Scott felt that the opportunities she experienced outdoors were very important to her and she looks back upon them with fond memories. Dr. Townsend credited her explorations with the chemistry set that she received for Christmas as a defining moment in her decision to become a scientist. She also had this to say about the importance of her early science experiences:

> I think they were very important. I really think those enrichment classes did a lot for me. Because I had that experience from first grade until fourth grade...And so I think that those sort of shaped how I saw science. (personal communication, J. Townsend, November 5, 2001)

Dr. Adams believed that her early science experiences "opened up her mind...and increased her awareness." She went on to say that they made her "realize that there's things out there far beyond what you can imagine" and that they "sparked an interest" in her for science (personal communication, M.Adams, November 5, 2001). Dr. Nix placed more emphasis on the effect those early science experiences have on what kind of encouragement she provides for her own child, what kind of toys she buys her, and the influence she has on her. She did say that her early motivational experiences with science are part of the puzzle, helping to make her who she is. Dr. Black believed that her early science experiences had a staggering effect on the path she chose in her life. She related,

> I just think to myself (pause) this is one of those staggering questions that give me chills down my spine. Where would I be had I been raised in the city? Had I been raised in a forty story high rise? I don't know the answer to that. That's kind of scary. But everything that has happened to me, everything that I have done, has led me to this chair. (personal communication, P. Black, November 5, 2001)

She also believed that those early science experience made her curious or "tapped her curiosity." Dr. Jones stated that she did not realize until later the bearing her science experiences had on her. She further contemplated whether or not she would have made the same decisions if she had not had those positive experiences in science. Dr. Johns felt that all of her collective experiences were important to her "because that's who you are. That's what makes you the person you are, the different experiences you have." She went on to say that her early experiences with science hold a great deal of meaning to her because, "This is where I am. It's important" (personal communication, J. Johns, November 29, 2001).

Science-Related Experiences

Middle School through High School Developmental Period

All seven of the women scientists participating in this study reported an increase in science experiences during this second developmental period. All of the motivational science experiences reported were science experiences provided in a formal school setting. Many of these experiences were reported to be motivational to these women because they were made fun and interesting. As a high school science teacher, whenever possible I attempt to make science an enjoyable and interesting experience. I have been told numerous times by graduating high school seniors (my former students) that they learned the most about science in my classes because I took the trouble to make science interesting and fun. Likewise, I still remember certain scientific laws and concepts because my high school biology teacher taught them in a memorable and enjoyable manner.

Other experiences in science reported at this developmental period were motivational to the women participants because they were successful at them. Two of the women recalled that because they were good in science and understood it, they were motivated to further study science and even help other students who were not faring as well.

Formal Science Experiences Made Fun and Interesting Motivational Theme

Each of the women reported that they enjoyed science and understood it better when they had fun while learning about it. Formal science experiences reported by the participants at this developmental period ranged from dissecting fetal pigs in biology, to investigating the motion of toy cars in physics to building a model car for a Science Olympiad competition.

Dr. Scott recalled "messing around" with slide rules in high school chemistry. She enjoyed using the slide rule and quickly mastered it and so soon she was helping other students. She remembered several fun physics labs in high school including rolling balls down inclined planes to calculate speed and velocity. And in biology she recalled dissection as a fun experience. When asked how important it was that science experiences were made to be fun in junior high and high school she replied, "Oh, that's the attraction…if it's fun, then you can learn something from it" (personal communication, J. Scott, October 22, 2001). She also worked with projectors and video cameras in high school and videotaped all of the school's basketball games. Dr. Townsend remembered "doing a lot of cool things" in her high school science courses. In high school chemistry, for example, she recalled making aspirin and soap. What was relevant to her at that time was that they were actually making something. She also enjoyed learning about how things worked in high school physics, using toy cars to study force and velocity. In high school biology she especially enjoyed dissecting a fetal pig, saying, "that was really neat to me" (personal communication, J. Townsend, November 5, 2001). Dr. Adams also enjoyed dissection in her high school biology class. In fact, she stated that it was "the highlight of the science experience" and "phenomenal" (personal communication, M. Adams, November 5, 2001). In her biology class, they dissected worms, frogs and fetal pigs. She said what she liked most about dissection was the fact that the "pig is the closest anatomically to a human. And so it was absolutely fascinating to see how you were set up on the inside" (personal communication, M. Adams, November 5, 2001). Dr. Nix recalled several motivational science experiences that began in her high school years. She remembered visiting an amusement park as part of her physics course where she "got to see how the rides were related to physics" (personal communication, D. Nix, November 22, 2001). In her high school chemistry class they "made aspirin and some other cool things" (personal communication, D. Nix, November 22, 2001). She was also part of a team of students who were selected to participate in a Science Olympiad where they constructed a life-sized vehicle to compete against vehicles constructed by teams from other schools. She was the driver and her team's car was the fastest one, which was particularly motivational to her since she enjoyed competing and winning. Dr. Black remembered an ecology class in high school in which the students studied the dynamics of a wood lot over time. Data had been collected for the past ten years and they divided the lot into quadrants, counted the number of trees and type of trees and measured the circumference of the trees in each quadrant and compared it to previously collected data. She said that she really enjoyed that experience. She also recalled enjoying the construction of a solar system to scale, complete with clay planets and growing plants in a horticulture class in high school. Dr. Johns remembered playing with mercury in a high school chemistry class. She recalled being fascinated by how the mercury rolled in balls and she enjoyed watching it move over watches and rings.

Educational Success Motivational Theme

Their own high achievement and good grades in science motivated two of the women scientists. Therefore, doing well in science was encouragement in itself for these two women.

Dr. Scott recalled that she did well and understood what was going on in her science classes and that motivated her and encouraged her to continue doing well. She remembered the success she had with the slide rule in her high school chemistry course and subsequently helping other students to master its use. She stated that she:

> did well in the classes and that was one of the things that motivated me, that I was good at it. Or I understood what they were talking about or something. That encouraged me to continue doing well in it. (personal communication, J. Scott, October 22, 2001).

She also recalled being encouraged by all of her teachers in general for making good grades. About her high school experience, she said:

> My teachers were very encouraging because I got very good grades. You know...in everything...I got good grades at that point. And so everybody was encouraging me...you know I was the one they would pat on the head or whatever. (personal communication, J. Scott, October 22, 2001)

She also recalled about her high school experience:

> I probably perceived it that way [teachers encouraging me] more than they were actually singling me out as being the best person in the class or whatever because there was a group of us that were kind of...you know...the best in the class. (personal communication, J. Scott, October 22, 2001)

Dr. Nix remembered science as being easy to her in middle school and high school. She stated, "I would ace the tests because they were always so simple for me....So I never had to work at it" (personal communication, D. Nix, November 21, 2001). She tested into algebra in junior high and was relieved to get out of the "boring" general math classes. She said, "When I got to algebra I thought, 'Finally here's something new.' And so that was more positive to me to do something else rather than the same old monotonous garbage" (personal communication, D. Nix, November 21, 2001). In high school chemistry she remembered, "It was easy. I wrote down the notes and remembered what I wrote" (personal communication, D. Nix, November 21, 2001). Throughout the interview, Dr. Nix continually referred to her competitive nature. She loved to compete against others and win. This behavior began in elementary school and continued through graduate school. When she made the highest grade or when she won something, she stated that "it was meaningful to me because it proved that I was where I belonged" (personal communication, D. Nix, November 21, 2001).

Science-Related Experiences

Undergraduate School through Graduate School Developmental Period

All seven of the participants in this study reported engaging in many enjoyable science experiences at this level but these experiences had increased in seriousness and decreased in enjoyment to some degree. So the fact that science experiences became less enjoyable and more serious appeared as a motivational theme. Another motivational theme that emerged in the category of science experiences in the final developmental period was fear of failure. Three of the women scientists reported experiencing a fear of failure that served to motivate them to continue studying and working toward their science career goals. And as discovered in the first two developmental periods, educational success as a motivational theme appeared again in this final developmental period. It was during undergraduate and graduate school that the women scientists began to focus on particular scientific areas that were interesting to them. When they did well in an area and experienced success in it and enjoyed it, they were motivated to continue to study it or conduct research in it. The fourth theme to emerge in the category of science experiences at undergraduate to graduate developmental period was that of relevancy of science to real life. Five of the seven women scientists reported that when science was made relevant to them, when its applicability and practicality was exposed, they experienced higher levels of success in it.

Experiences Increase in Seriousness and Decrease in Enjoyment Motivational Theme

Science concepts were taught at a much greater depth at the undergraduate and graduate level and the women participants recalled the tremendous amount of time and energy they expended conducting experiments and studying. I was not surprised at the fact that science became much more serious at this developmental period because I certainly experienced the same thing as a biology major in undergraduate school. Science experiences were still fun, but they also became much more serious as I had to spend so much time studying and completing lab requirements at night for chemistry and physics courses.

Dr. Townsend remembered spending a great deal of time at the chemistry lab during her undergraduate years and most of the rest of her time studying. Dr. Adams recalled the rigor involved in her graduate experience, often having to spend the night in the chemistry lab, sleeping in a lawn chair. Dr. Nix spent part of her time as an undergraduate volunteering at a large university hospital. She was hoping that the experience would help her gain entrance into medical school. But when she shifted from doing transplant follow-up work to helping on the trauma floor, she realized she could never be a physician because the emotional aspect of the illnesses and injuries was too traumatic for her. She also remembered the positive motivational experience of joining a new research group in graduate school. The assistant professor heading the group was newly hired and had to start her research from the ground floor. Dr. Nix enjoyed the process of planning the lab and getting everything set up and going. She saw that experience as fun yet challenging because she got to "see how everything went together" (personal communication, D. Nix, November 22, 2001). Dr. Black remembered a hematology class she took as an undergraduate in which the students drew each other's blood and conducted both red and white cell counts. She also recalled an especially enjoyable parasitology class in which she examined various slides of parasites including ringworm and other fungi that grows in the human body. She described those activities as "cool." Her favorite class as an undergraduate was organic chemistry because it "just made sense" to her. In graduate school after a discouraging time with a research group whose area was not interesting to her, she joined a new research group and from that point on she said, "I loved every single thing that I did" (personal communication, P. Black, November 5, 2001). In this new group, they were actually synthesizing compounds to be sent off to drug companies. Dr. Jones excelled in mathematics in undergraduate school and eventually took physical chemistry, which is applied mathematics, and did well in that subject also. She also remembered doing a lot of work in the biology lab in undergraduate school and enjoying the atmosphere of support for science that she found there. Dr. Johns remembered making media (food) for flies in her undergraduate genetics class. She recalled how good it smelled cooking on cold winter evenings. She realized she wanted to be a geneticist when she studied about genetics in her general biology course. It was a defining moment for her as she realized that genetics was a combination of all of her favorite sciences.

Fear of Failure Motivational Theme

Three of the women scientists reported experiencing a fear of failure that served to motivate them to continue studying and working toward their science career goals. It is interesting to note that this fear of failure was most predominant in the final developmental period explored in this study. I identified with the feelings these three women expressed as I also experienced a fear of failure as a biology major during undergraduate school and as a doctoral student in graduate school. That fear made me study longer and harder and kept me from giving up. Perhaps many people experience similar feelings but do not admit to those feelings, because they may indicate a sign of weakness to some people. The women scientists participating in this study indicated that they used their fear of failure as a motivational tool to increase their determination and drive to succeed in science.

Dr. Townsend remembered constantly worrying when she got to graduate school that she was going to fail; that she would have to leave. She said, "I don't know, I think it must be a family trait, but we don't fail at things. Just being sort of average is bad enough I felt like. But I was really worried that I was going to fail…" (personal communication, J. Townsend, November 5, 2001). She later stated that when a professor in undergraduate school hinted that maybe she should not go to graduate school because he did not think she could do it, she decided, "Well, I'll show you I can too" (personal communication, J. Townsend, November 5, 2001). So although it was a negative experience, she used it to motivate her to succeed. Dr. Adams stated that her biggest motivator in both undergraduate school and graduate school was, "Fear of failure. Plain and simple. I was not going to fail; it was never an option. I refused. I was not going to give my family the right to say 'I told you so'" (personal communication, M. Adams, November 5, 2001). Her fear of failure was mentioned several other times in the interview. Dr. Nix related that she has always been a competitive person. Her desire to win and not fail was an oft-repeated motivational tool mentioned throughout our conversation.

Educational Success Motivational Theme

Once again, educational success emerged as a motivational theme in the third developmental period explored in this project. Doing well in school, making good grades, and experiencing success motivated the women participants at every developmental period. For some women scientists, educational success meant doing better than other science students. Educational success with science as a motivational theme was one of the most prevalent and meaningful themes that emerged out of the stories shared by the women scientists. I have realized from the stories shared by these women that making good grades is a powerful motivator, much more so than I had thought.

Dr. Black remembered that her success in organic chemistry was a motivating factor for her. She loved it so much that she decided to make chemistry her major. She stated that she "just got it." And at that moment she knew she wanted to be a chemist. Dr. Jones found out she was good at math and science at the high school level. But when she got to undergraduate school she realized she was also good at it at a much higher level. In fact, her college algebra and trigonometry teacher told her he thought she should pursue a career in math since she was so good at it; so that was certainly a positive motivating moment for her.

Relevancy of Science to Real Life Motivational Theme

Five of the seven women scientists interviewed related how important it was that their experiences with science were made relevant to their lives. They indicated that when they could see what they were doing was applied, that when it was relevant to society and to themselves, their interest was piqued and they experienced higher levels of success in their science courses and science research. This research finding is not surprising to me because I recall two semesters I spent conducting research under the guidance of a professor, in which I did extremely well because I saw the relevancy of what I was doing. Because I was able to explore an organism with the electron microscope, take pictures of it, and then develop those pictures, the concept I was investigating became more real to me.

Dr. Nix recalled the enjoyment she experienced as she helped to develop a research program for a newly hired Assistant Professor at her graduate school. She particularly appreciated not being thrust into an ongoing research project, but rather she was involved in the entire research set up, from ordering lab equipment to the design of the lab itself. This made the entire research process much more relevant to her.

Dr. Black realized a turning point in her science career when she switched research groups as a graduate student. She recalled.

> The research that my second advisor was doing was much more applied, right there, you could actually see it. And that sparked my interest. I'm such a practical type of person that I can't do theoretical type of research. I have to do much more applied type of research. We would actually synthesize compounds that we would send off to drug companies..... And the drug companies would change it a little bit here and a little bit there to try to get it to behave more like they wanted it to behave. But it was so applied. Right there. You could see it. And that's what sparked my interest I guess. (personal communication, P. Black, November 5, 2001)

Dr. Black also recalled identifying with her parasitology professor, who was also an MD because he was so practical. She remembered that one semester he would teach parasitology and the next he would go to Africa and diagnose and treat parasitic diseases and then he would return and teach again. She stated, "I could see the practicality of what he was doing right there. Because he would actually teach it and go do it" (personal communication, P. Black, November 5, 2001).

Dr. Adams' Introduction to Chemistry professor "related everything to real life." She remembered "that certainly sparked my interest in chemistry" (personal communication, M. Adams, November 5, 2001).

Dr. Johns ultimately chose genetics as her preferred field of study because of the relevancy it holds to everyday life. When asked if she liked genetics more than the other sciences because it was more structured and mathematical, she replied, "That may have been the reason....It's just as far as I'm concerned, genetics is the basis for all of this" (personal communication, J. Johns, November 29, 2001). She gestured out with her arms as she made that statement, meaning to her, genetics is the basis for all of life, for all of the world.

Science-Related Social Interactions

Preschool through Elementary School Developmental Period

Several themes emerged within the category of science-related social interactions in the first developmental period. Encouraging and supportive parents was a theme mentioned by all seven of the women scientists. Four of the participants reported encouraging and supportive teachers during this developmental period. And four women also reported the positive influence of encouraging and supportive grandparents and other relatives during this developmental period. None of these findings were unexpected, as parents and grandparents are usually more involved with their children and grandchildren when the children are young.

Encouraging and Supportive Parents Motivational Theme

All of the women participants in this study reported positive parental influence during this early developmental period. Several of the women scientists recalled asking their parents for particular science-related toys that the parents subsequently provided. Other parents provided opportunities such as trips to science museums and environments in which interaction with nature and the outdoors was not only possible, but encouraged.

During this early developmental period, all of the participants reported that their parents encouraged them to do well in school and many of them reported that their parents were also helpful with science fair projects and other science-related pursuits.

Dr. Scott's parents provided her with a subscription to the nature cards that she enjoyed so much and they encouraged her to investigate and explore the outdoors. They encouraged her to do whatever she wanted to do and never told her there was anything she could not do, so she had their support from an early age. Dr. Townsend's parents purchased a chemistry set for her and encouraged her to explore with it. They were also helpful to her when she had to make science-related projects for school. Dr. Adams' parents encouraged her to investigate the outdoors and got her involved in the family garden. They wanted her to do well in school although they never encouraged her to go to college. Dr. Nix remembered her parents' early encouragement but later they became uninvolved. Dr. Black said her parents always encouraged her in everything she attempted. She especially appreciated the fact that neither of her parents ever told her she could not do something because of her gender. Dr. Jones' father was actively involved in helping her in several science fair projects and both of her parents encouraged her to do well in school. Dr. Johns also remembered her mother and father actively encouraging her to succeed in school and investigate nature. Her father helped her care for and show her horses at competitions and taught her to cook and both of her parents encouraged her to do whatever she wanted to do.

Encouraging and Supportive Teachers Motivational Theme

Most of the women participants reported more positive experiences with teachers at the middle school and high school levels than at the elementary level. Four of the women remembered particularly encouraging and supportive teachers who influenced them in science at this first developmental period explored. The women who reported experiencing the positive influences of teachers at this developmental period remembered those teachers working hard to provide meaningful and enjoyable science experiences. They recalled that those teachers put forth a great deal of effort to bring in additional resources associated with a specific scientific concept or worked to provide enriching experiences centered around some aspect of science. The teachers that the women participants perceived as motivational to them in science did not just present information and test over it. They searched for ways in which the students could interact with science so that by becoming personally involved in a concept, the students might better understand it and remember it. They attempted to make science fun and interesting. This finding was also not a surprise to me as I recall the positive influence my third grade teacher had on my science interest when she provided weekly science demonstrations. I knew, even as a third grader, that she expended a great deal of time and effort so that we could have science interactions, rather than just reading something about science from a text book, and I appreciated her for doing that. In fact, this woman had such a lasting influence on my life that I stayed in contact with her throughout my life and even traveled back to Spokane, Washington a few years ago to visit with her before she died.

Neither Dr. Scott, Dr. Adams nor Dr. Nix could recall any teachers who particularly motivated them at this particular level. But Dr. Townsend remembered some positive experiences revolving around science provided by her enrichment teacher from the first through the fourth grades. She remembered the effort made by that teacher to ensure that the science experiences were both fun and interesting. Her enrichment teacher obtained models and lunar rocks and lunar dust when they were doing a unit on space and the astronauts. Dr. Adams remembered the trouble her first grade teacher went to as she constructed the different learning centers associated with land biomes. Dr. Black recalled an elementary school teacher who took the time to explain to her why leaves turned color in the fall. She remembered being fascinated with the explanation that the teacher provided. Dr. Jones remembered a sixth grade teacher who took the time to not only perform meaningful and interesting science demonstrations for the class, but he also made it a point to always involve the students. Dr. Johns recalled several exemplary teachers she had in grammar school. One of her teachers stands out in her memory because she brought in lots of information about pine trees and stressed the importance of planting pine trees, even calculating how much money one tree could generate. Many of her teachers "saw to it that we got experiences," even though it was war-time and money was scarce (personal communication, J. Johns, November 29, 2001).

Exemplary Grandparents Motivational Theme

Parents were not the only relatives who encouraged, supported and provided science opportunities for the women taking part in this study. Two of them were fortunate to have grandparents who lived on nearby farms and many of their most memorable interactions with nature and the outdoors took place at the homes of grandparents. Dr. Townsend's grandparents also provided verbal encouragement to her to continue in school and praised her when she achieved her goals. Dr. Nix's grandmothers served as sources of inspiration to her as she pursued her science career goal. Dr. Black's grandfather was a role model for her because she felt as though he thought like a scientist. Because I never grew up around extended family members, I had never developed close relationships with my grandparents or any other family members outside of my immediate family. So I was surprised that the women participants placed so much emphasis on the positive impact of encouraging and supportive grandparents.

Dr. Scott's maternal grandparents lived on a farm, not far from where she lived and she was always welcome there. So she enjoyed interacting with the various farm animals and just generally investigating and exploring their farm. She felt fortunate that she "had a lot of opportunities outdoors," partly due to her grandparents and the proximity of their farm to her home (personal communication, J. Scott, October 22, 2001). Dr. Townsend's grandparents were particularly encouraging to her. She stated that her grandfather placed great emphasis on a good education. He always encouraged her to do well in school and get as much education as she could. Dr. Nix was close to both of her grandmothers. One of them was stricken with a stroke and the other procured Alzheimer's disease. Although she said they were not particularly encouraging to her, their medical conditions influenced her to try to become a physician, thinking that if she succeeded, she could be helpful to them. Dr. Black remembered the admiration for and identification she had with her grandfather who was an engineer with the Ford Motor Company. She stated that she liked the way he thought systematically, like a scientist. And she believed that his way of thinking influenced her as she wanted to be like him. She remembered both of her grandparents encouraging her to be whatever she wanted to be.

Science-Related Social Interactions

Middle School Through High School Developmental Period

It was interesting and surprising to see that none of the women scientists mentioned their parents as being particularly supportive and encouraging during this developmental period. I do realize that the teenage years are typically a time in which children begin to separate and distance themselves from parental influence and involvement. Perhaps that is the reason that parents seemed to not play as much of an influential role in supporting and encouraging their daughters as they did in the first period explored and as they will in the last period to be investigated. The women scientists mentioned two groups of people they interacted with in this developmental period who encouraged and supported them in their science interests. Those two groups were teachers and peers. What came as a complete surprise was the discouragement or lack of guidance from high school guidance counselors reported by six of the women scientists. After completing this study, I have realized that not only did I also not receive any direction at all from my high school guidance counselors, but the students at the school where I now teach also receive very little if any, individual attention from guidance counselors.

Encouraging and Supportive Teachers Motivational Theme

At this developmental period, there was a marked increase of encouragement and positive influence given by teachers, as reported by six of the seven women involved in this study. The women participants remembered many of their science teachers during this developmental period as teachers who were enthusiastic about their subjects and worked hard to make science enjoyable and interesting for their students. Some of these teachers were seen as encouraging and motivational by the women respondents because they took the time to get to know their students on a more personal level, finding out their career interests and goals and guiding them in the attainment of those goals. Some of these exemplary science teachers have maintained relationships with the women scientists participating in this study long after they graduated and went to college.

Dr. Scott liked her high school biology teacher. She and the other kids perceived him as "cool" and "laid back." Dr. Townsend's high school chemistry teacher, Mrs. Whiten, was one of the teachers who was most encouraging to her throughout her educational career. She recalled the encouragement Mrs. Whiten provided when she expressed the desire to major in chemistry in college. She stated that Mrs. Whiten told her about some of the different opportunities and lab work and she tried to warn her of the rigor involved in becoming a science major. Mrs. Whiten continued to have contact with Dr. Townsend's mother after she graduated high school, always interested in the progress she was making. Dr. Adams remembered Mrs. Michener, her high school biology teacher and the positive influence she had on her through the science activities she provided in her class. Dr. Adams remembered dissecting the fetal pig in that class and called that adventure, "the highlight of the science experience." She appreciated Mrs. Michener's teaching ability and said she was "just a neat lady" and "took a huge risk" letting young kids use scalpels (personal communication, M. Adams, November 5, 2001). Dr. Nix recalled her high school chemistry teacher as being positive and encouraging to her as far as science was concerned. He took a personal interest in her, always asking about her future plans. And he also got her out of other classes to help him grade papers or work on other projects. She enjoyed being singled out and given special attention. Dr.

Black remembered two exemplary teachers she was fortunate enough to have in high school science. She recalled:

> Both of them just absolutely positively loved what they did. And they had so much excitement and energy for their discipline that you couldn't help but be drawn into that....Probably part of their excitement was because they were both very young and high school teachers have to do their continuing education and they were both, at the same time, taking classes at the University of Michigan to earn their masters. So they were at that stage in their careers. So they were still just totally turned on. (personal communication, P. Black, November 5, 2001)

When asked what she gained from those two teachers, she thought she had gained passion. She knew that she wanted the same thing out of the job she had one day, to love every single minute of it. Dr. Johns recalled a social studies teacher who was particularly motivating to her and she remembered spending a great deal of time constructing a Georgia scrapbook for her class that had a lot of science concepts in it.

Encouraging and Supportive Peers Motivational Theme

During this developmental period, two of the women scientists reported positive and encouraging experiences with their peers regarding their achievement in science. The influence and importance of supportive peer relationships seemed to increase across developmental periods explored. During the middle school to high school time frame, one of the women reported relationships with friends who were study partners and competitors for the highest grades. Another remembered that the career aspirations of her friends encouraged her to set high goals as well.

Dr. Scott remembered a group of friends who were all in the same math and science classes and studied together. There was one particular male friend she hung out with and she stated that they would "push each other" and in the yearbook they were each voted "most studious." He ended up becoming a chemistry teacher in Pennsylvania. Dr. Nix remembered that several of the other people in her high school advanced classes wanted to be doctors or pharmacists so she thought she would do that as well. So their career choices influenced her own career decision.

Discouraging Experiences With Counselors Motivational Theme

Unfortunately, every one of the women interviewed related stories of negative experiences with counselors in this developmental period (except for one who had no counselors). In fact, it is interesting to note that none of the women participants reported any positive experiences with counselors during high school. Either the counseling was nonexistent, minimal at best, or completely misguided. One of the women even reported that her high school guidance counselors attempted to persuade her to follow a career path more closely aligned with what society deemed acceptable for her gender as a woman.

Dr. Scott stated, "We had a very horrible guidance counselor at the high school level" (personal communication, J. Scott, October 22, 2001). She went on to say that this woman counselor took it upon herself to decide what school you should go to based on your SAT scores. Penn State was her ultimate choice and if she didn't think your scores were good enough, she sent you to other smaller schools. As a result, Dr. Scott felt that because of this woman, she had very little option as to where she could go to college. She was handed forms to fill out to a couple smaller schools and that was it. Ultimately, she was accepted to both of the schools and ended up attending Kutztown University. Dr. Townsend reported that they:

> really got no counseling on where to go to school, where to get financial aid, whether or not we were good in the areas we were choosing. We got no help there. We got handed college applications and were told to go have a good time. I don't know if you'd call that encouraging or discouraging…it's just pretty much non-existent. Nothing one way or the other. (personal communication, J. Townsend, November 5, 2001)

Dr. Adams stated that the only experience she ever recalled with a counselor is that one told her that she was too bright to go to community college and they saw her choice as a failure. Dr. Nix reported that her school had three counselors for five hundred students so she "didn't get much out of them" (personal communication, D. Nix, November 22, 2001). Dr. Black also reported that there was no encouragement from counselors at her high school. In fact, she stated that the counselors at her high school "basically sucked" (personal communication, P. Black, November 5, 2001). Dr. Jones recalled a particularly negative experience with her high school counselors when they took the top six students of her graduating class in for counseling about college. Three of them were boys and three were girls, including Dr. Jones. She remembered:

> They gave us this long list of careers that you could go into and the guys were counseled to go into physical engineering. And the girls were counseled to go into nursing, medical technology, or teaching. None of which interested me. And primarily that's why I didn't go to college. Because what they were offering was not interesting to me so I just didn't go. And there wasn't input from my parents.

> There should have been, but there wasn't. At any rate, women didn't do those things and my parents were willing to go along with that. (personal communication, W. Jones, November 5, 2001)

This incident is an example of many that overlap between two or more categories of exploration in this study. It not only fits into the social interactions category, but also the gender influences category.

Science-Related Social Interactions

Undergraduate School through Graduate School Developmental Period

During this developmental period, social interactions seemed to have the most critical influence on their science motivation for the women scientists interviewed. The encouragement and support provided by peers who were also science students seemed to be extremely important during this most difficult developmental period. As a married undergraduate student living off campus, I missed out on forming supportive science peer relationships and as a result I often felt disassociated from the science experience and university life in general. Parental encouragement and support also re-emerged in this developmental period as the women made the transition from teenagers to young adults. Certainly this is understandable as the very nature of the relationship that exists between teenagers and parents evolves to become more of a symbiotic relationship between parents and young adult children as teenagers graduate high school and begin undergraduate and graduate school. Some of the women indicated forming beneficial relationships with other older women in science who served as role models. And many developed relationships with professors and advisors (male and female) that served to be a source of encouragement during both the undergraduate and graduate school years. The women participants who were married during their undergraduate or graduate years or both reported the positive influence of supportive and encouraging husbands. Not all of the relationships were encouraging however, as some of the women reported discouraging experiences with parents and other relatives, friends and professors.

Encouraging and Supportive Parents Motivational Theme

Most of the women reported an increase in the involvement of their parents during this final developmental period. And most of that influence was of a positive and encouraging nature. Also, many of the women reported identifying more with their fathers than they identified with their mothers although both parents were usually encouraging.

Dr. Scott remembered that at this period she most identified with her father "because he was very mechanically inclined....I identified with those abilities that he had more than my mother. She didn't have much of an ability to build things or interpret things" (personal communication, L. Scott, October 22, 2001). She went on to say that both of her parents encouraged her in whatever area she chose.

Several times in the interview with Dr. Townsend, she reported the encouragement provided by her mother during the difficult transition she experienced from undergraduate to graduate school. After some discouragement from one of the undergraduate professors, she began doubting her ability to succeed in science and spoke to her mother about her concerns. Her mother encouraged her to apply to graduate school anyway and to do what she wanted to do. She felt that her mother really wanted her to try graduate school and she remembered her mother continually encouraging her by making statements such as, "I think you could be good at this. I think you should do this" (personal communication, J. Townsend, November 5, 2001). She was adamant that her mother encouraged her more than her father did but that her father was not discouraging, he was more generally encouraging.

Dr. Adams received mixed messages from her parents regarding her desire to pursue science as a career. For the most part they were discouraging and detrimental to her, but at times they seemed to want her to do well.

Dr. Nix's parents were "uninvolved," but at the same time she stated that they were not particularly discouraging either.

Dr. Black credits both of her parents for always encouraging her in everything she attempted. Her parents were also supportive to her during her most discouraging moments in graduate school when she was involved in research that did not interest her. It was a difficult time for her at that point in other ways because she was further away from home than she had ever been. So she would drive home on the weekends and "rant and rave" to her parents about all the negative experiences she was facing in graduate school. They realized their role was to be listeners. Occasionally they would ask a question, but she just wanted them to listen to her and that is what they did. So they were a tremendous source of support during a difficult period of her life. When asked which of her parents encouraged her the most, she said it was probably her Dad, stating:

> Because he knew more about life than my Mom. My Mom didn't know anything. She didn't have a perspective....My Dad had a perspective....I guess he had a better perspective on the way the world really was than my Mom did. He went out everyday to work and he had a better perspective than she did. (personal communication, P. Black, November 5, 2001)

Dr. Jones believed that her personal and social encouragement came from her family throughout her undergraduate and graduate years. During that time, her mother was particularly supportive because she provided a great deal of childcare for Dr. Jones' three daughters as she attended classes. Like Dr. Jones, Dr. Johns was also married with children while she attended both undergraduate and graduate school. Her mother and mother-in-law provided much-needed childcare for her youngest child while she attended classes as well. She remembered both her parents and her in-laws as being supportive during her collegiate and graduate careers.

Discouraging and Non-supportive Parents and other Family Members Motivational Theme

While the majority of the women scientists who participated in this study reported encouragement from parents and other family members, there were some cases in which relatives were discouraging toward their pursuits of science careers. Some of the discouragement on the part of certain family members arose out of jealousy over the educational goals and achievements of the women. Other family members questioned the choices made by the women to go to graduate school because they believed the women were continuing their education so as not to have to work at a "real" job; these relatives perceived a college education as "frivolous." And still others worried about whether or not marriage and children would ever be an option, given the extensive time and effort required in obtaining a doctoral degree.

Dr. Townsend's paternal grandmother was not a positive influence on Jenny as she attended undergraduate and graduate school. Dr. Townsend was reluctant to say that this woman was discouraging, but she did say that she "never really understood what I was doing" (personal communication, J. Townsend, November 5, 2001). She remembered her grandmother constantly asking her, "Now what are you doing? Why is it you're still in school? Haven't you been gone long enough?" (personal communication, J. Townsend, November 5, 2001).

By far, Dr. Adams experienced the most negativity from her parents and other family members. She told me that her parents fought a lot and did not have a lot of energy left over to give to either her sister or herself. Neither of her parents had attended college.

She stated that her parents:

> certainly had no clue what college was about or the opportunities that were out there or how a student should go about selecting a college. I mean my whole career happened half-assed and by accident. I mean, it was not like these parents who start prepping their kids for the SAT their junior year and taking them to visit colleges. Everything that happened, happened despite my parents, not because of them. (personal communication, M. Adams, November 5, 2001)

She went on to say that her entire family perceived college as frivolous because all of them were farmers and blue collar workers and always had been. When she told them toward the end of high school that she wanted to be a doctor, she said,

> I had to wait fifteen minutes for them to get done rolling around on the floor. There were tears in their eyes from laughing so hard....They thought it was a hoot. Did not give it any credence whatsoever. So they weren't threatened by it at that point because they didn't perceive it to be a real threat....So when I decided to move from Pennsylvania to Buffalo, then it became a little more real. And then

> the criticism became a lot stronger. Who did I think I was to drag my husband off from his family? What a wonderful man he was to put up with what I was expecting of him. I mean just unbelievable opposition for leaving the homestead. (personal communication, M. Adams, November 5, 2001)

She remembered that she worked forty hours a week during the day and attended classes at night and then studied all weekend. On Saturday afternoons she would always try to schedule a nap and invariably her mother would call, "knowing that I was trying to sleep and give me hell for being lazy and I should be taking care of my husband and I should be doing this, I should be doing that" (personal communication, M. Adams, November 5, 2001). At times her mother seemed proud, but at other times she seemed threatened because "it was really hard for her because she didn't know how to process having a daughter that was doing things that she hadn't done" (personal communication, M. Adams, November 5, 2001). Her parents were not the only ones to discourage her. When she decided to go to graduate school rather than medical school she recalled:

> even my brother-in-law was like, 'When are you going to get a real job? When are you going out into the real world?' They just thought it was a cop out. A way to avoid having to work for a living. (personal communication, M. Adams, November 5, 2001)

Dr. Nix stated that her parents did not encourage her to pursue a science career. She said,

> I have probably the most uninvolved parents in the universe. When I said I wanted to college they said okay. When I said I wanted to go to graduate school they said, "Well, how are you going to pay for that?"....They really didn't have

> any frame of reference. They really didn't know anything about science. They just went to work and came home. (personal communication, D. Nix, November 21, 2001)

Dr. Black met some resistance from her older sister when she was in graduate school. Her sister was majoring in business at the time and when she found out that Pam had decided to go into the teaching aspect of chemistry she said, "Those who can, do. Those who can't, teach" (personal communication, P. Black, November 5, 2001). She was offended by the remarks at the time but has since realized that her sister was jealous that Pam had gone into science. She further elaborated that, "I was always competing with my older sister but as she was more and more discouraging, I would listen to her less and less" (personal communication, P. Black, November 5, 2001).

Dr. Jones recalled an aunt, her mother's sister, who was "very discouraging." She said that this woman,

> was constantly telling me that I needed to get a job. Because my mother did some childcare for me and I think she perceived that as being hard on my mother. But my mother seemed to be doing it willingly enough....After I got my master's degree, Aunt Nita wrote me a card and said, 'Now I hope you'll go get a real job.' And we just laughed at it and passed it off as ignorance of that generation. (personal communication, W, Jones, November 5, 2001)

<u>Encouraging and Supportive Husbands Motivational Theme</u>

Four of the women scientists participating in this study were married either during undergraduate school or graduate school or both. All four of these women reported that their husbands were encouraging and supportive to them as they attended undergraduate and graduate school. The men had to take on additional duties of grocery shopping, house cleaning, and even childcare in some instances. Although all three women indicated that their status as students pursuing advanced degrees in science was extremely stressful on their marriages, none of the marriages dissolved as a result of the strain. Three of the four women stated that they could not have completed their degrees without the support and encouragement provided by their husbands. I was somewhat surprised by these findings when I compared them to the conflict the single women reported as they attempted to establish and maintain significant relationships with men. Perhaps the husbands were supportive because they were married to the women before they obtained their doctoral science degrees.

Dr. Scott was married to another scientist. She stated that, "We didn't have a lot of conflict as far as him doing one thing and me doing another thing" (personal communication, J. Scott, October 22, 2001).

Dr. Nix married right out of undergraduate school, and although she did report some conflict as far as whose career was most important, she said that her husband provided childcare for their newborn daughter while she was working as a post doc.

Dr. Adams married right out of high school, so her husband was with her throughout undergraduate and graduate school. He moved out of the state with her so that she could pursue her education. She remembered him as being extremely supportive throughout her educational career. In fact, she told me:

> He was really supportive. If it wasn't for him, I wouldn't have done it. There is absolutely no doubt in my mind. I dedicated my thesis to him, even though our marriage was falling apart because I know that if he had not been there…I mean

> he took care of the household. He took care of the grocery shopping, he took care of everything from the time I started going back to school. And that had to be hard to take. I mean I was an absentee wife, especially during graduate school. You know...I'd be in the lab literally sleeping on a lawn chair overnight. And he'd bring me McDonald's. (personal communication, M. Adams, November 5, 2001)

Dr. Jones was also married out of high school but she waited nineteen years and had three children before deciding to go to college. When she started thinking about going back to school she remembered being encouraged by her husband and his support remained steadfast throughout her educational career. In fact, when she decided not to go into medicine but to become a chemist she said that "he was the first one to tell me that I needed to go to graduate school" (personal communication, W. Jones, November 5, 2001). They are still married.

Dr. Johns also married right out of high school and waited several years before pursuing an undergraduate degree. After obtaining two B.S. degrees, she began attending graduate school, which was quite a distance from where she lived. So she ended up sharing an apartment with a girl for half of a week every week and then staying for two consecutive summers. Her husband stayed behind in their hometown with their children. I asked her if her husband had any problem with her being gone so much and leaving him with the children and she replied:

> Oh no. Of course the oldest one was in college by the time I went up the first summer. The second one was two years behind her and the third one graduated high school the same year I finished my degree. But it wouldn't have mattered.

He could have taken care of them, little or big. He's a good cook (laughs). (personal communication, J. Johns, November 29, 2001)

Encouraging and Supportive Peers Motivational Theme

At this developmental period, more than any other period examined in this study, the women scientist participants reported a greater sense of collaboration and connection with other students of science. Some of these relationships were with groups and some were with just one friend. Almost all of the women reported to have benefited from collaborating and connecting with other students, mostly other female students. These relationships were supportive, encouraging and motivational. Two of the women reported friendships in which friendly competition for top grades took place. There was also a sense of camaraderie among certain groups of science students as they navigated their way through the trials of undergraduate and graduate school. Often these friendships were with other women science students because they felt that only other women could truly understand the unique problems they faced as women pursuing doctoral degrees in the hard sciences. Many times the women scientists participating in this study related weathering trying experiences as undergraduate and graduate students because they had other women they could talk to who understood and empathized, even though those other women may not have been able to solve the problems.

Dr. Scott remembered being a part of an advisement group as a graduate student that was made up of mostly females. She recalled that they all became very good friends. She stated,

There were four girls in my group and there were two guys and one was Chinese. So he didn't count (laughs). He couldn't understand English half the time. So

> there was this gang of us that (pause) we were just going to do it our way and who was going to stop us? (personal communication, J. Scott, October 22, 2001)

She also remembered a male friend in undergraduate school who she was study partners with. That relationship was encouraging to her as far as pursuing her science career.

Dr. Townsend recalled a wonderful male friend in undergraduate school. Once they got out of their sophomore year, they were in almost all of the same classes together. They were lab and study partners. She said,

> He just helped me not to get discouraged in a couple of classes. Because he was always a little bit smarter than I was. And he would help with certain things. We would work together so he was really helpful then. (personal communication, J. Townsend, November 5, 2001)

In graduate school, Dr. Townsend recalled that there were three other women pursuing science degrees that she befriended. When any one of them became discouraged, the others were there to talk to. She remembered that they would often go out to lunch together. She related, "Anytime you were having a problem, you could go out with these girls. And if they did not have the answer, at least you got to tell somebody what was going on" (personal communication, J. Townsend, November 5, 2001).

Dr. Adams stated that during both her undergraduate and graduate years, labs were always done in groups. She related:

> Chemistry works in groups for the most part. You always have a study group. If you don't, you're a fool. Because you are always going to be better at something that somebody else isn't and vice versa. So in the sense of getting through it, you always need a support system, you always need a group. And that's very positive

> to have that kind of feedback. (personal communication, M. Adams, November 5, 2001)

In her undergraduate years, Dr. Adams recalled that there was a group of ten students who were really good friends, seven women and three men. According to Dr. Adams, they "were really tight." And she stated that "We didn't always get along, but we never, ever let each other down. We were all in it together and it was rigorous and it was tough and it was hell and we carried each other at different times" (personal communication, M. Adams, November 5, 2001). She stated that the six females "all got discouraged from time to time but we knew we were the majority and they had to pay attention to us if we all banded together" (personal communication, M. Adams, November 5, 2001).

Dr. Nix also mentioned two female friends she had as an undergraduate who were very supportive to one another. She remembered,

> We were always in the same classes together and we would do our homework together. We complained about things together and we would compete to see who got the best grade out of the three of us....We kind of stuck together. We did the same labs together so we would always try to be lab partners, the three of us together. (personal communication, D. Nix, November 21, 2001)

Dr. Black had a female friend as an undergraduate who was a pre-med. major. She remembered this woman as being extremely intelligent. She recalled,

> I wanted to be like her. She was like my role model. She probably did it without even knowing she was encouraging me. It was more like a challenge. I could be as good as she was. And so she was probably the encouragement that I needed. (personal communication, P. Black, November 5, 2001)

As an undergraduate, Dr. Jones was not a traditional student. She was much older than most of the other typical students who were in their late teens and early twenties. But she did occasionally work in study groups with some of them. She told me,

> Most of my interactions with other undergraduates where I went to school were like, 'Let's work with Wendy because she knows what she is doing and we can suck her brain dry.' So I knew that at the time and I just used that as it was. Because I knew that even the most uninformed, most unstudied person in the class can often give you help when you can't figure something out. (personal communication, W. Jones, November 5, 2001)

She did remember that a large number of students worked in the biology department of her undergraduate school and she saw that department as a mentoring place, and a place where there was a lot of support for science .During her graduate years the situation changed. She said, "It was geek city. Everybody was pretty much in the same boat. So you'd work together" (personal communication, W. Jones, November 5, 2001) She particularly recalled the last group of three women that she became friends with in graduate school:

> We'd go out to eat like once a week. On birthdays we would all chip in and buy the birthday person a meal. One of those ladies actually went to help me purchase an appropriate scarf to wear with an outfit I was wearing to give a presentation. Which is something you couldn't get from a guy probably (laughs). Because I'm not very good at those kinds of things and she helped me. So there was a lot of positive things like that. (personal communication, W. Jones, November 5, 2001)

Encouraging and Supportive Male Professors and Advisors Motivational Theme

All of the women scientists reported developing relationships with male advisors and professors at the undergraduate and graduate levels that were positively motivating and encouraging. Some of these men were admired because their research was relevant and practical to the women, because they made their courses interesting and enjoyable or because they took a personal interest in the science career goals of the women. One advisor was appreciated because he was not easy on his female advisees because they were women. It is not surprising to me that all of the women reported at least one male professor or advisor who was encouraging and supportive to their science career goals. All of my biology professors were males and several of them were very encouraging and supportive of me.

Dr. Townsend credited her undergraduate biochemistry professor as the one who probably encouraged her the most. She remembered that he did that by telling her that even though her grades were not A's (she consistently made mid to high B's), she could still be a chemist. So when she was doubting her ability to become a chemist because she was not making the highest marks, he buoyed her spirits and encouraged her to continue on the path she had chosen. He told her that he thought she was doing a good job and he was instrumental in the procurement of a teaching assistantship position for her.

Dr. Adams remembered the influence her undergraduate Introduction to Chemistry Professor had on her. She stated:

> He taught at night and worked for Smith-Kline-Beecham during the day. So he was a research scientist. He was fantastic. And he was the reason I changed to

> chemistry….He was so good. I was just like, "That's it, I want to be a chemist!" So he was just fantastic….He was a black man. And I think maybe his experiences made him sensitive to gender/race issues. And he wasn't the kind of guy that (pause) he didn't put any barriers up to females so he was really encouraging. And he made it really fun. He related everything to real life. That certainly sparked my interest in studying chemistry. (personal communication, M. Adams, November 5, 2001)

Although Dr. Adams recalled some discouraging moments with her graduate advisor, in the end she said: "I think he was an awesome advisor and I think he did make me into a good scientist and there was never a moment at this job that I didn't feel 110 percent prepared" (personal communication, M. Adams, November 5, 2001).

Dr. Nix named her male advisor in undergraduate school as the most encouraging person to her in her entire educational career. She remembered him as being soft-spoken and eager to get to know his advisees on a personal level

Dr. Black remembered her male inorganic chemistry professor as being the person who motivated her to apply to graduate school. He provided her with all of the necessary information and materials and encouraged her to follow her dream. She also recalled the male parasitologist who was an "excellent" teacher. She said,

> If I had to pick somebody that I would have wanted to be like after graduation, it would have been him. Probably because he was so practical. He was teaching about all these parasites and then the next semester he would go and try to cure all these parasites. And so there he was going to Africa and diagnosing them with malaria or any other one of those tropical diseases and treating them. So I could

see the practicality of what I was doing right there. Because he would actually teach it and go do it. (personal communication, P. Black, November 5, 2001)

Dr. Jones recalled the interest a male professor showed in her in the first math course she took in undergraduate school. She was encouraged by the fact that he took the time to watch her during exams to see how she approached problem solving. He told her that he felt she was so good at math that she should pursue it as a career. He was right because she ended up going into physical chemistry, which is applied mathematics. She remembered that experience as the first positive experience she had at the undergraduate level.

Dr. Jones' advisor in graduate school was an older male professor who she said was "very supportive and I think did the very best for me that he could" (personal communication, W. Jones, November 5, 2001).

Dr. Johns recalled several male professors who were exemplary in both undergraduate and graduate school. One professor ended up becoming the director of the botanical garden at Yale University. She remembered that he always provided enrichment by bringing in a lot of materials.

Role Model Female Professors/Advisors Motivational Theme

Five of the women scientists who were participants in this study recalled women professors and advisors who acted as role models and mentors to them while they were undergraduate and graduate students of science. These women served as living examples of successful women in science to the respondents in this research project. I believe it is imperative that successful women scientists are made available to all girls and young women studying science or pursuing science careers. Institutions of higher learning should make every effort to recruit and hire women scientists whenever possible. When I was attending Western Kentucky University and majoring in biology, there were no women biology professors on the faculty. If I had been able to see successful women scientists, I may have been more likely to have applied to graduate school myself, rather than become a high school teacher.

Dr. Scott said that her favorite professor was also her advisor in undergraduate school. This was the first woman chemist hired at her school and the first woman scientist Dr. Scott had ever met. She believed that the reason she was her favorite teacher is that she was a woman who was succeeding in science and doing what she wanted to do. Dr. Scott recalled:

> She was really tall and thin and when she moved around (she had really long arms) she would do this kind of motion a lot (waves arms back and forth above her head) and it was okay. If she wanted to move around, it was okay, she could move around if she wanted to. She was in charge of the class. And I liked that. That she was able to be herself in front of the class and she didn't have to be a certain way to do good teaching. The other thing about her that helped motivate me....she only stayed at Kutztown for two years...And she decided to go back to medical school....So in my mind it was like, gosh, she's doing whatever she wants. She has the smarts to do whatever she wants and she was doing it. (personal communication, J. Scott, October 22, 2001)

This woman encouraged Dr. Scott to apply to graduate school and helped her write the necessary letters and fill out applications. She went on to say, "If you really think about women in science, the mentors really help people and that was part of why I'm here now.

To try to give back some of that to my students" (personal communication, J. Scott, October 22, 2001). Since obtaining her graduate degree, Dr. Scott has been actively involved in issues involving women in science. She was a speaker at a women in science symposia meeting in 1999 and when she worked at a college in north Georgia, they hosted a symposia for an organization of Georgia Professional Women and she and a colleague co-chaired a session entitled "Women Meeting Science's Challenges in the 20th Century."

Dr. Nix originally had four male members on her dissertation committee in graduate school. She had a problem with one of them and had him removed and replaced with a newly hired female chemistry professor (the only female in the chemistry department). She stated that this woman was "one of the most encouraging people there that worked with me and talked with me about stuff and helped me figure out what I was going to do" (personal communication, D. Nix, November 21, 2001). She went on to say that once the female professor became a member of her committee, "things turned around a lot from that point. Because she was a lot more helpful to me and a lot more interested in what I did" (personal communication, D. Nix, November 21, 2001).

In graduate school after suffering through a traumatic period in which she was in a research group whose focus did not interest her, Dr. Black recalled moving to a new group that was led by a newly hired female Assistant Professor. She remembered that the research that this woman was involved in was so much more applied and practical than what her first research group was doing. She stated that she "loved every single thing that I did from then on" and because this research was so much more applied she said, "It sparked my interest" (personal communication, P. Black, November 5, 2001). This woman eventually became her Ph.D. advisor and she was a very encouraging influence in Dr. Black's life and remains so to this day. She recently gifted Dr. Black with Barbara McClintock's book, Feeling for the Organism.

Dr. Jones remembered a positive experience with a female teacher in the chemistry department at her undergraduate school. She stated,

> I established a good relationship with her and we would sometimes sit and chat and other times we would talk about chemistry. And I maintained that relationship over the years. In fact, I just saw her when I went to a meeting in Cincinnati. She was working at UC. So I got to spend some time with her then. So we've maintained a very nice relationship over the years. It was very positively motivating. (personal communication, W. Jones, November 5, 2001)

She also remembered a female staff member in graduate school who had a Ph.D. in crystallography and was "very good." She worked with her conducting research and she recalled that she was "primarily responsible for getting me involved in things like posters and presentation of my material....So she was largely responsible for 'socializing' me into that aspect of science" (personal communication, W. Jones, November 5, 2001).

Dr. Johns remembered a female chemistry professor that she had in undergraduate school who was encouraging and another in graduate school who she has remained close friends with throughout the years.

Discouraging and Non-supportive Male Professors/Advisors Motivational Theme

Unfortunately, five women participants reported certain male professors and advisors as being discouraging towards their aspirations of obtaining doctoral degrees in science. Some of these discouraging experiences involved gender perceptions on the part of the male professors and advisors. Two of the women participants perceived the discouragement directed towards them by the male professors and advisors concerning attending graduate school was directly related to the fact that they were women. In some instances, the male faculty members attempted to persuade these women to consider alternative career pathways other than graduate school, such as obtaining master's degrees and becoming high school science teachers. The women scientists who reported these experiences believed the male professors and advisors discouraged them from pursuing doctoral science degrees simply because they were women. This was the most upsetting finding to me of the entire research project. I was surprised to see that educated male science professors, who are aware (it seems they should be anyway) that science is perceived to be a masculine field, would continue to reinforce that stereotype by discouraging their female students and advisees from pursuing advanced degrees in science. It is distressing to know that there are still men of science who are so narrow-minded that they seek to keep women out of science, despite the fact that all of humankind can only benefit when more women enter science careers and conduct scientific research.

Dr. Townsend recalled talking to a male professor in undergraduate school about what she wanted to do with her life. She had wanted to be a doctor and she stated,

> he pretty much told me that that there's no way I could be an MD if I wanted to be, that my grades just weren't up to par....And I felt like he was telling me, "You can't." And when I talked to him about graduate school he was sort of lukewarm about that. He didn't urge me on. He said, "Well, if that's what you want to do,

you'll probably get in somewhere." (personal communication, J. Townsend, November 5, 2001)

She recalled that he kept trying to convince her to be a high school teacher. She also remembered a negative incident in graduate school that also overlaps into the gender influences category of this study. When she got to graduate school, she remembered that in one particular class it seemed that

> the men came with a certain amount (pause) like the teacher (male) just realized that they knew (pause) they were on a certain level and we were lower and for us to get up there, we had to earn it. I felt like I had to surpass, that I couldn't do exactly what they did. I felt I had to do even more. (personal communication, J. Townesend, November 5, 2001).

Dr. Scott recalled a male professor in undergraduate school who kept trying to convince her to get a master's degree in chemistry rather than a Ph.D.

Dr. Black mentioned a discouraging experience she had as a graduate student when she was working with a male professor who was doing research that did not interest her. She remembered that because she was not interested in that particular research area, she was not motivated. As a result, the professor

> got more and more on me and he tried to motivate his students by giving them evaluations. And my evaluations went slowly down and down and by the last evaluation I got from him before I switched groups, I was next to scum. (personal communication, P. Black, November 5, 2001)

Although Dr. Adams reported that in the end she was happy with the guidance her male advisor provided for her, she certainly experienced some discouraging moments as his advisee. She remembered that his "method of training was to break you down the first two years and then start to build you up after that" (personal communication, M. Adams, November 5, 2001). When asked to elaborate further on how he "broke her down," she stated that he engaged in behavior such as:

> Telling you you're stupid. Asking if you were a f-ing idiot. Just abusive (pause) I mean, plain and simple abusive. Lying to you. Lying about you. I mean, it was almost as if he was trying to see how much you could take. (personal communication, M. Adams, November 5, 2001)

Dr. Nix was assigned to do research with a male professor in undergraduate school. She remembered that "he was not the most encouraging person" (personal communication, D. Nix, November 21, 2001). He really was not interested in helping her with anything so, "he kind of passed me off to a female graduate student" who ended up getting pregnant. The professor told this woman that she had to leave because of her pregnancy and so Dr. Nix never got much accomplished as far as research was concerned. And she ended up becoming discouraged since at this point it was time to move on to graduate school and she had very little research background.

Science-Related Gender Perceptions

Preschool through Elementary School Developmental Period

In this first developmental period, only one of the women scientists reported that she was discouraged from playing with certain toys or engaging in certain activities by her parents because they perceived them to be masculine.

<u>Parental Discouragement from Traditionally Masculine Toys and Activities Motivational Theme</u>

Most of the women scientists participating in this study noted very little or no gender influences during this developmental period. However, one of the older women remembered that as a child, she was discouraged from playing with certain toys or engaging in certain activities that her parents viewed as masculine. Dr. Jones was 49 years old at the time of this interview. It is interesting to note, however that Dr. Johns, the oldest participant (around 70 years old) did not report any of these attitudes from her parents. The fact that the majority of the women participants did not experience discouragement from pursuing science or other "masculine" interests is encouraging but not surprising as women's issues have come to take a more prominent position in the media within the last twenty-five years or so.

Dr. Jones remembered her parents' reluctance to purchase an erector set for her for Christmas like the ones her brothers had. She did end up getting the desired erector set but she recalled that, "of course by the time they got around to getting it for me, I had already picked up on the fact that it probably was not a cool thing for a girl to do" (personal communication, W. Jones, 2001). She also remembered the enjoyment she experienced playing basketball and baseball with her older brothers. She reflected that

> There was a limit, I guess because of the times, how much my mother would let me play ball with my brothers. And they do have one picture of me with a doll. But I pretty much played with my brother's toys. (personal communication, W. Jones, November 5, 2001)

Parental Encouragement to Pursue All Interests Motivational Theme

Six of the seven women scientists reported that their parents encouraged them in everything they were interested in, regardless of whether or not those activities were perceived as masculine or feminine. These parents never told their daughters that they could not engage in an activity, play with a certain toy, or pursue science as a career because they were females.

Dr. Scott reported that there was never anyone in her life who discouraged her from doing anything because she was female. She stated that she remembered them making comments such as, "Well, you want to try this? Go ahead. You know, I'll bet you can do it" (personal communication, J. Scott, October 22, 2001)

Dr. Black's parents also never told her that she could not do something because she was a girl. She recalled,

> My mother never pushed my brother to be a mechanic and us to be housewives....And truthfully, they have four kids, and the three daughters are more highly educated than my brother is. So the early influence had to be both grandparents and my Mom and Dad really making us believe that we could do anything we wanted to do. Not ever saying, 'You can't do that because you are a girl.' (personal communication, P. Black, November 5, 2001)

Science-Related Gender Perceptions

Middle School through High School Developmental Period

In the middle developmental period explored and in the category of science-related gender perceptions, only one theme emerged and it was reported by only one participant. Dr. Jones had an extremely detrimental experience with her high school counselors who discouraged her from pursuing a hard science degree because she was female.

It is encouraging to see however, that none of the women reported experiencing any discouragement in science from teachers because they were girls. These findings were not unanticipated because times have changed and attitudes are also changing regarding the roles of women in society (however apparently not enough as we shall see in the final developmental period).

Counselors Perceive Science as Masculine Motivational Theme

Unfortunately, and as mentioned previously, none of the women scientists reported having positive interactions with their high school guidance counselors. In fact, several of the experiences they shared about counselors were detrimental to their self-confidence, school choice, and decision to attend college at all. Some of the women reported experiencing little or no guidance about career affinity, financial aid information, or college choice even though counselors were present in the schools they attended.

Dr. Jones' experience with the guidance counselors at her high school who dissuaded her from physical engineering because she was a girl and mentioned in the previous section on social interactions also overlaps into this category of gender influences. She realized that as a young girl she let the expectations of others influence what she did or did not do, which is ultimately why she did not go on to college directly out of high school. She also recalled that in junior high she was a better basketball player than all of the varsity boy players but was not allowed to play because she was a girl and there was no girl's team at that time.

Science-Related Gender Perceptions

Undergraduate School through Graduate School Developmental Period

By far, this was the developmental period in which the women scientists reported the greatest amount of gender influences, from stereotyping and discrimination to conflicts between their science goals and significant relationships with men and family obligations. Themes that emerged included the discouraging affect of gender on science goals. Four of the seven women participants reported that they thought being female made it more difficult to become scientists. Another theme reported by five of the women was that of conflict between their self-image as women and motivation to become scientists. And six of the seven women scientists reported experiencing conflict between their goals to pursue science careers and significant relationships with men. And finally, five women reported experiencing discrimination or stereotyping as women in science.

The Discouraging Affect of Gender on Science Goals Motivational Theme

When asked if they thought their gender made it harder or easier to become a scientist, four out of the seven participants thought it made it harder. The other three thought that it either had no effect, or made it easier in some situations. Four women scientists reported greater difficulty in achieving their science goals because they were treated differently as women. They reported being made to feel less intelligent than male science students, being discouraged from attending graduate school or medical school, and being denied certain privileges offered to male science students such as more individualized attention from faculty, the provision of special study areas, and the procurement of summertime fellowship positions. The other three women believed that their gender was beneficial because they felt as though the graduate schools were more lenient on the grade requirements for female students than they were for male students.

Dr. Townsend felt that in graduate school, the fact that she was female made the road she had to travel more difficult. As previously mentioned, she remembered that she always felt that she had to do much more than the male science students did to get the same recognition. But she tried to turn that fact into an incentive to try harder and excel. When asked how she dealt with the discouragement that she perceived was related to gender, she stated that she relied on the other women graduate students of science who were her friends to talk through those problems with her, and she would do the same for them. So her friends were not only study partners, but they were also a support network that acted to help her through difficult moments.

Dr. Adams did not think that her gender was an ultimate factor in how difficult or easy it was to become a scientist. However, some of her later comments seem to contradict that statement. For example, Dr. Adams recalled that sexism was rampant at Canisius College, which was a Jesuit college that she attended as an undergraduate. She remembers that Canisius College:

> cultivated from a private male school called Saint Joe's all the best male students. All of the Saint Joe's students had offices and desks and labs and private places to study. The female students didn't get that. They didn't recruit female students. So it wasn't overt…they didn't talk down to us, they didn't tell us we were stupid, but there were subtle benefits to being a male. (personal communication, M. Adams, November 5, 2001)

She further elaborated that research fellowships in the summer time, private places to study and lots of encouragement were always available to all of the male students but only to the exceptional female students. She further elaborated that she believed, "that there is overt and covert sexism that will always exist by a certain type of man. And I think that you have to fight that" (personal communication, M. Adams, November 5, 2001). She then went on to state that

> one of the best ways to fight it is to play up the female. Men are such simple creatures and you can manipulate them so easily. And the women who have the most difficulty fighting sexism are the ones who try to be men. While they are criticizing you or coming down on you for being a woman, using the fact that you are a woman can completely disarm them. (personal communication, M. Adams, November 5, 2001)

I then asked her how a woman could use her sex to disarm a man and she said by flirting with them and charming them and manipulating them into thinking they came up with an idea. She believed that it is not a good idea to "come across as aggressive and manly and try to compensate for their sexism by being more anti-female." She also stated that if you have a suggestion or an idea to present to a man, "if you present it to them in a way that's not threatening, with a smile or a softer voice, they won't be so threatened" (personal communication, M. Adams, November 5, 2001). So basically what she was saying is that sexism is there and if you know how to deal with it intelligently as a woman, then it does not have to be a major issue.

Dr. Nix felt as though it was possible that being a woman could make it harder to become a scientist. She stated that you have to make concessions, that "you have to be willing to work in places that are all men and not be offended and not be upset by that" (personal communication, D. Nix, November 21, 2001). She actually preferred working with men over women, stating, "It's like this queen bee thing. That there can only be one queen bee in a place or there will be all this fighting" (personal communication, D. Nix, November 21, 2001).

Dr. Jones felt that her gender made it harder to become a scientist mainly because of social expectations and the fact that she was married with three children at the time she attended undergraduate and graduate school. She stated that

> it puts really tough strains on anybody to be married and have kids but more so on women. Because, like it or not, we're still expected, in most cases, to be the ones that raise the kids, the ones that do certain household tasks. I see that changing, but the ultimate basis hasn't really changed. (personal communication, W. Jones, November 5, 2001)

Dr. Black did not feel that her gender had any negative effect on her ability to become a scientist. In fact, she felt that because she was female she was encouraged more, especially in graduate school. She felt that her gender is what got her accepted into graduate school because her GPA was not that high, and her recommendation letters were fairly generic. She felt that "graduate schools try to help their female graduate students more than their male graduate students" (personal communication, P. Black, November 5, 2001)

Dr. Scott felt that it was only harder at the undergraduate level because there were so few women students. At the graduate level, she was in a group of mostly women and she felt that since they were the majority, they had more power and were more likely to be heard.

Dr. Johns did not think her gender had any bearing on becoming a scientist, either positively or negatively.

Conflict Between Self-Image as a Woman and Motivation to Become a Scientist Motivational Theme

Five of the seven women scientists interviewed reported experiencing conflict between their self-images as women and their motivation to become scientists. Most of the conflict experienced by the women participants arose out of society's cultural expectations for the behavior of women. Since many people, especially traditional people, find it unusual that a woman would elect to pursue a career rather than marry and have a family, several of the women participants reported having to endure repeated inquiries as to when they were going to finish school and finally get married. Some of the women also reported experiencing feelings of doubt associated with the demanding career choices they had made as time passed while they were in graduate school and personal friends and family members were getting married and having children. Others admitted taking on masculine characteristics, and denying their femininity to better fit into the science arena which has been historically perceived as masculine in nature.

Dr. Townsend recalled the turmoil she was experiencing towards the end of graduate school when she was trying to decide where to go to get a job and whether or not to end a relationship with a man. She associated her femininity with marriage, as did her grandparents who kept asking her when she was ever going to get married and finish her education. She opted to end the relationship with her fiance and accepted a position at a college in Virginia. She wondered if she made the right decision. She wondered what her life might be like today if she had not sacrificed that relationship with the man she loved or even if she had chosen a less rigorous career path.

Dr. Black said it was difficult for her to see her sisters and brother and friends marry and start families while she was still in graduate school. She felt like they were getting on with their lives and she was not, but she said that it never got to a point where she wanted to quit. It only made her want to try that much harder.

Dr. Jones did not report a conflict between her femininity and her motivation to become a scientist. Perhaps that is because she was already married and had three children throughout her educational career. She did not feel any less feminine as a scientist than she would in any other career field.

Dr. Nix remembered that as the only female in an all male research group in graduate school, she began to actually act like the men she was with so much. She stated,

> I found myself developing sailor mouth or an attitude where I wanted to fit in with them. If they would swear, I would swear. If they wanted to talk about nasty things or look at pornography on the Internet I would say, 'Oh, that's cool.' I would try to act like one of the guys. (personal communication, D. Nix, November 21, 2001)

Dr. Nix also reported a time as a post-doc in which she found herself wearing jeans with holes and lab coats and only tying her hair back when she went to work. She remembered feeling pretty miserable when she dressed like that.

Dr. Scott experienced conflict between her self-image as a woman and her motivation to become a scientist in the beginning of her educational career. She remembered that the female scientists who were her role models in the 80s were what she has heard called "science nuns" because they "act very aggressive and have to look (pause) they wear their hair in a bun or something....they had to act very masculine to get where they were" (personal communication, J. Scott, October 22, 2001). But she did not see that women scientists her age have to do that anymore.

Conflict Between Goals to Pursue Science Career and Significant Relationships With Men Motivational Theme

Six of the seven women scientists reported a tremendous conflict between their goals to pursue a science career or their current position as a scientist and significant relationships with men. Every unmarried woman scientist who participated in this study revealed that all of the relationships they have been involved in since obtaining doctoral degrees have been unsuccessful. All of them attributed this lack of success with significant male relationships to the fact that the men were threatened by the doctoral degrees held by these women in the hard core sciences. Two of the single female participants were so discouraged with the quality of the relationships they have had with men that they were considering giving up on dating completely. The married women reported that their pursuits to obtain science careers placed strain on their marriages, mainly due to the fact that the women had to spend so much time away from their husbands either in labs conducting research or studying. Once again, I was surprised at these discouraging findings. I had believed that many men were beginning to change their attitudes toward women. I had erroneously thought that women could hold positions of power and prestige and still have healthy relationships with men. Apparently, many men are threatened by successful women scientists to such a degree that they cannot comfortably be involved in a relationship with them.

Dr. Jones was already married when she began her college education, but her educational career put an extensive amount of stress on the relationship she had with her husband. She stated,

> The first year or two probably wasn't so bad but when you go on and on and on for six years it is very tough. And I would have to say that if it wasn't for the dedication that both of us had to hold the marriage together, we probably wouldn't have stayed together. Because if you have someone you are supposed to be having a relationship with and they're always gone, even when they're there physically and they're gone mentally, it definitely has an effect on you. (personal communication, W. Jones, November 5, 2001)

When asked if the conflict had an effect on her motivation to become a scientist, she said that sometimes it did, but her need to finish what she had started carried her through.

Certainly Dr. Townsend's motivation to become a scientist affected the relationship she had with the man she was intending to marry. It ultimately caused the demise of that relationship, as previously stated. Even today, she stated that she finds conflict between her position as a scientist and significant relationships with men. She related,

> It's amazing when I date men, they seem to think that that is so important (those three little letters after my name). But I'm like, 'I just went to school three years longer than you.' There is no big crown that I wear on my head all day long. (personal communication, J. Townsend, November 5, 2001)

When asked how she deals with men who are threatened by her education, she remembered a guy she dated in Virginia who she felt like she had to be so careful around, so as not to appear

> too smart, or too aggressive, or whatever. And finally I just got tired....I dated a couple of men when I first came here and they just think it's such a big deal. And it's really sad to say (pause) but I really don't date anyone that long that has those problems because you can't live the rest of your life not being yourself. (personal communication, J. Townsend, November 5, 2001)

Dr. Black also reported a great deal of conflict in this area. She related,

> It takes a very secure man to be involved with somebody whose got a higher degree than them. And I have found that. And the whole fact that graduate school and being a scientist is so time consuming that there's not a lot of time for that part. But yes, there was major conflict there. I think the biggest one is (pause) I think it's the whole security thing. A lot of men can't handle it, being involved with a person with a higher degree. That's quote "smarter." Which there's nothing (pause) I don't think smartness has anything to do with degrees....So I think there's a lot of problems there. (personal communication, P. Black, November 5, 2001)

Dr. Adams reported less of a conflict between her goals to pursue a science career and her relationship with her husband when she was still married than she does now as a single woman. She told me, "Now, (laughs) I think it's almost hopeless." She recalled a date she had that seemed to be going really well and they both seemed interested in one another. Of course he asked her what she did for a living and she said she did laser spectroscopy and had a Ph.D. in chemistry. He never called again. When discussing what happened later with her former brother-in-law, he knew right away what she did wrong. He told her that the next time she goes out with a guy to tell him anything but the truth, because that is the way guys are. She is currently in a relationship with another scientist but she is a higher rank than he is and makes more money than he does and she is hoping that it does not become an issue. She went on to say that, "If this relationship doesn't work out that I'm in, I will probably not have another one in this town" (personal communication, M. Adams, November 5, 2001). When asked what she thought was the best way to deal with that, she replied that she downplays it, that she acts down to earth and that she tries to not make it a part of who she is. But she said, "It's not going to work with men because they're always going to be intimidated by it. Unless they have a Ph.D. as well" (personal communication, M. Adams, November 5, 2001).

Dr. Nix was married throughout her graduate school career, but she did report some conflict between her goals to become a scientist and her relationship with her husband as far as conflicting careers are concerned. He never finished his undergraduate degree so she feels as though sometimes there was an "assumption" that she thought her career was more important than his, that his career was a side issue. She also experienced some conflict when her husband was the one who got to stay home with their newborn daughter as she was a post-doc and commuting a good distance into Washington D.C.

Dr. Scott was also married, although she is now divorced. She recalled that at the time she was married, there was "somewhat of an intellectual battle there." Her ex-husband was also a scientist and she always had the feeling that he was more intelligent than she was. I asked why she felt that way and she said, "Some of it was his pedigree. I wasn't the valedictorian of my class; he was. I went to a state school; he went to Notre Dame. That kind of thing" (personal communication, J. Scott, October 22, 2001).

Stereotyping/Discrimination Motivational Theme

Six of the women scientists reported being stereotyped or discriminated against as women in science. These incidents ranged from possibly being denied a position because of being female, to being told that they did not look like scientists, to being taken less seriously as science professors by students because of being female, to being discouraged from attending graduate school. These incidents of stereotyping and discrimination most often occurred at the hands of men. I was surprised that so many of the women reported this type of behavior from educated professors and scientists. These people have likely been educated about the detrimental effects of these attitudes on women, therefore, they are most likely aware of what they are doing as they do it. These acts of discrimination against women in science and stereotyping of women scientists therefore, seem to be deliberate acts on the part of some men to maintain their dominance in science professions.

Dr. Nix reported that it was possible that she was discriminated against as a woman in science when she was working as a post-doc in Washington D.C. She and another female post-doc had followed all of the perceived guidelines to become permanent hires, but when they finished up their post-docs they were told they would not be hired. Apparently all of a sudden, new written guidelines surfaced that they had not satisfied and so they were told they would not be hired. Dr. Nix and the other woman felt that the real reason they were not hired was because they were women. Eventually a lawsuit was filed by the other woman. Dr. Nix had to speak to counselors and give a statement, but she does not know if it was ever settled since she moved while it was going on. She mentioned that she was probably at her lowest point when she lost out on that position that she was counting on. Her life was disrupted. They had to move in with her in-laws, and she worked at various menial jobs for a year before being hired at the university where she now teaches.

Dr. Adams remembered being stereotyped when she was told that she did not look like a scientist. She stated that when she attended an American Chemical Society reception, she was at a bar with the rest of her group when the man sitting next to her, who was also a chemist asked her what she did for a living. When she told him laser fluorescence spectroscopy, he was completely surprised and told her she did not look like a chemist. Then she began to reflect upon the stereotypical chemist: the person with a calculator on his belt and a pencil pocket protector. She stated that as a woman, you should not have to give up your femininity to be a scientist. But she sees that happen often with the other female chemists she associates with who wear no makeup and take little care with their appearance.

Dr. Black believed that she had also been discriminated against by her students. She said that many of the female chemists in her department have had negative phone calls from parents placed to their boss. None of the male chemists have had that take place. She wondered if the students were quicker to find fault with the women chemists because they were women. As a result of that, she felt as though she has to constantly be aware of the image she projects to her students. She stated that she tries "not to be too ditzy or…too much of a stereotypical woman because I know that women aren't taken as seriously as men" (personal communication, P. Black, November 5, 2001)

Dr. Townsend believed she was stereotyped as an undergraduate by several of her professors because she was in a sorority and did all of the "sorority stuff." Because of that, she feels that many of her professors did not take her seriously. She also believed that the professor who tried to get her to teach rather than go to medical school or graduate school did that because she is a woman. That was a difficult time for her but her mother helped her stay focused on her goals and kept encouraging her to try graduate school despite what the professor had said.

Dr. Jones believed she was discriminated against by a major research university in Tennessee, when she applied to graduate school there. She had applied at four other schools and had heard back from them. But her first choice was that particular school, and they did not answer her. So she called them and they invited her for a visit, which she thought was unusual since they usually tell you that you are accepted before they invite you to visit. It turns out that they did not think she could handle graduate school since she was married and had a family. So they tried to dissuade her, even though in the end they sent her an acceptance letter. But she wrote a refusal letter to the head of the committee because she knew that she could not work in that type of environment.

CONCLUSION

The purpose of this dissertation was to better understand how female scientists interpreted the influence of various experiential factors on their motivation to become scientists. In accordance with this purpose, the concluding chapter discusses research answers to the research questions concerning motivational influences and the project comes full circle. The motivational experiences of the seven female scientists have been explored in such a manner that the reader not only discovers what encouraged (and sometimes discouraged) these women to succeed as scientists, but the reader is also offered an often fascinating vision of the women as individuals. The qualitative nature of this study has not only added to the insight of what motivational influences encouraged the interest of girls in science, but also how these motivational influences inspired them to purse science careers.

In this section, I will further interpret the motivational themes that emerged from this study and discuss findings (answers) to the research questions as stated in Chapter I. In this chapter, I will also discuss how the findings of motivational themes provide answers to the research questions: What are the interpreted motivational influences of science experiences, social interactions, and gender perceptions across the three developmental periods? I will also corroborate the research answers (findings of motivational themes) with the review of motivational research and clarify how the research answers of this study (findings of motivational themes) are similar to previous research. Next, I will show how the answers to the research questions in this study make a unique contribution to this field of research. The research findings will also be related to my own personal experiences in some cases. Limitations of the study and implications for how science is taught, how science teachers are trained, parental and counselor involvement will be explored. Finally, implications for further research will be discussed.

Many of the themes that emerged could have been linked with more than one of the investigated categories (science experiences, social interactions, and gender perceptions). As stated earlier, the general factors of science experiences, social interactions, and gender perceptions are not fixed and independent entities, but they represent interconnecting areas with overlapping borders.

Outline of Areas of Motivational Influence on Becoming a Female Scientist

The primary research questions will now be re-stated, and the resulting motivational themes that arose out of the stories of the women scientists during each developmental period are listed A summary of the outlined motivational themes across the stories of the women participants are as follows:

I. What are female scientists' interpretations of the influence of science experiences on their motivation to pursue science across the three developmental periods?

1. Preschool to elementary school period:
    - Enjoying and exploring nature and the outdoors.
    - Enjoyable informal science experiences.
    - Fun formal science experiences.
    - Educational success in science.
2. Middle to high school period:

- Formal science experiences made fun and interesting.
- Educational success in science.

3. Undergraduate to graduate school period:
    - Experiences increase in seriousness and decrease in enjoyment.
    - Fear of failure as a motivational theme.
    - Educational success as a motivational theme.
    - Relevancy of science to real life as a motivational theme.

II. What are female scientists' interpretations of the influence of social interactions on their motivation to pursue science across the three developmental periods?

1. Preschool to elementary school period:
    - Encouraging and supportive parents.
    - Encouraging and supportive teachers.
    - Encouraging and supportive grandparents and other relatives.
2. Middle school to high school period:
    - Encouraging and supportive teachers.
    - Encouraging and supportive peers.
    - Discouraging experiences with counselors.
3. Undergraduate to graduate period:
    - Encouraging and supportive parents.
    - Discouraging parents and other family members.
    - Encouraging and supportive husbands.

- Encouraging and supportive peers.
- Encouraging and supportive male professors and advisors.
- Female professors/advisors as role models.
- Discouraging male professors and advisors.

III. What are female scientists' interpretations of the influence of gender perceptions on their motivation to pursue science across the three developmental periods?

1. Preschool to elementary school period:
   - Parental adherence to traditional roles of females.
   - Parental divergence from traditional roles of females.
2. Middle school to high school period:
   - Counselor adherence to traditional roles of females.
3. Undergraduate to graduate school period:
   - The discouraging affect of gender on science goals.
   - Conflict between self-image as a woman and motivation to become a scientist.
   - Conflict between goals to pursue science careers and significant relationships with men.
   - Stereotyping and discrimination as women science students or scientists.

I generated the above themes in the final interpretive process as I re-examined and re-read the stories shared by the women participants. Many of the motivational themes that emerged from the stories of the women scientists who participated in this study are comparable to those factors that the literature deems to be motivational to girls in science. I will now examine and discuss my research answers (findings of motivational themes), show how they are consistent with factors identified in the review of motivational research, and relate the research answers to my personal experiences. I will also clarify how my research answers are similar to previous research yet make a unique contribution to this field of research.

Motivational Influences of Science Experiences

Pre-School to Elementary Developmental Period

Enjoying and Exploring Nature and the Outdoors Motivational Theme

Several of the women participants reported that their initial curiosity about science was sparked during childhood when they were permitted to interact with nature and the outdoors. Many of the women realize as adults the importance those early motivational experiences with nature had on their interest in science and eventual decisions to pursue science as a career. In fact, several of the participants credit their earliest informal experiences with science, when they were informally and intrinsically investigating and having fun with nature and the environment, as having been extremely instrumental in starting them on their career paths. Several studies have shown that girls will be motivated to achieve in science when science is made interesting to them (see, for examples, Glaton, 1981; Kahle, 1990; Yager & Penick, 1986). Although these earliest informal interactions with science were not structured school-related science experiences, they could still be classified as serious fun science experiences (Rea, Millican, & Watson, 2000). For example, Dr. Black's early "experiments" collecting organisms and trying to figure out how to keep them from dying is an example of an experience that incorporates elements of both seriousness and playfulness (Mann, 1996; Rathunde, 1991a, 1991b, 1992; Rathunde & Csitszentmhalyi, 1993; & Wasserman, 1990, 1992). I also recall similar interactions with nature as a child growing up on a farm in rural Kentucky that sparked my scientific curiosity. The literature indicates that the simultaneous integration of seriousness and fun makes for an ideal motivational experience (Rea, 1994, 1995, 1997; Rea, Millican & Watson, 2000). The stories shared by the women scientists about their early scientific motivational interactions with nature and the outdoors are thus consistent with the literature findings that indicate girls will be motivated to learn science when science is both enjoyable and interesting.

Enjoyable Informal Science Experiences Motivational Theme

The majority of the women participants reported other informal motivational experiences with science at the earliest developmental period explored. These experiences included playing with science-related toys, role-playing with science and a trip to a science museum. Dr. Townsend's early experiments with a chemistry set she received while in the second grade influenced her to continue studying science and eventually pursue a career as a chemist. I likewise recall with fondness the early "science experiments" I performed in the bathroom sink and with my brother's chemistry set. Those early interactions with science also motivated me to continue reading about science and asking questions of my teachers about science. Like the experiences with nature and the outdoors, these additional early informal science experiences could also be classified as serious fun science (Mann, 1996; Rea, 1995). Furthermore, these informal science interactions are consistent with the literature's research findings that girls will be motivated to pursue science when they find it interesting and fun (Glaton, 1981; Kahle, 1990; Samuels, 1999; Yager & Penick, 1986).

Fun Formal Science Experiences Motivational Theme

Two of the women scientists who participated in this study recalled participating in fun formal science experiences provided by teachers at the elementary school level. Dr. Adams remembered the enjoyable stations her first grade teacher created that sparked her interest in studying different environmental biomes. Dr. Townsend recalled numerous fun experiences her enrichment teacher provided when they were studying space science. I also recall my third grade teacher's weekly science demonstrations, including the day she magically passed an egg through a narrow bottleneck and then scientifically explained the phenomenon. Although these types of activities are much more structured and formal than the previous two subgroups of informal experiences mentioned, they would certainly be considered examples of serious-fun science (Rea, Millican & Watson, 2000). Therefore, the stories shared by the women participants about these early formal fun science experiences are once more in agreement with the literature's research findings that girls are more likely to grasp and remember scientific concepts when science experiences are made enjoyable and interesting to them (Glaton, 1981; Kahle, 1990; Samuels, 1999; Yager & Penick, 1986).

Educational Success in Science Motivational Theme

Two of the women reported that the good grades they achieved in science at the elementary level and the subsequent praise they received from teachers and parents as a result of those good grades, motivated them to continue to study and do well in science. The literature has shown that when girls are confident in their perceived scientific academic achievement, they are much more likely to attain necessary science skills (Debacker & Nelson, 2000; Glaton, 1981; Samuels, 1999). As the attainment of science skills increases for girls, the likelihood that they will rise to the challenge of science also increases (Debacker & Nelson, 2000; Glaton, 1981; Samuels, 1999). As the women scientists became more confident with science skills and more knowledgeable in science, they became more successful in their science achievement.

Middle School to High School Developmental Period

Formal Science Experiences Made Fun and Interesting Motivational Theme

All of the respondents reported an abundance of fun science-related experiences provided by teachers within the formal setting in high school. Often, it was those experiences that the women recalled with the most enthusiasm and many of them indicated that because those experiences were both fun and interesting, the science concepts involved were easier to understand. I still remember and understand several difficult science concepts because they were made fun and interesting to me through the experiences provided by my high school biology teacher. Once again, my research findings is in agreement with other research that has shown girls will be motivated to learn science when it is enjoyable and engaging to them (Glaton, 1981;, Kahle, 1990; Samuels, 1999; Yager & Penick, 1986).

Educational Success in Science Motivational Theme

There was a marked increase of academic success in science at this developmental period across the stories shared by the women participants. One of the women scientists recalled learning a difficult scientific concept so quickly that she helped other students who were not faring as well. Others remembered competing with peers for high grades in science. Many knew they were good at science at this point because they understood it, did well in it, and enjoyed it. As stated previously, this is consistent with the research findings that as girls attain science skills, the likelihood that they will rise to the challenge of science also increases (Collier, Spokane, & Bazler, 1998; Kahle, 1990; Samuels, 1999).

Motivational Influences of Science Experiences

Undergraduate School to Graduate School Developmental Period

Experiences Increase in Seriousness and Decrease in Enjoyment Motivational Theme

All of the women scientists were actively engaged in numerous science experiences during this developmental period including conducting their own research and working as part of research teams. Because the women had to spend such an extensive amount of time studying and conducting experiments, the enjoyment factor decreased. Even with the additional responsibility involved and energy expended as science students at this advanced developmental period, the women still had fun engaging in it. They not only enjoyed working with lab partners, they also experienced the pleasure of having achieved desired results in complicated science experiments. This finding in agreement with the literature's finding that women will be motivated to achieve in science through collaboration and connection (American Association of University Women, 1998; Baker & Leary, 1995; Belenky, Clinchy, Goldberger, & Tarule, 1986).

Fear of Failure Motivational Theme

Another motivational theme that emerged across the stories the women scientists shared was fear of failure, which is included within the notion of positive self-expectancy as explored in the literature review section of this paper (Ryckman & Peckham, 1987;

Ziegler & Heller, 2000). The fear of failure experienced by these women most often took place at the undergraduate and graduate school levels. Unlike many girls and women taking high school and college science courses, these successful women scientists did not seem to correlate failure with a lack of ability, but rather with a lack of effort (Beyer & Bowden, 1997; Ziegler & Heller, 2000). The literature indicates that in many cases girls associate failure with a lack of ability in science while boys may tend to associate failure in science with a lack of effort (Ziegler & Heller, 2000). The women scientists in this study who indicated experiencing a fear of failure in undergraduate and graduate school used that fear as a motivational tool to increase their determination and drive to succeed in science.

Educational Success Motivational Theme

Like the first two developmental periods explored in this study, the women respondents indicated that educational success in science at the undergraduate and graduate levels further motivated them to continue to work hard and succeed in science. The appearance of this theme across all three developmental periods indicates that it is indeed very supportive of the literature findings that girls and women who are confident in their scientific skills will more likely rise to additional science challenges. The educational success of the women scientists arose out of a positive self-expectancy, and that success further amplified their motivation to achieve in science (Beyer & Bowden, 1997; Ziegler & Heller, 2000).

Relevancy of Science to Real Life Motivational Theme

As mentioned in the literature review section of this dissertation, Belenky et al. (1986) indicate that girls are more likely to experience successful learning in science when they are permitted to empathetically enter into the concept being investigated, a phenomenon they describe as "connected knowing." Several of the women scientists interviewed reported experiences that were consistent with this finding. For some of the participants, science became more interesting if they could connect it with humanity, or if they could clearly see the practicality and applicability of it.

Motivational Influences of Social Interactions

Preschool to Elementary School Developmental Period

Encouraging and Supportive Parents Motivational Theme

Parental support and encouragement was most prevalent during this earliest developmental period explored. The parents of the women scientists provided science-related toys and experiences; they encouraged their daughters to do well not only in science, but in all of the subjects they took in school. As indicated in the literature review, numerous researchers have conducted studies that show parents, more than anyone or anything else, have the greatest influence on their daughter's lives and choices (see, for examples, Hammrich, 1997; Jordan, 1999; New England Consortium for Undergraduate Science Education, 1996; and Samuels, 1999). At this particular developmental period, many of the women scientists reported that their parents were prominent in encouraging them and supporting them in science and providing them with science experiences and some science-related toys.

Encouraging and Supportive Teachers Motivational Theme

During the preschool to elementary school years, a few of the women scientists reported that their teachers encouraged them to develop an interest in science by providing fun and interesting science experiences. The women participants who were fortunate enough to have been turned on to science at this earliest developmental period by exemplary elementary school teachers, recalled those engaging science moments at such an early age with fondness and enthusiasm. Most of the women, however, did not indicate an abundance of teachers who were particularly supportive in science or provided science opportunities for their students at this level. I was fortunate to have had a teacher in the third grade who made an effort to provide weekly science lessons that often involved simple science experiments and demonstrations to help explain certain concepts.

Encouraging and Supportive Grandparents and other Relatives Motivational Theme

Many of the women respondents reported the encouraging presence of grandparents, siblings and other relatives in their lives at this early developmental period. Some of the women's grandparents lived on farms, therefore, their early interactions with nature and the outdoors often took place at the homes of grandparents. Some women also reported that their grandparents encouraged them to do well in school and get as much education as they could. One scientist remembered her brother helping her with a science fair project. Unfortunately, I did not live near any of my grandparents so I never experienced their direct influence and involvement in my academic life. The literature does not mention the influence of relatives other than parents on daughters' science achievement or science career aspirations. Therefore, the research findings of this study offer a new source of motivation for the achievement of girls in science: the possible positive influence of grandparents and other relatives.

Middle School to High School Developmental Period

Encouraging and Supportive Teachers

The findings of this research study indicate that there is a marked increase in the presence of encouraging and supportive teachers of female science students in this developmental period as compared to the preschool to elementary school level. The teachers at this level (mainly high school teachers) stimulated the interests in science of the women respondents mainly by providing fun and interesting science experiences that were more challenging than those provided by elementary school teachers. Some of the participants also reported the personal interest taken by high school science teachers in their science career aspirations. That personal interest and concern shown by some high school science teachers encouraged the young women to continue taking additional science courses and achieving in those courses. According to some of the women participants, other high school science teachers motivated them in science via the enthusiasm and passion they had for their particular areas of science. That enthusiasm influenced at least one of the participants to pursue a science-related career. The stories shared by the participants in this study about their encouraging and supportive high school teachers is in agreement with the literature review findings that teachers can greatly assist their female students in career choice and self-image (Davis, 1999).

Encouraging and Supportive Peers Motivational Theme

This is the first developmental period in which the women scientists indicated that their science peers were influential in encouraging and supporting them in science. Two of the seven participants reported being influenced in high school in some positive way by other science students. One woman remembered a friendship she had with a male peer in science in which they became study partners and competitors for high science grades. She remembered that they pushed each other to do well and helped each other prepare for science tests. This information is consistent with the research findings of Belenky et al. (1986), which indicates that girls are more likely to involve their individual experiences with others in a collaborative and cooperative scientific effort.

Discouraging Experiences with Counselors

Surprisingly, six of the seven women scientists reported negative experiences with counselors at the high school level. Or they reported no interaction at all with high school counselors. The negative experiences reported included: an incident of inappropriate guidance due to gender stereotyping that caused one young woman to delay attending college for nineteen years; an incident in which a counselor did not encourage a young woman to attend the large university she wanted to go to because the counselor perceived her SAT scores to be insufficient; an incident in which a counselor led a young woman to believe she was a failure because she wanted to attend a community college; and incidents in which counselors shoved financial aid and college applications at students without providing assistance with filling out the forms. My own experience with the guidance department at my high school was nonexistent. I received no guidance whatsoever on college selection, career choice, or financial aid. Davis (1999) conducted a study that indicated guidance counselors play an influential role as door openers to science careers for young women. According to the research findings of this study, counselors are also gatekeepers to women seeking science-related careers.

Undergraduate School to Graduate School Developmental Period

Encouraging and Supportive Parents Motivational Theme

The positive influence of parents re-emerged during this developmental period as five of the seven women respondents reported that their parents were sources of encouragement during the stressful and transitional undergraduate to graduate school years. Although the women scientists participating in this study recognized the encouraging and supportive influences of their parents at this developmental period, most of them did not indicate that their parents were the most influential people in their lives as far as motivating them to do well in science and to pursue science-related careers. During the latter two developmental periods, the women seemed to be encouraged primarily by peers, teachers (professors and advisors), and female role models active in science than they were by their parents, who were not directly involved with their science experiences.

Discouraging Parents and other Relatives Motivational Theme

While the majority of the women scientists who participated in this study reported receiving encouragement from parents and other family members, there were some cases in which relatives were discouraging toward the respondent's pursuits of science careers. This discouragement ranged from jealousy displayed by siblings to ridicule of science goals by parents. Although the discouragement was detrimental to some degree in every case, the women participants attempted to adopt an "I'll show you" attitude that ultimately worked to their advantage because it served to motivate them even further to attain their science career goals. The literature does not address parental discouragement directed toward their daughter's science goals except when it refers to the adherence by some parents to the cultural attributions of femininity, which discourages girls from pursuing a science career due to its perceived masculinity (Bem, 1988; Fennema & Peterson, 1985)

Encouraging and Supportive Husbands Motivational Theme

Five of the women scientists who participated in this study were married either during undergraduate school or graduate school or both. Four of these married women stated that their husbands were extremely encouraging and supportive to them throughout their educational career. These four respondents did not think they would have been able to obtain doctoral degrees had they not had the support of their husbands. These men were largely responsible for the running of the household and caring of children in some cases for extended periods of time while their wives attended classes, carried out research and spent countless hours studying as undergraduate and graduate science students.

Encouraging and Supportive Peers Motivational Theme

The vast majority of the women scientists reported having greater success in science when they worked and studied with their peers. This was particularly true for the final developmental period explored. This serves to confirm the research found earlier in this study that indicates that girls and women prefer a cooperative learning environment. The American Association of University Women's (AAUW) report (1998) states that cooperative learning "is designed to eliminate the negative effects of classroom competition while promoting a cooperative spirit…" (p. 126). Dr. Adams mentioned that the nature of chemistry as a science lends itself quite well to collaboration because of its complexity; one individual may grasp a concept that others do not and that person can help others. She further stated that those who choose not to work in study groups were fools, because everyone needs a support system.

The formation of study groups and study partners seemed to begin in the high school developmental period for many of the women scientists interviewed. The importance and occurrence of the formation of these study groups increased as the women began undergraduate school and seemed to peak at the graduate school level. Two of the women recalled having male study partners who encouraged them or even motivated them in science by competing with them for higher grades. More often, their study groups were made up of other women science students who may have initially been lab partners but then became study groups and eventually personal friends. Many of the women formed bonds with other women in science because they believed women could provide a specific type of support that they could not get from male science students. The participants continually repeated the intensely positive implications the relationships with their study partners and groups had for them, as these peers were a sounding board and a source of encouragement and support through many difficult times.

Encouraging and Supportive Male Professors and Advisors Motivational Theme

Many of the women participants reported the positive influence of encouraging and supportive male undergraduate and graduate professors and advisors. Many of these men took a personal interest in the science achievements of their female students and advisees. Others served as mentors and role models in science for these women participants. This is consistent with the research findings that teachers can greatly influence the career choice and self-image of their female students (Davis, 1999).

Female Professors/Advisors as Role Models

The preponderance of the women taking part in this study shared storied in which one or more of them benefited from the presence in their lives of female scientists as role models. More female role models in science were reported during the final developmental period investigated (undergraduate to graduate school years) by the women participants. One of the participants regarded the presence of a female scientist in her life to be so significant and motivational to her that she now, as a practicing woman scientist, makes a conscious effort to be a positive role model (as a successful woman in science) to her female students of science. Other women participants reported that the intervention of particular women scientists during discouraging times as graduate and undergraduate students conducting research completely changed those negative experiences into positive ones. Four of the participants shared stories in which women advisors or professors at the undergraduate to graduate levels took a personal interest in them, guiding them and encouraging them through periods of difficulty, making such a positive impact that many are still in contact (some after many years) with those women scientists who served as role models.

This study is coherent with the research findings in the literature review that indicate the positive implication of the presence of female role models in science for girls and young women considering or pursuing science careers. As mentioned previously in this study, Pattacucci (1998) states that "visible women in science can often provide sufficient incentive for a person struggling to persevere in her own career endeavor against what seem to be insurmountable odds" (p. 70).

Discouraging Male Professors and Advisors Motivational Theme

At the undergraduate and graduate school levels, some distressing information emerged concerning the negative impact of several discouraging male professors and advisors on the self-images and science career goals of some of the women participants.

My research findings are therefore consistent with the literature's indications that women in higher education often experience discouragement on the part of male professors and administrators (Astin & Malik, 1994; Davis & Astin, 1990; Lie, 1990; Lie, Malik, & Harris, 1994; Lie & O'Leary, 1990; Packard & Wong, 1997).

Two of the women scientists remembered being discouraged by male professors from going to graduate school; these men attempted to steer the women toward secondary science positions and masters degrees rather than advanced degrees. Another respondent recalled being made to feel, by particular male professors in graduate school, as though she, as a female student of science, was on a lower level intellectually than male science students. Other respondents reported lack of interest on the part of male advisors in what they were trying to do as female science students. One of the women scientists even experienced extensive verbal abuse from her advisor. I also recall my undergraduate male advisor's lack of interest in my career goals; often, he was not in his office for scheduled appointments I had with him, and when he was there, he never counseled me on course choices or career goals, he just signed what I handed him and ushered me out of his office.

Belenky, Clinchy, Goldenberger & Tarule (1986) indicate that some male faculty produce and educational atmosphere that is overtly competitive and unfriendly to women. Lazarus, Ritter, and Ambrose (2002) discuss the discouragement and lack of support of female science students from male professors and advisors in graduate school programs of science. They state that the fields of science and engineering are saturated with snares for women seeking doctoral degrees in science, and they offer suggestions to women students for successful navigation of graduate school science programs.

Motivational Influences of Gender Perceptions

Preschool to Elementary School Period

Parental Adherence to Traditional Female Roles Motivational Theme

Fortunately, most of the women scientists participating in this study reported very little or no gender influences during this developmental period. One of the older women participants did recall that her parents were somewhat reluctant to allow her to play too much with her brothers and did not want to purchase a "masculine" erector set for her when she asked for it. But for the most part, the parents of the participants did not convey to their daughters that there were some activities they could not or should not do because they were girls.

Parental Divergence from Traditional Female Roles Motivational Theme

Six out of the seven women scientists remembered that their parents encouraged them in everything they did at this early developmental period, regardless of the perceived masculinity or femininity of the activity. As young girls, the majority of them were encouraged by their parents to take part in sports and play with science-related toys. As mentioned earlier, Fennema and Peterson (1985) claim that the process of aligning one's behavior with the associated perceived social expectations (gender-role congruency) is the single most derisive factor involved in the disassociation of girls from science. Fortunately, most of the women who participated in this study had parents who, at this early developmental level, did not force them to adhere to the cultural attributions associated with femininity as far as science-related experiences was concerned

Middle School to High School Developmental Period

Counselor Adherence to Traditional Female Roles Motivational Theme

Dr. Jones' extremely discouraging experience with her high school guidance counselors is an example of the negative influence school officials can have on the lives of their female students when they attempt to force society's gender expectations on girls who are interested in science. Rossiter (1982) describes the cultural stereotype of science as tough, rigorous, rational, impersonal, competitive, and unemotional—those characteristics embroiled with issues of men's gender identities. The experience of Dr. Jones with her high school counselors is consistent with Baker and Leary's (1995) findings that the male-dominated science identity strongly influences the activities and choices of girls in the pre-college years. Certainly this is true when counselors themselves associate science with masculinity because those beliefs will influence the career choices of young women they counsel.

Undergraduate School to Graduate School Developmental Periods

The Discouraging Affect Gender on Science Goals Motivational Theme

The majority of the participants thought the fact that they were women made it more difficult for them to become scientists, predominantly during the undergraduate to graduate school years. The perceptions of the women scientists that being female made it more difficult to achieve science career goals arose out of discouraging interactions with male professors and advisors, sexism on the part of male professors and school officials, social expectations associated with the obligations of women to their husbands and children, the perceived masculinity of science, and a lack of female science role models. All of these discouraging issues originate with the social construction of gender and its resulting gender congruent and incongruent roles (Bem, 1983; Fennema & Peterson, 1985). As previously stated, gender is a social construction that develops over time and is distinguished from sex, which is biologically determined at birth (Vetterling-Braggin, 1982). Oakley (1972) states that gender in personality emerges very early in cultural learning and gender differentiation increases with age. What ultimately results, according to Bem (1993), is "an androcentric social structure that operates systematically and in the here and now to preserve male power" (p. 135).

Conflict Between Self-Image as a Woman and Motivation to Become a Scientist

Motivational Theme

The majority of women scientists interviewed reported feelings of conflict, at one time or another, between how they see themselves as women, and their goals to pursue science. Some of the participants reported that many women scientists changed their behavior and appearance to better fit into the masculine world of science. One respondent recalled how she dressed and acted masculine during graduate school to blend into the all male research group that she was involved in. Another recalled the women scientists who served as role models to her as being very masculine in appearance, wearing men's trousers and short hair. When women scientists change their behavior and appearances in an effort to appear more masculine and less feminine to their male science colleagues, they are reinforcing the stereotype of the typical scientist as male. Several studies have indicated when girls perceive science as a masculine domain, when they see women scientists acting and looking like men, they tend to be repelled from displaying an interest in science or perhaps from considering a science-related career (Baker & Leary, 1995; Kelly, 1985; Samuels, 1999).

Conflict Between Goals to Pursue Science Careers and Significant Relationships with Men Motivational Theme

Four single women participants reported extensive difficulty in establishing and maintaining significant relationships with men. Each of these four women stated that most of the men they have dated are so intimidated by their Ph.D.'s in chemistry that a successful and satisfying relationship is not possible. Three of the four single women were at the point of giving up on relationships with men completely. One woman decided that if she can not have a successful family life, then she will put all of her energy into a successful professional life. The youngest woman interviewed has had such difficulty maintaining relationships with men that she questioned her decision to become a scientist. She wondered if she has forfeited a life with a husband and children for a science career; she wondered what might have been different in her life if she had chosen a career less intimidating to men. My research findings are once again consistent with the literature's findings that indicate women in academia often experience conflict between the maintenance of a successful career and family obligations (Lie, 1990; Lie, Malik, & Harris, 1994; Lie & O'Leary, 1990).

Conflict Between Goals to Pursue Science Careers (or the career itself) and Family Obligations Motivational Theme

All three of the married women participants reported some degree of conflict between their goals to pursue science careers and family obligations. Because society continues to place the preponderance of the burden of childcare on mothers, the women scientists reported feeling torn between their desires to pursue science careers (or maintain science careers) and their desires to spend time with and care for their children.

Not only did one participant experience feelings of guilt because her husband was home with their newborn daughter while she was pursuing post-doctoral work, but she also felt guilty because she did not always want to be at home with the baby. All of the married women participants reported difficulty in maintaining relationships with their husbands and children while attending undergraduate school or graduate school simply because they had to spend so much time away from home, and when they were at home physically, they were gone mentally. Fortunately, the two married women with three children each had extremely supportive husbands. My research findings are in agreement with those of Lazarus, Ritter, and Ambrose (2002), who state that the system in place in many graduate science programs works against women with major roles in child-rearing.

Summary of Prevalent Motivational Themes and Developmental Patterns

Particular motivational themes within each category (science experiences, social interactions and gender perceptions) recurred across two or more developmental periods. Because of their developmental prevalence, these themes were exceptionally relevant as motivational experiences. My research findings also indicated that some of these themes appeared to be more meaningful to the women participants at certain developmental periods for different reasons. Therefore, the implication of some themes transformed over time. The most prevailing themes and developmental patterns will now be identified. The nature of the evolution of these themes across developmental periods will also be examined.

Motivational Science Experiences

Fun Formal Science Experiences Motivational Theme

Within the category of science experiences, the motivational theme of fun formal science experiences occurred across all three developmental periods. Throughout the interviews, the women scientists repeatedly reported that they were motivated in science when science was made interesting to them. Fun formal science experiences were those science experiences provided by teachers that were enjoyable and interesting. The women participants reported the fewest fun formal science experiences in the earliest developmental period, although they did report taking part in numerous informal fun science experiences. In the middle school to high school developmental period, the women participants reported an extensive increase in the number of these types of experiences, especially at the high school level. Many times, it was while being involved in these experiences, that the women reported an intensified interest in science. At the undergraduate to graduate school level, the number of fun formal science experiences was still elevated, but the nature of these experiences had changed; although they were still fun, they had become much more serious and required greater effort and time.

Educational Success Motivational Theme

Another motivational theme for science experiences that recurred across all three developmental periods was that of educational success. The women scientist participants reported that when they made good grades in science and understood science, they were motivated to further succeed in science. Ultimately, in undergraduate and graduate school the women reported that they pursued specific fields of science because those were the fields in which they excelled. Educational success as a motivational theme was most prevalent in the middle school to high school and undergraduate to graduate developmental periods.

Motivational Science-Related Social Experiences

Encouraging and Supportive Parents Motivational Theme

In the first and the last developmental periods explored, the presence of encouraging and supportive parents emerged as a motivational theme. Understandably, the nature of the relationships that existed between the women and their parents evolved over time. In the preschool to elementary school developmental period, parents provided science-related toys and experiences and generally encouraged their daughters to do well in school; in the difficult undergraduate to graduate developmental period, parents were essentially sources of emotional support to the women participants. Possibly, the absence of encouraging and supportive parents as a motivational theme during the middle school to high school period was due to the natural distancing that often occurs between parents and teenagers.

Encouraging and Supportive Teachers (including professors and advisors) Motivational Theme

Also within the category of science-related social interactions, encouraging and supportive teachers (including professors and advisors) emerged across all three developmental periods as an extremely meaningful motivational theme. The women scientists reported fewer encouraging and supportive teachers of science in the earliest developmental period as compared to the latter two developmental periods. This could possibly be explained by the fact that fewer elementary teachers have the science background necessary to be comfortable performing science demonstrations and experiments in front of their classes. The women participants often perceived their science teachers at the high school level to be encouraging and supportive if they worked hard to provide enjoyable and interesting science experiences, were enthusiastic about teaching science, and displayed a personal interest in the science goals of their students. At the undergraduate to graduate level, the women perceived their professors and advisors to be encouraging and supportive if they took a personal interest in their students, were passionate about what they did, and inspired their students to attain their science career goals. It is apparent from both this study and the literature review, that teachers play a vital role in the motivation of girls to achieve in science and possibly pursue science related careers.

Encouraging and Supportive Peers Motivational Theme

During the last two developmental periods, the presence of encouraging and supportive science peers emerged as a motivational theme out of the stories shared by the women scientists. At the middle school to high school level, dependence on peers as a support system was not as prevalent or imperative as it came to be in the undergraduate to graduate school developmental period. As undergraduate and graduate science students, the women participants reported over and over again how consequential it was to have encouraging and supportive science student peers. Often, these encouraging friends were other women science students. Many of the women participants relied on their science peers to help them through difficult times, whether those difficulties were related to science research or interactions with professors and advisors, or personal matters. Therefore, the importance of encouraging and supportive peers at this most difficult developmental period was preeminent in the lives of many of the women scientist participants.

Motivational Science-Related Gender Perceptions

In the category of science-related gender perceptions, no theme appeared across two or more developmental periods. Primarily, gender-related issues emerged only in the undergraduate to graduate school developmental period. This was not surprising to me because there was a preponderance of female science teachers at the earlier motivational periods explored, and because until undergraduate school, none of the women were strictly science students. At the undergraduate level, all students eventually declare majors, and it is at this point that the women participants began to be exclusively associated with science as a major field of study. As graduate students of science, the women were very much a part of a domain that has historically been considered to belong to men. So it was during this final developmental period, as doctoral students of science, that the participants experienced the greatest difficulty associated with being a woman in a field historically deemed masculine.

Overlapping Themes

Because the general factors of science experiences, social interactions, and gender perceptions are not fixed and independent entities, some themes fit in more than one category. For example, some women participants reported more encouraging relationships with female science peers because women better understand issues affecting women. Not only would this theme fall within the category of science-related social interactions, but it would also qualify for the science-related gender-perceptions category.

Therefore, this theme along with several others was mentioned more than one time within two separate categories of influence.

Influence of Motivational Factors Across Developmental Periods

This research study has indicated that the relative weight of the motivational factors of science experiences, social interactions, and gender influences changes with developmental period. Some of the motivational factors (science experiences, social interactions and gender influences) appeared to be more important in one particular developmental period than in another. It was clear for example, that the motivational factor of science-related social interactions was most important to the women participants at the third developmental period. At this particular developmental period, my research findings are in agreement with the literature's finding that social support and encouragement are more important for motivating women in science than interest or competence in science (Baker & Leary, 1995; Belenky, Clinchy, Goldberger, & Tarule, 1986; Eisenhart & Finkel, 1998; Martin, 1985, 1994).

At the first and second developmental periods, my research findings demonstrated the reverse to be true; interest and enjoyment in science was much more important than science-related social interactions. Therefore, my findings indicate that girls will be motivated in science when it is made fun and interesting to them predominantly at the first two developmental periods. This is in agreement with other literature findings (Glaton, 1981; Kahle, 1990; Samuels, 1999; Yager & Penick, 1986) that stress the importance of making science fun and interesting to the motivation of female students of science.

Gender influences were far more meaningful at the third developmental period, according to this research study. As the women scientists shared their stories as science students at the undergraduate and graduate school levels, it became apparent that in many cases, gender influences negatively affected their science career goals. The women reported experiencing discrimination, stereotyping, and numerous gender-related conflicts including conflicts between science career goals and significant relationships with men. They also reported experiencing conflict between family obligations and science career goals. Almost all of these discouraging gender influences were only reported in this final developmental period. Of course, significant relationships with men and family obligation conflicts would not be present in the first two developmental periods because the participants were younger. The women participants reported numerous discouraging gender influences at this final developmental period, as previously mentioned. However, there are very few studies in the literature addressing this phenomenon. An extremely recent study by Lazarus, Ritter, and Ambrose (2002) indicates that the discouraging gender influences reported by many of the women scientists in my study at the graduate school level are not unusual. According to Lazarus, Ritter, and Ambrose (2002), graduate schools of science are permeated with pitfalls for women students. Because the climate towards women at many graduate schools of science is so chilly, Lazarus, Ritter, and Ambrose (2002) have written and published a graduate school navigational guide for women science doctoral students.

Deciding to Become Scientists

Only two of the seven women participants knew from the first developmental period explored that they seriously wanted to pursue science as a career. Dr. Adams knew she wanted to be a surgeon when she role-played with her Barbies as a young child, and Dr. Townsend knew she wanted to pursue science after the experiences she had with the chemistry set she received during the second grade. Dr. Nix was the only participant who decided to pursue science as a career during the middle developmental period explored. Dr. Nix knew wanted to be a doctor in high school. She was pre-med. as an undergraduate student and only changed her mind about becoming a physician after volunteering in a hospital and realizing the emotional trauma associated with medicine. For a while after that she didn't know what she wanted to do, so it was after undergraduate school that Dr. Nix decided to attend graduate school and study chemistry. The other four women scientist participants did not make the decision to pursue science as a career until the final developmental period. Dr. Scott had originally planned to major in telecommunications, but those classes were full when she went to register, so she ended up taking general education classes. The summer following her freshman year of undergraduate school she decided to study physics because her cousin had a degree in physics and she admired the knowledge he had about how things worked. When registering as a sophomore, she was told that before she could take physics, she must first take chemistry and calculus. So when she got in that chemistry class, she enjoyed it so much and did so well in it that she decided to become a chemist. Dr. Black was a medical technologist and was not happy in her position, so several years into her medical technology career, she decided to return to undergraduate school and get a chemistry degree. Her defining moment in her decision to attend graduate school and pursue a Ph.D. in chemistry came when she was told it would be free. Dr. Jones was interested in attending undergraduate school and majoring in physical engineering as a high school senior but she was discouraged from doing that by her high school guidance counselors. Nineteen years later she finally enrolled in undergraduate classes and enjoyed chemistry so much and did so well in it that she decided to attend graduate school to obtain a Ph.D. in chemistry. Dr. Johns, the eldest woman scientist who participated in this study also did not make her decision to pursue science as a career until well into undergraduate school. She also married right out of high school and had three children by the time she attended graduate school; the eldest was in college when she started graduate school. So like most of the other women participants, she did not make her decision to pursue science as a career until many years after high school and well into undergraduate school. I was surprised that the majority of the women scientists reported that their decisions to pursue science were not planned years in advance. Perhaps one of the reasons for the late decisions to pursue science on the part of some of these women was that there was a lack of female scientists as role models in the first two developmental periods. Most of the women indicated that they had very little access to female scientists until attending undergraduate school. Perhaps if successful women of science had been present as role models in the earlier developmental periods, the participants would have been more likely to decide upon science careers much earlier in life. Dr. Jones was interested in pursuing science as a career in high school but was discouraged from doing that by guidance counselors. As a result, her career was postponed nineteen years. Dr. Johns was busy with family obligations as she married and began having children right out of high school. So she too made her decision to attend graduate school in microbiology rather late in life.

Using the Hermeneutic Phenomenological Theoretical Framework

Approaching this study from a hermeneutic phenomenological perspective allowed me to find meaning in the human experiences shared by the women scientists. This interpretation of their stories began the moment they shared them; this is consistent with Willis (1991), who stated that once lived experiences are considered, then they immediately begin to be interpreted. While I was listening to the women speak, while I was taking notes, I was also interpreting their stories. Furthermore, as the women were sharing their stories, they were simultaneously developing understandings of the historical steps they took that led to who they are today (scientists). They reconstructed early science-related motivational experiences, social interactions, and gender perceptions and determined if their meanings had changed from the time of their occurrences until now. As the research process continued, as transcripts were made and sent back to the participants, they further reflected upon those experiences, and all of the women realized that those early motivational experiences were more important to their becoming scientists than they had previously realized. They also reinterpreted their current identities as female scientists in light of their past motivational experiences and in turn they began to reinterpret their past motivational experiences in light of who they had become. Therefore, they traveled the hermeneutic circle, in which (according to Heidegger) is "hidden a positive possibility of the most primordial kind of knowing" (p. 195).

My role as researcher in the analysis of the lived experiences shared by the women scientists was first to provide a "thick description that accurately captured and communicated the meaning of the lived experiences for the informants being studied" (Cohen, Kahn, & Steeves, 2000). According to Denzin (1989) and Geertz (1973), a thick description is one that expresses the shared experiences of informants in their fullest and richest complexity. The hermeneutic circle guided the process of this inquiry on several levels. I first provided a realistic context and background information for holistically understanding each interview. The holistic contextualization of individualized interviews set the stage for the thematic analysis of interviews across the participants. In accordance with Cohen, Kahn, and Steeevs (2000), I then began analysis as I attempted to understand parts of the text in relation to the entire text and vice versa. Furthermore, according to Cohen, Kahn, and Steeves (2000), once the whole of the data is better understood, re-examination of the same data at a deeper level or examination of different data allows for even further analysis. This is the hermeneutic circle, which is described by Geertz (1988) as a process in which individually detailed stories are explored, followed by the examination of the holistic data. Over and over, I alternately examined and re-examined the smallest details of the individual stories of the women participants and holistic patterns across the motivational stories of all of the women scientists until I could view both simultaneously. To make this process easier, I constructed an outline of the themes that appeared in the stories of each woman scientist in the three categories of science experiences, social interactions, and gender reflections across each of the three developmental periods. Making use of the hermeneutic circle in the data interpretation of this study meant that I considered every statement shared by the women scientists in terms of the largest cultural contexts. And in between individual statements and large cultural contexts were other contexts that were also considered including the individual women scientists, their family relations, friends, etc. Finally, by making my forestructures known before conducting the interviews, and by adding my insights regarding some of the stories shared by the women participants, a portion of my experience was incorporated into the women's stories. This is known as the fusion of horizons.

Contributions and Limitations of this Study

The purpose of this inquiry was to investigate the elicited stories of seven south Georgia women research scientists so that their retrospective motivational experiences with science as girls and young women inside and outside the formal school setting might better be understood. This inquiry examined specific motivational themes that encouraged or discouraged these women to pursue careers in science.

Other studies have been conducted that addressed the positive and negative factors influential in encouraging or discouraging women to pursue careers in science. My study uniquely contributes to the literature in that it asked the respondents to recall motivational science experiences, social interactions, and gender perceptions across three developmental periods. The categorization of motivational science experiences, science-related social interactions, and science-related gender perceptions across the developmental periods of preschool through elementary school, middle school through high school, and undergraduate through graduate school allows for a more accurate determination of how and when girls and women are ideally motivated in science. By pinpointing motivational science experiences, social interactions, and gender perceptions across three developmental periods, implications for teachers, parents, counselors, and others at each level are discerned with greater ease.

My study also particularly contributes to the literature because it was approached from a hermeneutic phenomenological perspective. Because this study asked the women scientist participants to elicit in-depth personal meanings from their lived experiences, it went beyond asking the women to just recall past experiences. As stated earlier, my phenomenological questions allowed and encouraged the respondents to explain what it was like to have experienced a particular motivational phenomenon. It asked them to delve deeper into their experiences to bring forth the essences of the experiences, which then allowed for the interpretation of those events in ways previously unforeseen. The unique hermeneutics generated from the in-depth interviews served to illuminate how these women got turned on to science as girls and how they persevered in science despite many motivational obstacles.

As with all studies, there are limitations. Because the major method of data collection was the interview, it was an extremely time-consuming process. Therefore, the number of participants was limited to seven. Therefore, there is a lack of generalizability with this study; the stories shared are individual stories, and the themes that emerged from this study cannot be universally applied to all women scientists. Because I conducted in-depth interviews with each of the participants, the amount of data collected was extensive. Since the number of participants was limited to seven, the research findings were much more than a mere collection of motivational themes. They were thick, unique, descriptions of motivational science experiences and hermeneutic reflections shared by successful women scientists.

All of the women scientists who participated in this study were working and living in southeast Georgia, which is a narrow geographical area. However, only two of the women were native to that area. Three participants grew up in Pennsylvania, one in Ohio, and one in Michigan. Therefore, since the majority of the study explored issues faced while the women were still in school, the shared stories arose out of a much larger area of the United States than the area from which the participants were selected.

It is possible that my lack of skill as an interviewer influenced the quality of data collected or resulted in improper comprehension of responses (Marshall & Rossman, 1999). It is also possible that the lived experiences shared by the participants were distorted and incomplete, as the informants must rely only on their own personal recollections without verification by others such as family members, teachers, and fellow students. Since this is a qualitative study, I do not make the claim that it is statistically valid. Hammersley (1990) defines validity as "truth: interpreted as the extent to which an account accurately represents the social phenomenon to which it refers" (p. 57). I agree with Silverman (2000) who stated: "Qualitative researchers have no 'golden key' to validity" (p. 176). Although I did use respondent validation when I returned the transcribed interviews to the participants for clarification, verification, and alteration to be certain that I was accurately stating their stories.

Implications for How Science Is Taught and How Teachers are Trained

It is important to understand that this study has primarily focused upon what worked in the lives of the seven women scientist participants to encourage them to pursue science interests and eventually succeed in science careers. From the favorable motivational themes that emerged from this study (and from some discouraging themes), implications for how science is taught and how teachers are trained are garnered.

The seven women scientists participating in this study overwhelmingly reported the positive implications of the presence of serious fun science across the three developmental periods explored. Unfortunately, it seems that during preschool and elementary school, formal science activities were few and far between. Furthermore, not many of the science activities that the women recalled during the first developmental period investigated could be classified as serious fun science, which both the literature and the findings of this study have confirmed to be a successful method of teaching science to girls. Most of the respondents indicated that their interest in science was initially sparked at the high school level. How science is taught in preschool and elementary school should be thoroughly explored to determine why more girls are not turned on to science at this earlier, more opportune time. Elementary teacher education programs should include a greater emphasis on science content and science teaching skills. Staff development programs that address what serious-fun science is and how to make use of it to motivate not just girls, but all students, should be provided for preschool and elementary school teachers. The earlier girls gain confidence in their science achievement, the more likely they are to continue their science interests.

This research study as well as the literature review findings have demonstrated that the presence of female role models in science can have a profoundly positive effect on female science students. Unfortunately, female role models in science were not accessible to most of the women participating in this study until the final developmental. If the presence of successful women in science as role models during undergraduate and graduate school had such a positive impact on female students of science at that level, imagine what those role models could do for women and girls of science at the first two developmental periods. Teachers of science at the preschool through high school levels therefore, should make every effort to actively recruit successful women scientists as role models for their female students.

The seven women scientists participating in this study reported the importance of encouraging and supportive teachers to their interest in science and pursuit of science careers. They were fortunate to have had many exemplary science teachers who provided them with fun science interactions, were interested in their career aspirations, and enjoyed science and teaching science. Therefore, science teachers have the potential to not only inspire the science interests of their students (both male and female), but they might also provide contributory support in terms of the possible attainment of science careers.

Both the literature review and the findings of this study demonstrate that science continues to be perceived as a masculine field although none of the seven women participants reported being discouraged from science by teachers in the first two developmental periods because they were girls. Most of the discouragement and difficult times the participants in this study faced were reported to have occurred during the last developmental period, while they were undergraduate and graduate students. And the majority of those negative experiences were enmeshed within gender issues. Until going to college, most of these women did not report having been exposed to science-related gender discrimination, stereotyping, or other conflicts associated with gender. Problematical gender issues faced during undergraduate and graduate school by the women in this study included: being discouraged from attending graduate school or medical school by male advisors or professors; feeling as though some faculty perceived female students to be on a lower intellectual level in science than male students; and male science students receiving extra educational perks and encouragement over female students. Science faculty of institutes of higher education must be educated about the detrimental effects the perceived masculinity of science has for women pursuing science careers. They must self-evaluate their teaching practices and alter those practices that work to discourage women from pursuing science-related goals and careers.

Implications for Counselors

Six of the seven women participants reported either negative experiences with counselors at the high school level, or a lack of guidance from counselors. One respondent was guided away from pursuing a career in the hard sciences by her high school counselors because she was female. Most of the other participants were not counseled at all. The literature indicated that counselors could either be door openers or gate keepers to women in science. For the women scientists in this study, most of their high school guidance counselors acted as gate keepers. Counselors need to be certain that their students are informed of career affinity, college choices, financial aid and scholarship opportunities. All students should be encouraged to pursue whatever careers they desire (as long as they have the intellectual ability) regardless of gender.

Implications for Parents

In the first developmental period, all of the women participants reported that their parents encouraged them to do well in school and/or provided them with science-related toys and science experiences outside of the formal school setting. During the second developmental period, there was a general decrease in parental involvement and encouragement. This could be due to the natural distancing that occurs between parents and teenagers. During the final developmental period, most of the participants reported the re-involvement of their parents as motivators and supporters. Because many of the women scientists believed their parents to be instrumental in their motivation to pursue science careers, parents of female science students must make a conscious effort to provide support and encouragement for their daughters throughout each developmental period. Parents of girls interested in science must take extra pains to ensure that their daughters are given every opportunity to engage in science. They must be a consistent and informed source of encouragement for their daughters, and they must take it upon themselves to talk to guidance counselors to be certain their daughters are not led away from science as a career possibility. Parental involvement and encouragement should not decrease with time; it should be a consistent source of motivation for girls pursuing science careers.

Implications for Further Research

It is imperative that we do not forget that the women participants in this study were successful in science in school and did become scientists. From their stories, I have learned that they had science teachers in high school who made science interesting and fun, female scientist role models, encouraging teachers (professors and advisors too), and most had parents who were involved in their lives and encouraged them throughout their educational careers. So through their stories, we see what works. It would be interesting to interview girls who never got turned on to science at all, or girls who expressed an interest in science and thought about pursuing a science career but did not, or women who began the pursuit of science careers but either did not finish, or switched to another subject area. The stories they share could provide useful information pertaining to why some girls don't like science or why some women do not succeed in meeting their science career goals.

Another avenue for exploration arises out of the stories shared by these women about their science experiences in the earliest developmental period. Very few of these women remember many experiences at all in science at the elementary school level. Most of them reported that their interest in science was sparked at the high school level. Perhaps one could investigate what is being taught at the elementary school level in science to determine why more girls are not turned on to science at this earlier, more opportune time. Perhaps one could also investigate how to incorporate more serious-fun science activities into the formal elementary curriculum.

It is interesting that most of the women participants did not experience negative gender/science issues until pursuing undergraduate and graduate degrees. Most of the women reported that their parents never told them they could not do something because they were girls. The majority of the women also did not recall gender discrimination in science throughout elementary, middle, and high school. This revelation is encouraging because it tells me that parents and teachers in the preschool through high school grade levels are now encouraging girls in areas such as science that were once perceived as masculine fields. Because most of the discouragement and difficult times the participants in this study faced were reported to have occurred during the last developmental period, and because they were enmeshed with gender issues, further exploration is needed to determine the climate at undergraduate and graduate schools of science toward women science students. Unfortunately, there are many men, especially at the undergraduate and graduate school levels, who continue to perceive science as a masculine field. The negative implications of that misconception for women in science are extensive. Therefore, both male and female professors of science and male and female students of science should be interviewed or surveyed to determine their attitudes and experiences with gender issues in science. The resulting information could be helpful in restructuring the undergraduate and graduate school science environments so that they do not discriminate against women.

Other issues associated with gender reported by the women respondents during undergraduate and graduate school include conflict between their self-images as women and their goals to pursue science careers, conflict between family obligations and goals to pursue science careers and conflict between significant relationships with men and their careers as scientists. All of these conflicts arise out of the stereotypical roles society has assigned women. Society continues to place the greatest burden of childcare and family duties on women, making the pursuit of a demanding scientific career and a healthy and fulfilling family life difficult to achieve for women. Before conducting this study, I had believed that the roles of women had evolved so much that probably most women in science did not experience gender conflict like the conflicts shared by the women participants in this project. I was surprised to find that a lot has not changed, that women are still oppressed, maybe not as overtly as we once were, but the social oppression is still there.

Final Thoughts

The positive implications of this study for young women contemplating careers in science, for the parents of those young women, for science educators and counselors at all levels are consequential. Likewise, the positive implications for humankind are also extensive if the information gathered in this inquiry leads to more women in science (thus more contributions to science and more benefits for all people). Finally, if this study leads to more women pursuing science careers, the nature of science may expand to equitably include the perspectives of both men and women so that science becomes a human field.

REFERENCES

Abrams, M. (1993). A glossary of literary terms. USA: Harcourt Brace & Co.

Adamson, L., Foster, M., Roark, M., & Reed, D. (1998). Doing a science project: Gender differences during childhood. Journal of Research in Science Teaching, 35(8), 845-857.

Aldrich, M. (1978). Women in science. Signs: Journal of Women in Culture and Society,4(1), 39-45.

American Association for the Advancement of Science, (1989). Project 2061: Science for all Americans (AAAS Publication 89-015). Washington D.C.: Author.

American Association of University Women. (1992). How schools shortchange girls. Washington D.C.: Author.

American Association of University Women (1998). Gender gaps where schools still fail our children. Washington D.C.: Author.

Association of American Colleges. (1982). The classroom climate: A chilly one for women? Washington, DC: Project of the status and education of women.

Astin, A., Green, K., Korn, W., & Riggs, E. (1991). The American freshmen: Twenty-year trends, 1966-1985. Los Angeles, CA: Higher Education Research Institute.

Astin, H. & Malik, L. (1994). Academic women in the United States: Problems and prospects. In S. Lie, L. Malik, and D. Harris (Eds.), The gender gap in higher education. Philadelphia, PA: Kogan Page.

Bae, Y., & Smith, T. (1996). The condition of Education 1996/ Issues in focus: Women in mathematics and science. Retrieved February 26, 2002, from <http://nces.ed.gov/pubs/ce/c97005.html>

Baker, D., Lindsey, R., & Blair, C. (1999). Girls summer lab: An intervention. Journal of Women and Minorities in Science and Engineering 5(1), 79-95.

Barthes, R. (1977). Image-music-text. New York: Noonday Press.

Bartsch, I., Snow, E., & Bell, S. (1998). Fledge-ling: A science program for girls. Journal for Women in Science and Minorities, 4(3), 321-331.

Beerman, L., Heller, K., & Menacher, P. (1992). Math: Not for girls? Bern, Switzerland: Huber.

Belenky, M., Clinchy, B., Goldberger, N., & Tarule, J. (1986). Women's ways of knowing: The development of self, voice, and mind. New York: Basic Books.

Bem, S. (1974). The measurement of psychological androgyny. Journal of Consulting and Clinical Psychology, 42(2), 155-162.

Bem, S. (1983). Gender schema theory and its implications for child development: Raising gender-aschematic children in a gender-schematic society. Signs: Journal of Women in Culture and Society, 8(4), 598-616.

Bem, S. (1988). Gender schema theory: A cognitive account of sex typing. Psychological Review,88(4), 354-364.

Bem, S. (1993). The lenses of gender: Transforming the debate on sexual inequality. New Haven, CT: Yale University Press.

Beyer, S., & Bowden, E. (1997). Gender differences in self perceptions: Convergent evidence from three measures of accuracy and bias. Personality and Social Psychology Bulletin, 23, 157-172.

Blake, S. (1993). Are you turning female and minority students away from science? Science and Children, 30(7), 32-35.

Bleier, R. (1984). Science and gender: A critique of biology and its theories on women. New York: Pergamon.

Boyer, S., & Lamoreaux, C. (1997). Flow theory as a construct for analyzing learning environments in a 7th grade classroom. Paper presented at Annual Meeting of the American Educational Research Association. (Chicago, Ill. March 24-28).

Brown, L., & Gilligan, C. (1992). Meeting at the crossroads: Women's psychology and girls' development. New York: Ballantine Books.

Butler, J. (1990). Gender trouble: Feminism and the subversion of identity. New York: Routledge.

Buytendijk, F. (1947). Het kennen van de Innerlijkheid. Utrecht: N.V. Dekker & van de Vegt.

Chodorow, N. (1978). Reproducation of mothering: Psychoanalysis and sociology of gender. Berkeley, CA: University of California Press.

Cohen, M., Kahn, D., & Steeves, R. (2000). Hermeneutic Phenomenological Research: A Practical Guide for Nurse Researchers. Thousand Oaks, CA: Sage Publications.

Collier, C., Spokane, A., & Bazler, J. (1998). Appraising science career interests in adolescent boys and girls. Journal of Career Asessment,6(1), 37-48.

Creswell, J. (1998). Qualitative inquiry and research design: Choosing among five traditions. Thousand Oaks, CA: Sage Publications.

Cskiszentmihalyi, M., Rathunde, M., & Whalen, S. (1993). Talented teenagers: The roots of success and failure. Cambridge: Cambridge University Press.

Danet, B. (1996, February). Text as mask: Gender and identity on the internet. Paper presented at the conference on Masquerade and Gender Identity, Venice, Italy.

Davis, D. & Astin, H. (1990). Life cycle, career patterns and gender stratification in academe: Breaking the myths and exposing truths. In S. Lie & V. O'Leary (Eds.), Storming the tower. New York: Nichols/GP Publishing.

Davis, K. (1999). Why science? Women and scientists and their pathways along the road less traveled. Journal of Women and Minorities in Science and Engineering, 5, 129-153.

Debacker, T., & Nelson, R. (2000). Motivation to learn science: Differences related to gender, class type and ability. Journal of Educational Research,93(4), 245-255.

Denzin, H., & Lincoln, Y. (1998). Strategies of qualitative inquiry. Thousand Oaks, CA: Sage Publications.

Denzin, N. (1989). Interpretive interactionism. Newbury Park, CA: Sage Publications.

Dewey, J. (1933). How we think. Boston: D.C. Heath & Company.

Didion, C. (1995). Mentoring women in science. Educational Horizons, 73(3), 141-144.

Diener, C., & Dweck, C. (1978). An analysis of learned helplessness: Continuous changes in performance, strategy, and achievement cognitions following failure. Journal of Personality and Social Psychology, 36(5), 457-464.

Dweck, C. (1986). Motivational processes affecting learning. American Psychologist, 41(10), 1040-1048.

Eccles, J. (1987). Gender roles and women's achievement-related decisions. Psychology of Women Quarterly,11(2), 135-172.

Eccles, J., & Jacobs, J. (1986). Social forces that shape math participation. Signs: Journal of Women in Culture and Society, 11(2), 367-80.

Eger, M. (1993). Hermeneutics as an approach to science: Part I. Science & Education, 2(3), 1-29.

Eisenhart, M., & Finkel, E. (1998). Women's science. Chicago, IL: The University of Chicago Press.

Entwisle, D., & Baker, D. (1983). Gender and young children's expectations for performance in arithmetic. Developmental Psychology, 19, 200-209.

Erb, T. (1983). Career preference of early adolescents: Age and sex differences. Journal of Early Adolescence,3, 349-359.

Evans, M., Whigham, M., & Wang, M. (1995). The effect of a role model project upon the attitudes of ninth-grade science students. Journal of Research in Science Teaching, 32(2), 195-204.

Felder, R., Felder, G., Mauney, M., Hamrin, J., & Dietz, E. (1995). A longitudinal study of engineering student performance and retention, III: Gender differences in student performances and attitudes. Journal of Engineering Education, 84(2), 151-163.

Fennema, E. & Peterson, P. (1985). Autonomous learning behavior: A possible explanation of gender-related differences in mathematics. In L. Wilkerson & C. Marrett (Eds), Gender influences in classroom interaction (pp. 17-35). Orlando, Florida: Academic Press.

Freeman, J. (1984). Women: A feminist perspective. Palo Alto, California: Mayfield Publishing Company.

Gadamer, H. (1975). Truth and method. New York: Crossroads.

Gadamer, H. (1976). Philosophical hermeneutics. London: University of California Press.

Gadamer, H. (1987). The problem of historical consciousness. In P. Rabinow & W. Sullivan (Eds.), Interpretive social science: A second look (pp. 82-140). Albany, NY: State University of New York Press.

Gaines, L. (1998). The roots of a woman. In A. Pattatucci (Ed.), Women in science: Meeting career challenges (pp. 73-81). Thousand Oaks, CA: Sage Publications.

Geanellos, R. (1998). Hermeneutic philosophy. Part II: A nursing research example of the hermeneutic imperative to address forestructures/pre-understandings. Nursing Inquiry,5(4), 238-247.

Geertz, C. (1973). The interpretation of culture. New York: Basic Books.

Gilligan, C. (1982). In a different voice: Psychological theory and women's development. Harvard University Press: New York.

Glaton, M. (1981). Differential treatment of boy and girl pupils during science lessons. In A. Kelly (Ed.), The missing half. Manchester, England: Manchester

University Press. Retrieved February 26, 2002, from <http://www.ed.psu.edu/ci/Journals/97pap26.htm>

Green, K. (1989). A profile of undergraduates in the sciences. American Scientist,77, 475-480.

Greenfield, T. (1997). Gender- and grade-level differences in science interest and participation. Science Education, 81(3), pp. 259-276.

Hammrich, P. (1997). Yes, daughter you can: Empowering parents is the first step toward improving females' achievement in science. Science and Children, 34(4), 20-24.

Harding, S. (1986). The science question in feminism. Ithaca, CT: Cornell University Press.

Harding, S. (1991). Whose science? Whose knowledge? New York: Cornell University Press.

Haynes, R. (1989). The scientist in literature: Images and stereotypes – their importance. Interdisciplinary Science Reviews,14(4), 384-398.

Heidegger, M. (1962). Being and time. New York: Harper & Row.

Hein, S., & Austin, W. (2001). Empirical and hermeneutic approaches to phenomenological research in psychology: A comparison. Psychology Methods, 6(1), 3-17.

Holland, J. (1990). The occupations finder. Odessa, FL: Psychological Assessment Resources.

Hoy, D. (1982). The critical circle: Literature, history, and philosophical hermeneutics. Berkeley, CA: University of California Press.

Irarte-Gross, J. (1998). Expanding your horizons in science and mathematics: A hands-on conference for switching middle school girls on to science. Paper presented at the Expanding Your Horizons in Science and Mathematics Conference: Middle Tennessee State University.

Jones, L., & Smart, T. (1995). Confidence and mathematics: A gender issue? Gender and Education, 7 (2), 76-90.

Jordan, D. (1999). Black women in the agronomic sciences: Factors influencing career development. Journal of Women and Minorities in Science and Engineering, 5, 113-128.

Kahle, J. (1990) Why girls don't know. In Rowe, M. (Ed.), What research says to the science teacher: The process of knowing (pp. 55-67). Washington, D.C.: National Science Teacher's Association.

Kahle, J., & Meece, J. (1994). Research on gender issues in the classroom. In Champagne, A. (Ed.), Handbook of research on science teaching and learning (pp. 131-140). New York: Macmillan.

Keller, E. (1983). A feeling for the organism. New York: W.H. Freeman.

Kelly, A. (1985). The construction of a masculine science. British Journal of Sociology of Education,6(2), 133-153.

Kennedy, H., & Parks, J. (2000). Society cannot continue to exclude women from the fields of science and mathematics. Education,120(3), 529-538.

Kerry, D., & Armour, K. (2000). Sport sciences and the promise of phenomenology: Philosophy, method and insight. Quest,52(4), 1-17.

Koch, T. (1995). Interpretative approaches in nursing research: The influence of Husserl and Heidegger. Journal of Advanced Nursing, 21, 827-836.

Law, D., Pellegrino, J., & Hunt, E. (1993). Comparing the tortoise and the hare: Gender differences and experience in dynamic spatial reasoning tasks. Psychological Science, 4(11), 35-40.

Lazarus, B., Ritter, L., & Ambrose, S. (2001). The woman's guide to navigating the Ph.D. in engineering and science. Piscataway, NJ: IEEE Press.

Lie, S. (1990). The juggling act: Work and family in Norway. In S. Lie & V. O'Leary (Eds.), Storming the tower. New York: Nichols/GP Publishing.

Lie, S., Malik, L. & Harris, D. (Eds.) (1994). The gender gap in higher education. Philadelphia, PA: Kogan Page.

Lie, S. & O'Leary, V. (Eds.) (1990). Storming the tower. New York: Nichols/GP Publishing.

Lima, M. (1998). Piecewise discontinuous function: Experiences in engineering. In A. Pattutucci (Ed.), Women in science: Meeting career challenges (pp. 82-88). Thousand Oaks, CA: Sage Publications.

Lorber, J. (1994). Paradoxes of gender. New Haven, CT: Yale University Press.

Maccoby, E., & Jacklin, C. (1974). The psychology of sex differences. Volumes 1 and 2. Stanford, CA: Stanford University Press.

Mann, D. (1996). Serious play. Teachers College Record,97(3), 446-469.

Marshall, C., & Rossman, G. (1999). Designing qualitative research. Thousand Oaks, CA: Sage Publications.

Martin, J. (1985). Reclaiming a conversation: The ideal of the educated woman. New Haven, CT: Yale University Press.

Martin, J. (1994). Excluding women from the educational realm. In L. Stone (Ed.), The education feminism reader (pp.105-121). New York: Routledge.

Mason, C., Kahle, J., & Gardner, A. (1991). Draw-a-scientist test: Future implications. School Science and Mathematics,91(5), 193-198.

Matkins, J. (1996). Characteristics of women scientists: Science in different voices. Unpublished dissertation.

Mayberry, M., Welling, L., Phillips, J., Radeloff, C., & Rees, M. (1999). Feminism and science education: An interdisciplinary knowledge and practice project. Journal of Women and Minorities in Science and Engineering, 5, 1-16.

Mead, M., & Metraux, R. (1957). Image of the scientist among high school students: A pilot study. Science, 26, 384-390.

Meier, K. (1988). Embodiment, sport and meaning. In W. Morgan & K. Meier (Eds.), Philosophic inquiry in sport (pp. 93-101). Champaigne, IL: Human Kinetics.

Merleau-Ponty, M. (1962). Phenomenology of perception. London: Rutledge & Kegan Paul.

Meyer, K. (1998). Reflections on being female in school science: Toward a praxis of teaching science. Journal of Research in Science Teaching,35(4), 463-471.

National Center for Educational Statistics (1995). The educational progress of women. Washington D.C.: U.S. Department of Education, Office of Educational Research and Improvement.

National Science Foundation (1996). Women, minorities and persons with disabilities in science and engineering: 1996. Arlington VA: Author.

National Science Foundation (1997). Women, minorities and persons with disabilities in science and engineering: 1997. Arlington, VA: Author.

National Science Foundation (1998). Women, minorities and persons with disabilities in science and engineering: 1998. Arlington, VA: Author.

National Science Foundation (2000). Women, minorities and persons with disabilities in science and engineering: 2000. Arlington, VA: Author.

New England Consortium for Undergraduate Science Education (1996). Achieving gender equity in science classrooms. Providence, RI: Brown University, Group Independent Study Project.

Nicholls, J. (1975). Causal attributions and other achievement-related cognitions: Effects of task outcome, attainment value, and sex. Journal of Personality and Social Psychology, 31(4), 379-389.

Nokes, S. (1998). Because I did not know I was different. In A., Pattatucci (Ed.), Women in science: Meeting career challenges (pp. 89-98). Thousand Oaks, CA: Sage Publications.

Oakes, J. (1990). Opportunities, achievement and choice: Women and minority students in science and mathematics. In C. Cazden (Ed.), Review of Educational Research (pp. 153-222). Washington D.C.: American Educational Research Association.

Oakley, A. (1972). Sex, gender and society. New York: Harper & Row.

Olsen, K. (1998). Women, science and self-esteem. In A. Pattatucci (Ed.), Women in science: Meeting career challenges, (pp. 61-65). Thousand Oaks, CA: Sage Publications.

Owens, P. (1998). No bones about it, science is for girls. Continuum Magazine, summer, 1998. Available on-line: [http://www.alumni.utah.edu/continuum/summer98/nobones.html].

Packard, B., & Wong, D. (1997). Clash of future selves in college women considering science careers. Paper presented at American Educational Research Association Annual Meeting: Chicago, Illinois.

Packard, B., & Wong, D. (1999). Future images and women's career choices in science. Paper presented at American Educational Research Association Annual Meeting: Montreal, Canada.

Pattatucci, A. (1998). Trespassers on private property. In A. Pattatucci (Ed.), Women in science: Meeting career challenges (pp. 1-14). Thousand Oaks, CA: Sage Publications.

Patton, M. (1990). Qualitative research and evaluation methods (2nd Edition). Newbury Park, California: Sage Publications.

Peltz, W. (1990). Can girls + science – stereotypes = success? The Science Teacher, 57(9), 44-49.

Pert, C. (1997). Molecules of emotion: The science of mind-body medicine. New York: Touchstone.

Peterson, C., Maier, S., & Seligman, M. (1993). Learned helplessness. New York: Oxford.

Rathunde, K. (1991a). A path with a heart: The role of interest in the development of talent. Paper presented at the American Educational Research Association Annual Meeting, Chicago.

Rathunde, K. (1991b). Family influences on interest and talent development. Paper presented at the American Educational Research Association Annual Meeting, Chicago.

Rathunde, K. (1992). Playful and serious interest: Two faces of talent development in adolescence. In N. Colangelo, S. Assouline, & D. Ambroson (Eds.), Talent development: Proceedings from the 1991 Henry B. & Jocelyn Wallace National Research Symposium on talent development (pp. 320-324).Unionville, NY: Trillium Press.

Rathunde, K., & Csikszentmihalyi, M. (1993). Undivided interest and the growth of talent: A longitudinal study of adolescents. Journal of Youth and Adolescence, 22, 385-405.

Rea, D. (1994). Motivating at-risk students with reversal theory. In J. Miller (Ed.), Addressing the problems of youth at risk: Approaches that work (pp. 139-148). Statesboro, GA: College of Education, Georgia Southern University.

Rea, D. (1995). Motivating at-risk students with serious fun. In D. Rea & R. Warkentin (Eds.), Youth at risk: Reaching for success (pp. 22-36). Dubuque, Iowa: Benchmark and Benchmark.

Rea, D. (1997). Achievement motivation as a dynamical system: Dancing on the "edge of chaos" with "serious fun". (ERIC Document Reproduction Service No. ED 415 287)

Rea, D. (2001). Maximizing the motivated mind for emergent giftedness. Roeper Review,23(3), 157-164.

Rea, D., Millican, K., & Watson, S. (2000). The serious benefits of fun in the classroom. The Middle School Journal,31(4), 23-28.

Rholes, W., Blackwell, J., Jordan, C., & Walters, C. (1980). A developmental study of learned helplessness. Developmental Psychology, 16, 616-624.

Rieber, L., & Matzko, M. (2001). Serious design for serious play in physics. Educational Technology, 8(1), 14-24.

Rieber, L., Smith, L., & Noah, D. (1998). The value of serious play. Educational Technology, 11(12), 29-37.

Root-Bernstein, R. (1996). The sciences and arts share a common creative aesthetic. In A. Tauber (Ed.), The elusive synthesis: Aesthetics and science (pp. 49-82). Boston: Kluwer Academic Publishers.

Rop, C. (1997-1998). Breaking the gender barrier in the physical sciences. Educational Leadership,55(4), 58-60.

Rosser, S. (1993). Female friendly science: Including women in curricular content and pedagogy in science. The Journal of General Education, 42(3), 191-220.

Rossiter, M. (1982). Women scientists in America: Struggles and strategies to 1940. Baltimore, MD: Johns Hopkins University Press.

Ryckman, D., & Peckham, P. (1987). Gender differences in attributions for success and failure situations across subject areas. Journal of Educational Research, 81(2), 120-125.

Samuels, L. (1999). Girls can succeed in science: Antidotes for science phobia in boys and girls. Thousand Oaks, CA: Corwin Press, Inc.

Sanders, J. (1994). Lifting the barriers. Port Washington, NY: Author.

Schiebinger, L. (1999). Has feminism changed science? Cambridge, MA: Harvard University Press.

Schleiermacher, F. (1977). Hermeneutics: The handwritten manuscripts. Missoula, Montana: Scholars Press.

Seymour, E., & Hewitt, N. (1997). Talking about leaving: Why undergraduates leave the sciences. Boulder, CO: Westview Press.

Skolnick, J., Langbort, C., & Day, L. (1982). How to encourage girls at math and science. Englewood Cliffs, N.J.: Prentice Hall.

Stanton-Salazar, R., Vasquez, O., & Mechan, H. (1995). Engineering success through institutional support. In A. Murado (Ed.), The educational achievement of Latinos, Vol. II. (pp. 100-137). Santa Cruz, CA: Regents of the University of California.

Strenta, E., Elliot, R., Adair, R., Scott, J., & Matier, M. (1994). Choosing and leaving science in highly selective institutions. Research in Higher Education,35(5), 513-547.

Subrahmanyan, L., & Bozonie, H. (1996). Gender equity in middle school science teaching: Being "equitable" should be the goal. Middle School Journal, 27(5), 3-10.

Tobias, S. (1990). They're not dumb, they're different: Stalking the second tier. Tucson, AZ: Research Corporation.

Tobias, S. (1992). Revitalizing undergraduate science: Why some things work and most don't. Tucson, AZ: Research Corporation.

Trammel, R., Sidlik, L., Piburn, M., Baker, D., & Leary, R. (1992). Student's attitudes towards science: Implications for career development. Paper presented at the annual meeting of the American Association for Counseling and Development, Baltimore, MD.

Valian, V. (1999). Why so slow? The advancement of women. Cambridge, MA: The MIT Press.

Van Manen, M. (1990). Researching lived experience. Ontario, Canada: State University of New York Press.

Vetterling-Braggin, M. (1982). Femininity, masculinity, and androgyny: A modern philosophical discussion. New Jersey: Littlefield, Adams & Co.

Wasserman, E. (2000). The door in the dream: Conversations with eminent women in science. Washington D.C.: Joseph Henry Press.

Wasserman, S. (1990). Serious players in the primary classroom: Empowering children through active learning experiences. New York: Teachers College Press.

Wasserman, S. (1992). Serious play in the classroom. Childhood Education, 68, 133-139.

Willis, G. (1991). Phenomenological inquiry: Life world perceptions. In E. Short (Ed.), Forms of curriculum inquiry (pp.173-186). Albany, NY: State University of New York Press.

Wood, E. (1973). Fun and spirit: The universal relevance of hard-core science. The Physics Teacher, 5, 241-244.

Yager, R., & Penick, J. (1986). Perceptions of four age groups toward science classes, teachers, and the value of science. Science Education, 70(4), 355-363

Ziegler, A., & Heller, K. (2000). Effects of an attribution retraining with female students gifted in physics. Journal for the Education of the Gifted, 23(2), 217-243.

APPENDICES

APPENDIX A

Conditional IRB Approval Form

Georgia Southern University
Office of Research Services & Sponsored Programs

Institutional Review Board (IRB)

Phone: 912-681-5465
Fax: 912-681-0719
Ovrsight@gasou.edu
P.O. Box 8005
Statesboro, GA 30460-8005

To: Sandy Watson
Curriculum, Foundations and Research

Cc: Dan Rea, Faculty Advisor
Curriculum, Foundations and Research

From: Mr. Neil Garretson, Coordinator NG
Research Oversight Committees (IACUC/IBC/IRB)

Date: May 2, 2001

Subject: Status of Application for Approval to Utilize Human Subjects in Research

---

After an expedited review of your proposed research project titled "Women in Science: Making Sense of the Journey: A Hermeneutic Phenomenological Exploration of Motivation," it appears that the research subjects are at minimal risk and appropriate safeguards are in place. I am, therefore, on behalf of the Institutional Review Board able to certify that adequate provisions have been planned to protect the rights of the human research subjects. This proposed research is approved through an expedited review procedure as authorized in the *Federal Policy for the Protection of Human Subjects* (45 CFR §46.110(7)), which states:

> (7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

However, this approval is conditional upon the following revisions and/or additions being completed prior the collection of any data:

1. We would like additional details regarding your methodology, specifically how you plan to securely store the data during analysis and dispose of the data at the completion of this project. This is an essential component of your guarantees of confidentiality.

If you have any questions, comments, or concerns about these conditions of approval, please do not hesitate to contact the IRB Coordinator. Please send a copy of all revised and/or additional materials to the IRB Coordinator at the Office of Research Services and Sponsored Programs (PO Box 8005).

This IRB approval is in effect for one year from the date of this letter. If at the end of that time, there have been no changes to the exempted research protocol, you may request an extension of the approval period for an additional year. In the interim, please provide the IRB with any information concerning any significant adverse event, **whether or not it is believed to be related to the study**, within five working days of the event. In addition, if a change or modification of the approved methodology becomes necessary, you must notify the IRB Coordinator **prior** to initiating any such changes or modifications. At that time, an amended application for IRB approval may be submitted. Upon completion of your data collection, please notify the IRB Coordinator so that your file may be closed.

APPENDIX B

Final IRB Approval Form

Georgia Southern University
Office of Research Services & Sponsored Programs

Institutional Review Board (IRB)

Phone: 912-681-5465
Fax: 912-681-0719
Ovrsight@gasou.edu
P.O. Box 8005
Statesboro, GA 30460-8005

To: Sandy Watson
Curriculum, Foundations and Research

Cc: Dan Rea, Faculty Advisor
Curriculum, Foundations and Research

From: Mr. Neil Garretson, Coordinator
Research Oversight Committees (IACUC/IBC/IRB)

Date: May 8, 2001

Subject: Status of Conditional IRB Approval to Utilize Human Subjects in Research

---

The Institutional Review Board (IRB) Committee has received your revised and/or additional application materials for the approved research titled, "Women in Science: Making Sense of the Journey: A Hermeneutic Phenomenological Exploration of Motivation." You have satisfactorily met the conditions of your Institutional Review Board (IRB) approval, as detailed in the May 2, 2001 approval letter.

Please remember that this approval is in effect for one year (5/2/01 – 5/2/02) and if at the end of that time there have been no substantive changes to the approved methodology, you may request a one year extension of the approval period.

Good luck with your research efforts, and if you have any questions, comments, or concerns about the status of your approval, please do not hesitate to contact me.

APPENDIX C

Cover Letter: Women in Science

Dear _____________________________:

My name is Sandy Watson. As an educator working in high school education, I am interested in learning more about the reasons why women do not often choose to pursue careers in science. Because you are a woman and have chosen and persevered in a science-related career, your lived experience is very important to my study. You have been recommended as someone who could contribute positively to this research project. Participation is completely voluntary. There is no penalty should you decide not to participate or if you later withdraw from the study. If you agree to participate, please complete the attached consent form.

The focus of this interview will be upon your personal lived experiences as a young girl and as a young woman with science in both formal and informal settings. You will be asked questions and will be allowed to respond. There will be an initial interview lasting about one hour and then a follow-up interview at a later date so that you will have the opportunity to interject comments and voice concerns. Both interview sessions will be audio taped so that the texts may be transcribed later. Notes will be taken during the interviews. If you are uncomfortable with the use of your name, a pseudonym will be provided. Likewise, other identifying information may also be changed.

Again, participation in this study is voluntary and consent for participation can be discontinued at any time. The research materials will be catalogued and stored in a safe place. If you would like more information on this research study in order to make your decision, or if you simply want to discuss any questions or concerns you might have, please contact Sandy Watson (home: 912-427-7232, work: 912-427-1088) or the supervising professor, Dr. Dan Rea (Georgia Southern University: 912-871-1547). If you have any questions or concerns about your rights as a research participant in this study, they should be directed to the IRB (Institutional Review Board) Coordinator at the Office of Research Services and Sponsored Programs at: 912-681-5465.

Thank you for your time and cooperation.

Yours truly,

Sandy Watson
Graduate Student-Curriculum, Foundations & Research
Georgia Southern University

APPENDIX D

Letter of Consent: Women in Science

I ___________________________________(participant) agree to participate in the qualitative study being conducted by Sandy Watson (researcher) of Georgia Southern University. I understand that this research is to be used in the researcher's doctoral dissertation, *A Hermeneutic Phenomenological Exploration of the Motivation of Females in Science: Making Sense of the Journey of Women Scientists.* In this study, the researcher will use life experiences of women in science to explore factors that served to encourage their pursuit of science careers, and factors that served as deterrents to their pursuit of careers in science. I will be asked to share life experiences and personal interpretations orally, during audio taped interviews. The researcher will take notes during the interview and transcribe the audio tape. Estimates of time required for my participation in this study are approximately 2-4 hours for taped interviews, and 1-2 hours for reading of the research analysis.

I give permission for my voice to be recorded. All materials will be held in strict confidence and will be kept in a secure location. I also understand that the tapes and transcripts of interviews and notes are the property of the researcher and will not be released to a third party without my written permission. Because this study involves my own interpretations of practices and events, I will have the opportunity to read and approve the analysis of the data before it is published and to request that particular information not be used in the published report. I have the right to refuse to answer any questions and to withdraw from the study at any time. Participation in this study is voluntary and consent for participation can be discontinued at any time. My name will not be used in the published report unless I give my written permission. Upon completion of the research project, if I desire a copy of the report, I will receive one. There is no anticipated risk to me due to my participation in this study.

Participant's signature: ________________________________ Date: ____________

Researcher's signature:________________________________ Date: ____________

Use of Actual Name or Pseudonym

_____I give my permission for my actual name to be used in the dissertation and publications related to it.

_____I do not give permission for my actual name to be used in the dissertation and publications related to it.

_____I wish to be called by the pseudonym ___________________________.

_____I choose to have the researcher select a pseudonym for me.

If you have questions about this research project, please call the researcher, Sandy Watson, at 912-427-7232 or the supervising professor, Dr. Dan Rea at Georgia Southern University: 912-871-1547. If you have any questions or concerns about your rights as a research participant in this study, please direct them to the IRB Coordinator at the Office of Research Services and Sponsored Programs at 912-681-5465.

APPENDIX E

Guiding Interview Questions: Women in Science

WOMEN IN SCIENCE INTERVIEW (The following questions will be asked across and adapted to three time periods – early childhood and elementary years, middle school and high school years, and undergraduate and graduate years.)

I. Questions about how early science experiences influenced your motivation to become a scientist.

1. Tell me some personal stories about your early experiences with science (could include activities, toys, travels, visits to science museums, informal or formal, etc.) that strongly encouraged or discouraged you to pursue science.
2. What were your most encouraging science experiences? Tell me a story about this experience.
3. What was your most discouraging science experience? Tell me a story about this experience.
4. What were these motivational experiences like?
5. Did you have these experiences alone or with others?
6. How did these experiences encourage or discourage you to pursue science?
7. How did you feel when you had these experiences?
8. What did you gain from these experiences?
9. In what ways did these experiences contribute to your becoming a scientist?
10. Were any of these experiences defining moments or turning points in your decision to become a scientist? How so? What was a defining moment or turning point in your decision to become a scientist?

11. What helped you to sustain your motivation to become a scientist when you felt discouraged about or had difficulties with science? Tell me about a specific situation or incidence.

12. Did you realize how important these experiences were when you were young?

13. When you look back on these experiences today, what do they mean to you?

II. Questions about how others (parents, teachers, counselors, relatives, friends, etc.) influenced your motivation to become a scientist

1.In what ways did your teachers or counselors encourage or discourage you to become a scientist? Tell me some stories about how they encouraged or discouraged you.

2.Did you have some favorite teachers who motivated you to become a scientist? Tell me some stories about these teachers.

3. In what ways did your parents or relatives encourage or discourage you to become a scientist? Tell me some stories about them.

4. Who encouraged or discouraged you the most to become a scientist, your mother or your father? How so?

5. In what ways did your peers encourage or discourage you to become a scientist? Tell me some stories about them.

6. What helped you to sustain your motivation to become a scientist when you met resistance from others? Tell me about a specific situation.

III. Questions about how gender influenced your motivation to become a scientist.

1. Do you think your gender made it harder or easier to become a scientist? How so?
2. In what ways did your gender encourage or discourage you to become a scientist?
3. How did you deal with discouragement or encouragement that was related to gender?
4. Did you experience any conflict between your self-image as a woman and your motivation to become a scientist?

5. Did you experience any conflict as a woman between your goals to pursue a science career and significant relationships with men? How did it affect your motivation to pursue science? How did you deal with it?
6. Did you experience any conflict as a woman between your goals to pursue a science career and marriage and family? How did it affect your motivation to pursue science? How did you deal with it?
7. Were you ever stereotyped or discriminated against as a woman in science? How so?
8. What helped you to sustain your motivation to become a scientist when you were stereotyped or discriminated against as a woman? Tell me about a specific example.

APPENDIX F

Pre-Interview Information

1. What is the title of your job?
2. Briefly describe the nature of your job.
3. What is your marital status?
4. What is your age?
5. Do you have siblings? Male or female? Ages?
6. What were the occupations of your parents when you were a child?
7. What is your educational background?

APPENDIX G

Researcher's Personal Interview

II. **How do female scientists interpret the encouraging and discouraging influences of formal and informal science experiences (such as playing with science toys, exploring nature, experimenting, having science-related hobbies, participating in planned science activities) on their motivation to become scientists across three developmental periods?**

My earliest recollections that I had involving informal science experiences took place when I was around six or seven years of age. I clearly remember entering our family bathroom, closing the door and hunting through the cabinets for a variety of products that I would mix together in the bathroom sink. Invariably what resulted was a fascinating concoction that bubbled, fizzed, stunk, and often changed colors (and possibly could have been quite dangerous). Not long after I started the foray into bathroom chemistry projects, I asked for a chemistry set for Christmas. My mother was convinced that a chemistry set was no toy for a girl, so instead I got dolls, a toy kitchen, a miniature iron and an ironing board. My brother, however, did receive a chemistry set one year. I was immediately intrigued with the tiny beakers, test tubes, chemicals and other items found in the kit. I remember offering to trade him numerous items for that set, but of course he didn't want any girl's toys. So I had to settle for the role of assistant as he performed exciting experiments.

Being merely an assistant to my brother was frustrating and discouraging. It crossed my mind that because I was female I did not inherently possess the ability to be a scientist. I was discouraged from pursuing science until I gained confidence in my scientific ability through academic success in science.

My third grade teacher took the time each week to perform some type of science demonstration. I looked forward to those times and clearly recall the fascination I experienced as I watched her perform the scientific "magic" that allowed an egg to pass through the narrow neck of a bottle. It was in her class that I recall taking field trips to a bread company to watch the process of bread-making and packaging, to a dairy to watch the operation of milking cows and preparing the milk for transport, and to a farm to see a variety of farm animals. These were encouraging science experiences for a child who lived on a military base, with little access to nature and farm animals. The adventures I enjoyed with science in her classroom were the first and only formal experiences I had with science in my elementary school years. The other teachers I had never took the time to perform science experiments, or plan science-related field trips. Often, for whatever reason, science was left out of the curriculum completely.

In the sixth, seventh and eighth grades, science was "taught" by bringing in a television and having us watch a science teacher give a lesson and sometimes perform experiments. The television teacher was boring and the information was too advanced for me so I chose that time to do some homework or take a nap.

During that same period of time, the local game wardens came to speak to us about a conservation camp we could attend during the summer. I applied and was accepted to go for a week during the summer before I entered the sixth grade. Girls and boys were not at the camp at the same time so when I attended, only girls were there. Looking back on that experience now I realize that my success at that camp may have been due, at least in part, to the absence of boys and the resulting uncompetitive and collaborative environment. We took nature, hunting, archery, first aid, casting and fishing, swimming, and boating classes. If we performed proficiently enough in each class, we received a patch for that class at the end of the week. It was rare for anyone to get all seven patches in two years, and almost unheard of to get all seven in one year. I did get all seven in two years, and was pronounced an "outdoorsman" and given one large "outdoorsman" patch. The confidence the achievement gave me, coupled with the pure enjoyment I got from taking part in all of those activities were instrumental in my later decision to pursue a science-related career.

I ultimately decided to pursue science as a career in high school after taking biology and advanced biology with the same exemplary science teacher. Mr. Scott made science an adventure. Rarely would a day go by when he didn't have a demonstration, a lab activity, or a trip through the woods planned. We dissected worms, frogs and pigs. We became adept at using the microscope and proficient at identifying area trees and other plant life. His enthusiasm for the subject was contagious, and I quickly became infected. He encouraged me in science and gave me the confidence to declare a major in biology at Western Kentucky University.

The laboratory experiences I had as a biology major at Western Kentucky University were challenging and exciting. I probably spent at least 6-8 hours a week involved in experiments in laboratories for subjects in physics, chemistry and biology. I clearly recall treks into the woods and across town to various sites to observe and identify birds, and even stuffing a bird for my ornithology class. The anatomy and physiology lab activities always captivated my curiosity as we performed tracheotomies on live rats, measured our own lung capacity, and explored urine output after consuming different concentrations of salt water. In radiation biophysics we went to two area hospitals and learned to calibrate the x-ray machines. We also used potassium crystals to measure the amount of radiation given off by a magnetic resonance imaging machine, computers, television screens and other objects and environments. Many hours were spent in the physics labs calculating the heat of fusion of ice, detecting radiation using a Geiger counter and measuring the speed of sound. The campus planetarium was the site for my astronomy class. We also took several trips to the campus observatory to view the moon through one of the country's largest telescopes. During my senior year, I conducted an undergraduate research study with one of my professors in which we examined particular structures projecting from the bodies of organisms known as heliozoans. During this period, I became adept at using the electron microscope, taking pictures with it, and then developing those photographs. The success I enjoyed with that particular research experience provided me with much-needed self-confidence and encouraged me to continue studies in science. All in all, science experiences offered to science majors were plentiful, motivating, challenging and enjoyable. By actively participating in science research and science labs I became more proficient at lab skills. As I began associating with science professors on an individual level, I benefited from their expertise and the encouragement they offered me.

II. How do female scientists interpret the encouraging and discouraging influences of social interactions (with parents, relatives, teachers, counselors and others) on their motivation to become scientists across three developmental periods?

In 1970, my father retired from the military and we moved from the state of Washington to a farm in Kentucky where my father had grown up. This marked a major turning point in my life as my father became the primary caregiver and my mother took a job outside of our home. We eventually acquired cows, pigs, chickens, horses, and several dogs and cats. We grew a very large garden and my brother and I were expected to help take care of the garden as well as the animals. No longer was my mother around to ensure that I engaged in only feminine activity. My Dad bought me a rifle and taught me how to hunt, and a fishing pole and taught me to fish. He gave me a small tent and it was not unusual for me to camp out at night by myself beside the creek, catch a fish and cook it for my dinner. We often walked through the woods where he would point out the different types of trees and other plant life. My father and I enjoyed riding horses together (my brother was afraid of them!) and we became very close. I began to excel in school in all areas and when I showed an interest in science, he encouraged me. Both of my parents were very supportive when I told them I wanted to go to college. As an undergraduate, they continued to support me both financially and emotionally. This unconditional support was what I relied upon when the pressures of my studies became difficult to bear. I always looked forward to the visits with my parents on Sundays because I would consistently come away emotionally "recharged" to continue my studies in science from the encouragement and support they provided. The conversations I enjoyed with my father on those Sundays at that time in my life were intellectually stimulating as I shared with him the experiences I had in science classes and labs at the university. In fact, my father once played an instrumental role in some scientific research in animal physiology that was taking place at my university. I had told the professor who was studying the effects of temperature extremes on rabbits about a similar study my father had conducted while he was in the air force on assignment in the Arctic Circle. Ultimately, my father's photographs of rabbits in extreme temperatures were used in my professor's research. The fact that my father, who had no college education, impressed my college professors with scientific research that he had conducted, gave me additional confidence in my abilities to succeed in a science career.

Beyond my parents, there were very few people who personally encouraged me to pursue a science career before I entered college. Probably the only other most influential person was my high school biology teacher, Mr. Scott. He not only piqued my science curiosity with all of the activities he provided in his biology courses, but he encouraged me one-on-one in personal conversations as well. When I was a junior in high school, I was required to take a career aptitude test. The results of that test showed that I had the characteristics of someone who would do well in a science career. When I told Mr. Scott, and he saw my excitement, I remember that he predicted I would succeed in science because he thought I had the ability to work hard and have fun at the same time. His comments had a profoundly positive effect on the confidence I had in myself regarding my science abilities. He went out of his way to encourage me on an individual basis in science and that encouragement served to further motivate me to pursue science in college. I can recall no meetings with guidance counselors concerning career choices, and no other teachers who encouraged me to pursue a science career. I was not particularly discouraged by the neglect of the counselors at my school because they did no career counseling for any of the students. At the same time, no one was particularly discouraging either.

My undergraduate years at Western Kentucky were stressful as I married during my freshman year and consequently tried to balance married life, a job, and the pressures of being a fulltime pre-medical student majoring in biology. My advisor was a male professor who was distant and discouraging. He was hard to get in contact with, and when I did manage to schedule an appointment with him, he repeatedly made it clear that as far as he was concerned, I had chosen a field in which I had very minimal chances of success because of my sex and because I was already married. He spent an extensive amount of time getting to know and advising his male advisees. But his female advisees were quickly ushered in and out of his office if they were lucky enough for him to even keep their appointments. I quickly decided that I could advise myself from that point on and did so, without the help of an advisor. All of the biology, chemistry and physics professors were men at that time, except for one woman who was a professor of physics and astronomy. This woman was highly regarded by the students as someone who would take personal time with each of us if we needed help with difficult concepts. I clearly recall asking her to elaborate upon a concept in astronomy and she obtained a model of the planets and took great pains in explaining the concept to me. Because she was a woman of science and also a caring teacher, I admired her and identified with her as a female role model.

Most of the male professors were very encouraging and their classes were interesting, yet challenging and fast-paced. Maybe ten percent of the pre-med students were women who quickly got to know each other and studied together. I was not a part of that group as I was married and no longer living on the campus. So I struggled with my studies at home or at the library alone. Because I felt ostracized from my female peers in science, my motivation to pursue science was negatively affected. Many times I entertained the idea of giving up.

There were no formal support groups for women majoring in the hard-core sciences, and there was only one woman in the science department that I can recall, so there was an obvious lack of female role models for women students in the sciences. At the time that I was a college student, it was probably normal that my university had an under-representation of women professors in the sciences. I did not expect to find many women in science with whom I could identify. However, I now realize that had there been female science role models and support groups for women science students, my scientific motivation would have been positively affected.

I had no one in whom I could confide at the university. And when I became pregnant, I abandoned the idea of becoming a medical doctor because I felt that I would not be able to care for a baby and go to medical school. No one offered to help me with child care and no one encouraged me to continue in that area. I basically felt that the door to my dream had closed and would not open again.

III. How do female scientists interpret the encouraging and discouraging influences of gender perceptions (such as sex role stereotyping, gender bias, gender preference) on their motivation to become scientists across three developmental periods?

During my elementary school years, I recall wanting to accompany my father and brother on a nature and backpacking expedition into the Idaho mountains. No amount of pleading or begging would change my father's mind; I was ultimately left behind, not because I didn't have the physical stamina to keep up, but because I was a girl. I was devastated and frustrated once again at being shunned from an opportunity that could have allowed me to experience my environment on a biological level and might have encouraged me in science.

Probably during the high school years I experienced the least amount of gender stereotyping and received the most encouragement to pursue science. By then both of my parents had realized who I was and what I was capable of doing academically, and both of them equally encouraged me in science. My high school biology teacher was also actively encouraging me and I was experiencing success not only in science but in all of my other classes.

Sex-role stereotyping was not what I would call an explicit practice in the science department of my university, but it was present and it negatively affected me and probably many other women science students. The overwhelming presence of the number of male science students and male science professors as compared the numbers of female science professors and students undoubtedly served as an intimidating factor to myself and other women.

Invariably, I was placed in small lab groups with other students who were male. When we were working together I was often ignored or belittled by the male students. The belittling discouraged me at some times and at other times it made me more determined to succeed. In almost every case in which male students were demeaning, I became more withdrawn and reluctant to voice my opinions regarding the lab work we were pursuing. In fact, the only time I was given any recognition at all by the other male students was when I was pregnant and my developing baby became an object of study in our physiology lab.

Upon graduation, I recall hearing of a job opening for a "health environmentalist" for the county in which I lived. Before interviewing for the position, applicants were required to take a written test that lasted several hours and covered biology and chemistry. I apparently scored well enough on the test to be called in for the interview. When I arrived for the interview, the waiting room was filled with men. I was the only woman there. The person conducting the interview was a white male. Very quickly he let me know that the job I was seeking was not a position for a woman. He mentioned the fact that I would be required to perform environmental tests at building sites where sewage tanks and lines were being placed, at oil fields where tanks were leaking oil, and in other areas that could cause me to wear heavy boots and wade through mud and debris. He actually asked me what I would do if I broke a nail or got my clothing stained. I knew before I left the room that I would not be considered for the job, even though I was clearly qualified, because I was a woman and because that particular man had preconceived ideas of what he thought should be appropriate conduct for women. The frustration I experienced with my first attempt at finding employment as a scientist left a lasting negative impression that I fought to overcome for many years.

Sex-role stereotyping was prevalent and acceptable in my early youth. Therefore, I suffered from a lack of involvement with the "masculine" activities associated with science. Although I cannot predict how my life might have been different had I been allowed to freely investigate everything that piqued my curiosity, regardless of the cultural attributions associated with it, had there been a support system in place for women science students at the college level, had I had someone to encourage me to continue in medicine despite my pregnancy, I might just very well have been a practicing physician by now. The perceived conflict in roles and goals that I experienced as a pregnant woman and a pre-med student also seriously discouraged my pursuit of science and caused me to give up my plan to become a medical doctor.

APPENDIX H

Sample Interview Transcript

Interview with Dr. Missi Adams (pseudonym): November 5, 2001.

SW: Let's start with the questions about how early science experiences influenced your motivation to become a scientist. Can you tell me any personal stories about your early experiences with science in the age group from childhood to elementary? That could include toys, science activities, and so on.

MA: I was trying to think…I remember first grade…that's the earliest memory I have of anything scientific…in first grade we were putting together pretty little projects. And ours was to develop a poster of a tundra. I thought that was neat. I liked learning about all the animals too and the plants and things that were involved in the tundra. And they had little stations that you would go to for different…like grasslands, tundra, wetlands. Things like that.

SW: That's neat.

MA: It was great. I liked those little stations.

SW: That's great for first grade!

MA: Yeah, and I thought that that was terrific and I really enjoyed it. And after that…I don't remember ever waking up and going, "I'm going to be a scientist." I just know that that was what I was drawn to…I mean I like all subjects. I enjoyed everything. But I really liked science. And I don't know…there's nothing my parents did that pushed me there but that's what I enjoyed.

SW: What about toys?

MA: I played with Barbies (laughs). I hate to admit it, but I played with Barbies (laughs). No, my Baribies were always surgeons, so that's okay.

SW: Your Barbies were surgeons?

MA: And as long as I can remember, that's what I thought I was going to be.

SW: Do you have siblings?

MA: I have an older sister. She's eighteen months older.

SW: Okay, no brothers?

MA: No.

SW: Okay. So you never really had any toys that you would consider science toys?

MA: Absolutely not. I mean we played with the normal stuff. You know, blocks, Barbies, games.

SW: What about outdoors? Did you like to play outdoors?

MA: Oh yeah. We weren't couch potatoes at all. And my parents gardened, so it helped. We were forced into gardening (laughing).

SW: (laughs) So they didn't mind you going out and getting dirty and playing?

MA: Oh no, no, no. Absolutely not. They encouraged that.

SW: Okay. Going to the middle school to high school years (pause) what about some of those experiences with science?

MA: Dissection. Absolutely. It was a highlight of the science experience. Physics I didn't care for. Physics I didn't like very much. But we dissected frogs, worms and fetal pigs. And that was phenomenal.

SW: What did you like about it?

MA: The worms and frogs were fun because you got to cut stuff up. The pig is the closest anatomically to a human. And so it was absolutely fascinating to see how you were set up on the inside. You know you felt for the pig, but you got over that pretty quickly.

SW: So you related it to human anatomy?

MA: Uh huh.

SW: In high school, did you have science teachers who had a lot of labs?

MA: We always had a lot of labs…from seventh grade on. From junior high through high school, everything had a lab associated with it. And that (pause) I mean I went to a fairly decent district up in Pennsylvania and we had a lot of resources. And so we had fairly good equipment. I mean I don't know how many high schools have you cut up fetal pigs. Maybe a lot. But this was a long time ago so it seems pretty cutting edge. To me at the time.

SW: Uh huh.

MA: We had a great chemistry lab. The teacher was insane but we had a great chemistry lab.

SW: What makes you say the teacher was insane?

MA: Oh, he'd throw chalk at us. He'd tell us we were stupid. And most of the time we were. He just wasn't what you'd call nurturing(laughs). He wasn't a warm, fuzzy kind of guy.

SW: He made it fun though?

MA: I thought it was fun because I enjoyed trying to see how much chalk we could get thrown at us. And so it was (pause) we liked trying to antagonize him, but he was not what I would call a positive influence.

SW: Alright, going on to undergraduate and graduate years (pause)what about some of those experiences with science?

MA: I started at community college. I'm a first-generation college student. And the community college I went to was a fairly decent one as far as community colleges go. And I had a professor for the introductory to chemistry course, Paul Cross. He taught at night and worked for Smith-Kline-Beecham during the day. So he was a research scientist. He was fantastic. And he was the reason I changed to chemistry. I was pre-allied health at that point. And he was so good. I was just like, "That's it, I want to be a chemist!" So he was just fantastic. I had great teachers all the way through. I went from community college to a private college in New York called Canisius. And the student-teacher ratio was, you know, incredible there. My graduating class had ten people in it. Seventy percent of us were females.

SW: Wow.

MA: In chemistry (pause) chemistry majors. Not the whole class.

SW: How old are you?

MA: I'm 36.

SW: Okay.

MA: But I wasn't a traditional student. I spent eight years getting my undergraduate degree. So by the time I got to Canisius, it was January of 1989. And I graduated in 1991. So I only spent two and a half years there.

SW: Okay, can you think of something that you would say might be your most encouraging science experience?

MA: I think Dr. Cross's class in general. I mean he was not at all (pause) he was a black man. And I think maybe his experiences made him sensitive to gender/race issues. And he wasn't the kind of guy that (pause) he didn't put any barriers up to females so he was really encouraging. And he made it really fun. He related everything to real life. That certainly sparked my interest in studying chemistry, which I had never thought I was going to do after my experience in high school with that lunatic.

SW: What about a discouraging science experience?

MA: Sexism.

SW: Where?

MA: Everywhere. I mean not in high school. I had a female teacher for the class in which I dissected the pig. In fact I had mostly female teachers in science in high school. Undergrad, I went to the last great bastion of male supremacy. Canisius College is a Jesuit college. So there were no female faculty members (in chemistry), even though there were seventy percent females in my graduating class. They cultivated from a private male school called Saint Joe's all the best male students. All of the Saint Joe's students had offices and desks and labs (private places to study). The female students didn't get that. They didn't recruit female students. So it wasn't overt (pause) in terms of (pause) they didn't talk down to us, they didn't tell us we were stupid, but there were subtle benefits to being a man.

SW: Such as?

MA: The encouragement, the private places to study, the research fellowships in the summer time.

SW: Those were not open to females?

MA: They were open to exceptional females. I was an average female. And so I kind of fell between the cracks in terms of opportunities. But I made my own so it's okay.

SW: The encouraging experiences in science that you had (pause), what did they mean to you?

MA: I didn't need (pause) I wasn't a particularly needy person in terms of what I chose to do career-wise. I wasn't going to be made or broken by external influences...positive or negative. I knew what I wanted to do, or I thought I knew what I wanted to do. And I was going to get it come hell or high water. It was nice to have positive experiences, but there were far more negative experiences than positive experiences and it didn't (pause)it just didn't make that big a difference. I was always fairly focused. I wanted to go to medical school at the time. I had the goal my junior year. I said, "When I graduate, I want to go to medical school." But my grades weren't there. So I still...I mean I had a plan B...there was always something ready to fall back on. But it didn't (pause) the positive experiences...you use them and take them and go with them however you can. The negative experiences probably had more of an effect.

SW: Right. The experiences that you had that you considered to be positive experiences (pause) for example, in the undergraduate to graduate years...were those experiences more alone or with other people?

MA: Labs were always done in groups. Chemistry works in groups for the most part... you always have a study group, if you don't you're a fool. Because you're always going to be better at something that somebody else isn't and vice versa. So in the sense of getting through it, you know, you always need a support system, you always need a group. And that's very positive to have that kind of feedback. The negative experiences were usually more (pause) if you perceive sexism or you perceive a lack of support it's usually directed to you. Now the alternative to that is if you have a lunatic as a teacher where the whole class is suffering (pause) but then the whole class is just like, well whatever. You know, you get over it.

SW: Can you think of a particular experience that was negative that was directed just towards you?

MA: I don't know if this is appropriate for what you're asking about. You can decide. But this was probably actually a positive experience cloaked as a negative. I remember being a junior in undergrad., and still thinking that I was going to be able to apply to medical school, because I was a nontraditional student. I was married. I had personal issues. And though my GPA wasn't high enough I thought, you know, they'd still consider me because I was older, I was more mature, I was female. And one of my closest mentors at Canisius said, "Missi, you need to let go of this. Medical school takes only the best of the best. Why would they pick you?" And I don't think he meant it to sound as harsh as it came out. But it was a reality check that I needed to hear, because I wasn't going to get into medical school with a 3.0 (laughs). You know, it just wasn't going to happen. I don't care how female or how much older or how many personal problems I could write off or whatever. I took it very hard when he said that. And I took it very personally. And I don't think that in hindsight it was meant that way. So overall, I think it helped me focus on developing a plan B (laughs). But at the time it was (pause) I perceived it to be (pause) well if I was a guy or if I was from Saint Joe's or if I was this (pause) he'd never have said that to me.

SW: Okay. Going back to the early experiences with science that you mentioned like in first grade, what did those early experiences mean to you?

MA: I think it just opened up your mind. I mean they (pause)if you're not getting that kind of information at home (pause) and most people aren't, you know most parents don't have those kinds of bulletin boards displayed (laughs). It just increases your awareness. It makes you realize that there are things out there far beyond what you can imagine.

SW: So do you think those early experiences encouraged you to pursue science?

MA: I think they certainly gave me the opportunity. They made me (pause) the awareness sparked an interest. And what you do with that is up to you. I certainly chose to follow the interest. It's like (pause) given the choice to study English for the rest of my life or to study science, science is going to win hands down; it's far more interesting.

SW: Right. So you feel like you gained from those early experiences?

MA Absolutely! I think that if you're going to get kids into science, and we're universally realizing this, college is too late, high school is too late. You've got to grab those kids in kindergarten. And get them in the K through six years. And if you don't do that, chances are you've lost them forever.

SW: Can you think of any of the experiences that you mentioned as being crystallizing moments or defining moments or turning points in your decision to become a scientist?

MA: I thought of this one long and hard last night. I don't know when I decided I was going to be a scientist. When I started community college, it was as a computer science major. No actually it was business. I was in an accounting class and hating that pretty much. Then it was computer science, and I realized that really wasn't going to work for me. Then I went psychology. I thought that was going to be a lot of fun. And I always enjoyed that in high school. And it wasn't quantitative enough. It was too abstract. I needed answers. Real, hard, fast answers. And then I went pre-allied health. I figured I'd open up my possibilities and get this undergraduate science degree of some sort, whether biology or chemistry or whatever. And then I guess in Paul's class is when I realized I was going to be a chemist. But I don't know when it happened (pause) that I decided I'm going to be a scientist when I grow up.

SW: Now Paul is Dr. Cross?

MA: Uh huh. Dr. Cross, my Intro to Chemistry teacher.

SW: Okay, you mentioned a few times that there were some moments when you were discouraged later on, like in the undergraduate and graduate years. What helped you to sustain your motivation when that took place?

MA: Um, in the undergraduate years, it was the fact that there were six other females in the class. And we all got discouraged from time to time, but we knew we were the majority, and they had to pay attention to us if we all banded together. So that helped substantially. Plus, you know I was a first generation college student. I got married at nineteen, dragged my husband off to Buffalo to go to school. It was just me and him up there, and my family had no point of reference for what I was trying to do. Or what was involved. The school was thirteen thousand dollars a year, just for tuition. And I was on financial aid and scholarships and everything else, and I didn't take out any loans. Failure was not an option (laughs). You didn't drop classes like they drop (pause)they drop them like flies here. I'm in awe at the number of students who drop classes arbitrarily. I just refused to give my family the upper edge. And the "I told you so" rights. And I knew I was damn lucky to be going to a school as good as Canisius. And I was not going to fail. So I didn't care how discouraged I got. It wasn't going to happen.

SW: Did you realize when you were very young, how important those early experiences were at the time?

MA: No.

SW: When you look back on those experiences today, what do they mean to you?

MA: Well, like I said, they were the experiences that make you realize the opportunities out there. At the time, you're just having fun. You're just learning about gophers, you know, aren't they cute? And you're having fun, and it's neat to do. Now you realize that if you didn't have that experience, you'd probably be asking, you know "Do you want fries with that?" (laughs)

SW: In what ways did your childhood teachers encourage or discourage you in science if they did at all?

MA: I don't recall any teacher in my K through six experience focusing on any career path for anybody. I think they just wanted to get you well-rounded.

SW: But you weren't discouraged at that point either?

MA: No, no. I did not go to a sexist district. I went to a racist district. Our district was completely white. We only had one black student; she was the daughter of a Philadelphia Phillies professional baseball player. So she might as well have been white. Because she was rich. So it didn't make any difference. But it was not sexist. There was no gender bias that I perceived in any of my high school or pre-high school years.

SW: What about in the middle school to high school years? Did any teachers or counselors encourage you in the science area? Or discourage you?

MA: The only thing I remember a counselor ever saying to me was that I was too bright to go to a community college. They were disappointed that that was where I was going to be starting. And they perceived that as a failure. But they didn't understand my family situation. The fact that there was no encouragement to go to college at all. So community college was a huge step for me. I was involved in a lot of stuff, and I don't know that they knew that I wanted to be a scientist or that I had an interest in that. Because I had an interest in everything. I was in drama; I was a cheerleader. I did a lot of stuff. So they just wanted us to succeed and go to school so they could report the numbers for the district as being high (laughs).

SW: I think you already mentioned a story about being discouraged and also encouraged in undergraduate and graduate school. Can you think of a favorite teacher in your early childhood who motivated you?

MA: Not in science. In seventh grade, Mrs. Michener was my freshman biology teacher, and she's the one who helped us dissect the pig. That was neat. I enjoyed that.

SW: How did she motivate you?

MA: She let us cut up pigs (laughs). I mean, it was a big risk for her. You turn young kids loose with scalpels, it's not necessarily a good idea (laughs). She took a huge risk. And she was great at teaching. We had things we were supposed to do to this poor pig, and we did so much more. Because we just wanted to see everything and so when you were done cutting out things you were supposed to cut out, if you wanted to cut out extra stuff, that was fine with her. As long as you did it properly and diagrammed it. So she was just a neat lady. But she never said, "Go get em girl. Be a scientist. You can do it." I mean, nobody ever really did that.

SW: So your parents really didn't encourage you in science? And they didn't discourage you either?

MA: I come from a fairly turbulent childhood. And they were so busy hating each other that they didn't really have a whole lot left to give to either Cindy or me. I wouldn't say that they did the best job of parenting. And I think that they always wanted us to do well. I'm not sure that they understood what that meant. They certainly had no clue what college was about or the opportunities that were out there or how a student should go about selecting a college. I mean my whole career happened half-assed and by accident. I mean…it was not like these parents who start prepping their kids for the SAT their junior and taking them to visit colleges and everything that happened, happened despite my parents, not because of them. They wanted us to get good grades. They wanted us to work hard. But I'm not sure why. Because they didn't have any plans for us to go to college and there certainly wasn't any money for it. So I'm not sure what their overall scheme was. But they certainly were glad that I got good grades and were tough on my sister for not getting them.

SW: What about other relatives?

MA: No. My entire family (pause) I was the first person in my Mom's family (pause I don't have much contact with them. My Dad's family are farmers and blue collar workers. And college was not something you did. It was perceived as frivolous. And I understand the necessity. I mean they're farmers! You get your butt out there and farm. My Dad had to fight to finish high school. My Mom didn't finish high school. And so it just wasn't something that was pushed. So I was the first person in the family to go to college. I mean the whole family. All of it. So it was a very different situation.

SW: Once they saw what you were doing and that you were succeeding…did your parents begin to encourage you?

MA: They were very threatened by it.

SW: They were?

MA: Very threatened by it. Initially, when I said I wanted to be a doctor, I had to wait fifteen minutes for them to get done rolling around the floor. There were tears in their eyes from laughing so hard. And then they said, "You faint at the sight of blood. How is this going to happen?" They thought it was a hoot. Did not give it any credence whatsoever. So they weren't threatened by it at that point because they didn't perceive it to be a real threat. When I decided to move from Pennsylvania (pause) nobody had ever left the hometown. So when I decided to move from Pennsylvania to Buffalo, then it became a little more real. And then the criticism became a lot stronger. Who did I think I was to drag my husband off away from his family. What a wonderful man he was to put up with what I was expecting of him. I mean just unbelievable opposition for leaving the homestead. And they would have been perfectly happy if I worked my way through school in Pennsylvania as a secretary and they would have been very happy if I had stayed there, as a secretary because that wouldn't have been threatening to them in any way. My Mom was kind of for it. There were times when she would want me to succeed and would be supportive, but I was working forty hours a week and then I'd go to school from six until eleven four nights a week and on Friday nights I was comatose. On Saturday and Sunday, the entire weekend was spent doing homework. And every Saturday afternoon at two I'd be guaranteed taking a nap. And she would call, knowing that I was trying to sleep and give me hell for being lazy and I should be taking care of my husband and I should be doing this, I should be doing that. And so I think she wanted me to do well because it would give her bragging rights. But I don't think she wanted me to do well because it made her feel like she had failed. Because she hadn't done well. So it was really hard for her because she didn't know how to process having a daughter that was doing things that she hadn't done. On the one I hand I think she was proud, and on the other I think she was very, very threatened. And so I took a lot of grief throughout my entire Buffalo career. It was just constant mixed messages of go get 'em, but don't go too far. And then when I decided to go graduate school instead of medical school, even my brother-in-law was like, "When are you going to get a real job? When are you going out into the real world?" They just thought it was a cop out. A way to avoid having to work for a living.

SW: What about your peers during undergraduate and graduate years, did they encourage you?

MA: Undergraduate years we were really tight. I mean the ten of us (pause) even three guys who were token males (pause) were token boy toys (laughs). We had a really great class. The ten that graduated in '91. And we didn't always get along. But we never, ever let each other down. We were all in it together and it was rigorous and it was tough and it was hell and you know, we carried each other at different times. That was an incredibly wonderful experience. Even when we were fighting. I know it was just stress. But we slept in the lab. You know this course load was incredibly rigorous and it was a great experience. Graduate school was a lot more competitive. And everybody's out for themselves because they all want to get out. And there was competition for resources, there was competition for the attention of the advisor in terms of time, there was competition for equipment. We had one (pause) everybody did laser spectroscopy (pause) we had one laser system and you had to sign up and it went by seniority. And so if you didn't want to be working the entire weekend (pause)you know there was a competition to get daytime hours on it. It wasn't as cut-throat as some of the bigger programs would have been, like at Illinois or Indiana or Purdue, but it was your own thing. I mean (pause) you could get support from your group members and there were people that you teamed up with and collaborated with but it was pretty much you. And so it was not as supportive as undergrad.

SW: What school was that again?

MA: The State University of New York at Buffalo.

SW: So at the time when you were working so hard, what helped you to sustain your motivation during that period?

MA: Fear of failure. Plain and simple. I was not going to fail. It was never an option. I refused. I was not going to give my family the right to say "I told you so."

SW: Did you ever come to a point where you thought you were on the edge?

MA: No. I mean I had meltdowns. But I knew that that's what it was. And I was going to be okay. Because I refused not to be.

SW: Do you think your gender made it harder or easier to become a scientist?

MA: Overall, I don't think it's ultimately a factor. I think that there is overt sexism and covert sexism that will always exist by a certain type of man. And I think that you have to fight that. And I think one of the best ways to fight it is to play up the female. Men are such simple creatures, and you can manipulate them so easily. And the women who have the most difficulty fighting sexism are the ones who try to be men. While they are criticizing you or coming down on you for being a woman, using the fact that you are a woman can completely disarm them.

SW: In what way?

MA: You can flirt with them. You can charm them. The smartest thing that women can do is let men think that they came up with the idea. I mean they're so easy to manipulate. They're so easy to fool. I had a guy on my committee who was very demanding. I'm not sure he was sexist. He probably was. I think he found women scientists, or women graduate students entertaining. And so you'd play that. You'd say "Hi Dr. Bruckenstein. How are you doing?" It's not like in a real sexual way. It's just (pause) if you come across aggressive and manly and try to compensate for their sexism by being more anti-female, I think you're doing yourself a disservice. The bottom line is, when it comes time to take an oral exam in front of a committee of all men, you're either going to know the material, or you're not. And if you present it in a way to them that's not threatening, with a smile…or a softer voice, they won't be so threatened. They're threatened by your strength. And they're threatened by you treading on their territory. And so if you tread lightly, even though you have the knowledge, it's less threatening to them. So it's out there, it's frustrating that it has to be dealt with, that part of it is almost sickening. But if you deal with it intelligently, then it doesn't have to be a major issue. Now I would never, in a million years, suggest that dealing with it intelligently would mean wearing short skirts and low cut tops and bending over in front of guys. That's not what I'm talking about. I'm talking about having to wade through the waters gingerly. And personally, I find that revolting. I find it absolutely physically sickening, that we have to deal with that. But having tried it both ways, that's definitely the better approach. I tried it the other way too and it doesn't work. Men are not ready to deal with strong women, and I hate to say that, and I hate to make generalizations because there are men out there who are prepared. But the majority of them are not. No matter what they say or give lip service to.

SW: Have you ever experienced any conflict between your self-image as a woman and your motivation to become a scientist?

MA: That's a difficult question. I suffered conflict with my self-image, but I don't think it's related to being a scientist. I think it more has to do with childhood issues. The process of getting a PhD in chemistry as a female can be demoralizing. If you already have a low self-esteem, it can really take its toll. And it did. My advisor's method of training was to break you down the first two years and then start to build you up after that. If you don't realize what he's doing, it can be really hurtful. I quit graduate school the fall of my first year and was convinced to stick with it for six months and see if I didn't like it better after that.

SW: How did he break you down?

MA: Telling you you're stupid. Asking if you were a f-ing idiot. Just abusive…I mean plain and simple abusive. Lying to you, lying about you. It was almost as if he was trying to find out just how much you could take.

SW: Did he do that with male students?

MA: Not the same way. He didn't do it the same way with every student. There was a female student in our group who came behind me. We called her Chrissy Sissy Baby, because she was just this little delicate flower and you know. You looked at her wrong (pause) and she had this blonde hair and blue eyes (pause) big blue eyes that would just well up with tears. She was absolutely gorgeous, and Frank was never as hard on her as he was on me. He claims that he knew exactly what it took to make a scientist out of every student, based on their personality. Of course Frank had a rather inflated ego, but I would never have worked for anybody else, even after everything I went through with him. I think he was an awesome advisor, and I think he did make me into a good scientist, and there was never a moment at this job that I didn't feel 110 percent prepared. And I've seen other people come and go and fail at this job because they weren't prepared. So I have no complaints. It was really hard to take. The guys (pause)it was a different type of banter. It wasn't as overtly abusive. It was more the way guys interact, with jabs and (pause) just the way guys interact. It was different.

SW: You said you got married at nineteen. Are you still married?

MA: No.

SW: Did you experience any conflict as a woman between your goals to pursue a science career and this relationship that you had with your husband?

MA: No. He was really supportive. If it wasn't for him, I wouldn't have done it. There is absolutely no doubt in my mind. I dedicated my thesis to him. Even though our marriage was falling apart because I know that if he had not been there (pause) I mean he took care of the household. He took care of the grocery shopping, he took care of everything from the time I started going back to school. And that had to be hard to take. I mean I was an absentee wife, especially during graduate school. I'd be in the lab literally sleeping on a lawn chair over night. And he'd bring me McDonald's. But I was never going to be a traditional wife for anybody anywhere. I mean (pause) Martha Stewart I'm not. And so that wasn't an option. And he knew that when he married me (pause) that I had ambitions. I wasn't going to be little Miss Domestication. So I don't think that that was a factor.

SW: You never had children?

MA: No.

SW: How about now? Do you have a conflict between your role as a scientist and relationships with men?

MA: Much more so now. I think my husband was (pause) it's hard to say if he was threatened by it or not. People would give him grief about the difference when we moved here. But he was a very secure person for the most part. I think there were times that it bothered him. But when push came to shove, he was like (pause) "Well, whatever she earns, we're going to share. So it doesn't really make any difference. We're in this thing together." Now (laughs), I think it's almost hopeless. I'm seeing someone who is also a scientist. That helps a lot. I earn more than he does. I'm higher rank in this department, and he's in this department. I'd like to think that it's not an issue. I think that as men go, he's one of the better at dealing with it. But after I was divorced, I didn't really want to date. I'd just never been comfortable with the whole dating thing. But I did go out with this one guy. I had seen him actually at a restaurant and talked on the phone a couple of times and that was the extent of our pre-conversation. We went out to lunch, and I was very impressed, and I would have been very interested in seeing him again, and he never called. And this was my first date after the divorce so I was devastated. So I called my former brother-in-law (pause) I'm still close to him. He's an engineer. And I said, "Tim, it's been a week and he hasn't called. What did I do wrong?" And he said, "Well tell me about the lunch." And I said "Well, we were sitting there, making chit chat." And he said, "Did he ask you what you do?" And I said, "Yeah." And he said, "You didn't tell him did you?" And I said, "Yeah." And he said "What did you tell him Missi?" And I said, "Well, I told him that I did laser spectroscopy." And he said, "Oh, there it is." (laughs) He said, "Tell him you're a barmaid. Tell him you're a waitress. Tell him anything. Don't tell them you have a PhD in chemistry." I said, "Why?" He said, "Missi, he's a guy!" I was like, ok, there it is. I think if this relationship doesn't work out that I'm in, that I will probably not have another one in this town. I think it (pause) and it's so bizarre to me because it's like (pause) I mean you're pursuing your doctorate, and I don't know what it means to you (pause). I don't know how much of your ego hangs on having those letters after your name and a doctor in front of your name. It's not part of who I am, it's something I had to do to get a job that I wanted. It doesn't apply to me. I don't get off on being called doctor. It's not even something I'm cognizant of on a daily basis. The first time after I was here, students would be calling my name, and I wouldn't respond because I didn't associate the doctor with my last name. There are people to whom that means everything. That's not who I am. This is what I do. It doesn't apply to me. Men put (pause) people put (pause) I mean my hairdresser puts more on it. She's so intimidated to talk about anything that has to do with science to me. Because she thinks I'm going to cut her down. I was asking a question of my dental technician and she was explaining something about my teeth and I don't know anything about the mechanism of hydroxyappetite growth (which is what your teeth are made of). The only reason I knew what she was talking about is that a friend of mine did her PhD on it. And after she found out that I was a chemist, she got all embarrassed. And she said, "Oh, I must have sounded so stupid." And it's like...people stop it! You know, stop judging me based on what you think I am because of some degree I hold, and men do it worse than anybody. Although it's not limited to men. So do I think it's a factor? Absolutely! A huge factor, unfortunately.

SW: So what's the best way to deal with that?

MA: Not be an arrogant idiot. I think there are so many people out there who insist on being called by their title (pause) at a restaurant. My students who have graduated, they don't have to address me by title. I think it's appropriate for them to address me by my title in the classroom. I volunteer at the Nature Center and there are students of mine that call me Missi when I'm over there because I'm not anything other than Missi when I'm over there. And I think that the few who make it so much a part of their identity are going to continue to enforce that stereotype, unfortunately. And the best that I can do is to be down to earth and be me. Not make it a part of who I am. And it's not going to work with men because they're always going to be intimidated by it, unless they have a PhD as well.

SW: Can give me another specific example of being stereotyped or discriminated against as a woman in science?

MA: I was told repeatedly that I didn't look like a scientist.

SW: You didn't look like a scientist?

MA: And that's by students here. There was a guy from ACS (American Chemical Society) who's fairly high-placed in the organization. The guy, the mentor who told me that medical schools wouldn't take me, is still one of my closest friends today. He was being honored at the ACS reception. It's a big thing for western New York. And so I was wearing what I thought was a pretty nice dress. I was dressed up. And I was sitting at the bar. We were waiting for the reception to start. And I sat next to this guy (the one from

ACS – the big wig). And he knew I was with the group, but he said, "So, what do you do?" And I said, "Laser fluorescence spectroscopy." I thought he knew I was a chemist or a chemist in training because I was a fourth year graduate student at this time. And his eyebrows went off the top of his head. And he said, "You're a chemist?" And I said, "You're surprised?" And he said, "You don't look like a chemist." And I'm like, "What's a chemist supposed to look like?" (laughs) Now there's a stereotype. Because I don't have my pencil pocket protector and a calculator on my belt? What does that mean? That you can't be fashionable or take pride in your appearance? And a lot of female scientists don't want wear makeup. And the most prominent that I know (pause) I was taught by one of the best scientists in the country. She was head of the National Science Foundation's Chemistry Division until recently. Huge name. And she came through either Cal. Tech. or Stanford, and she dresses like a man. If you didn't know she was married, you'd think she was a lesbian, because of the way she looks and I hate to make that stereotype. But very short hair, she dresses like a man. She buys men's pants. Not a stitch of makeup, and she's a stunning woman. And that's how she got the focus off of her being a woman, by not looking like one. I think that's unfortunate. And if you look around (pause) it's getting better (pause) but I can think of only one other female in this department who wears makeup, besides me. I mean if you took all female chemists in the country, I think one percent of them, who aren't in industry where appearances matter more, bother to put makeup on in the morning or do more with their hair than pull it back into a ponytail. And I don't know what the origin of that is. But I think it's sad. I don't think you have to give up being feminine to be a scientist.

SW: What is the title of your job here at this university?

MA: I am an Associate Professor of Chemistry.

SW: And can you briefly describe the nature of your job?

MA: Put up with lots of whining from students (laughs). I teach 12 to 15 contact hours across a broad range of courses. You have a service component that is said to be important but obviously is the least important of the three: scholarship, teaching, and service. My breakdown is 50 percent teaching, 25 percent service, 25 percent research. But it doesn't really break down that way.

SW: I've heard the service part before; what exactly is that?

MA: Committees: departmental, college-wide and university-wide.

SW: And your research interest is in laser spectroscopy?

MA: There was nothing here when I got here to do my research with. It has taken me a long time to build it up. We now have a laser system, not that I have time to use it because my research has now gone in the interim in other directions. I'm involved in a lot of environmental research (sol-gel science), which is artificially created glasses. But I'd like to get back into the laser stuff now that we have it.

SW: When you were a child, what were the occupations of your parents?

MA: My mother was a laborer at a sewing factory. My father was a laborer at U.S. Gauge Ametek Division. He made airplane and spacecraft gauges. He still does. She now cleans houses. She's very bright. My mother's very bright. She just had a disadvantaged childhood. Now she has her own cleaning business and she has people to clean the houses for her. And she also makes stuff for people (sewing) she takes orders from people.

SW: So you went to elementary school in Pennsylvania?

MA: Up through two years of undergraduate at community college in Pennsylvania.

SW: You were at the community college and you decided to go somewhere else. Why was that?

MA: I needed to finish my degree. You could only get a two-year degree there. Why I decided to go to Buffalo was on the recommendation of one of the attorneys that I worked for.

SW: In Buffalo you got your B.S., is that right?

MA: I got my B.S. from Canisius College, and I stayed for four more years and got my PhD from SUNY Buffalo.