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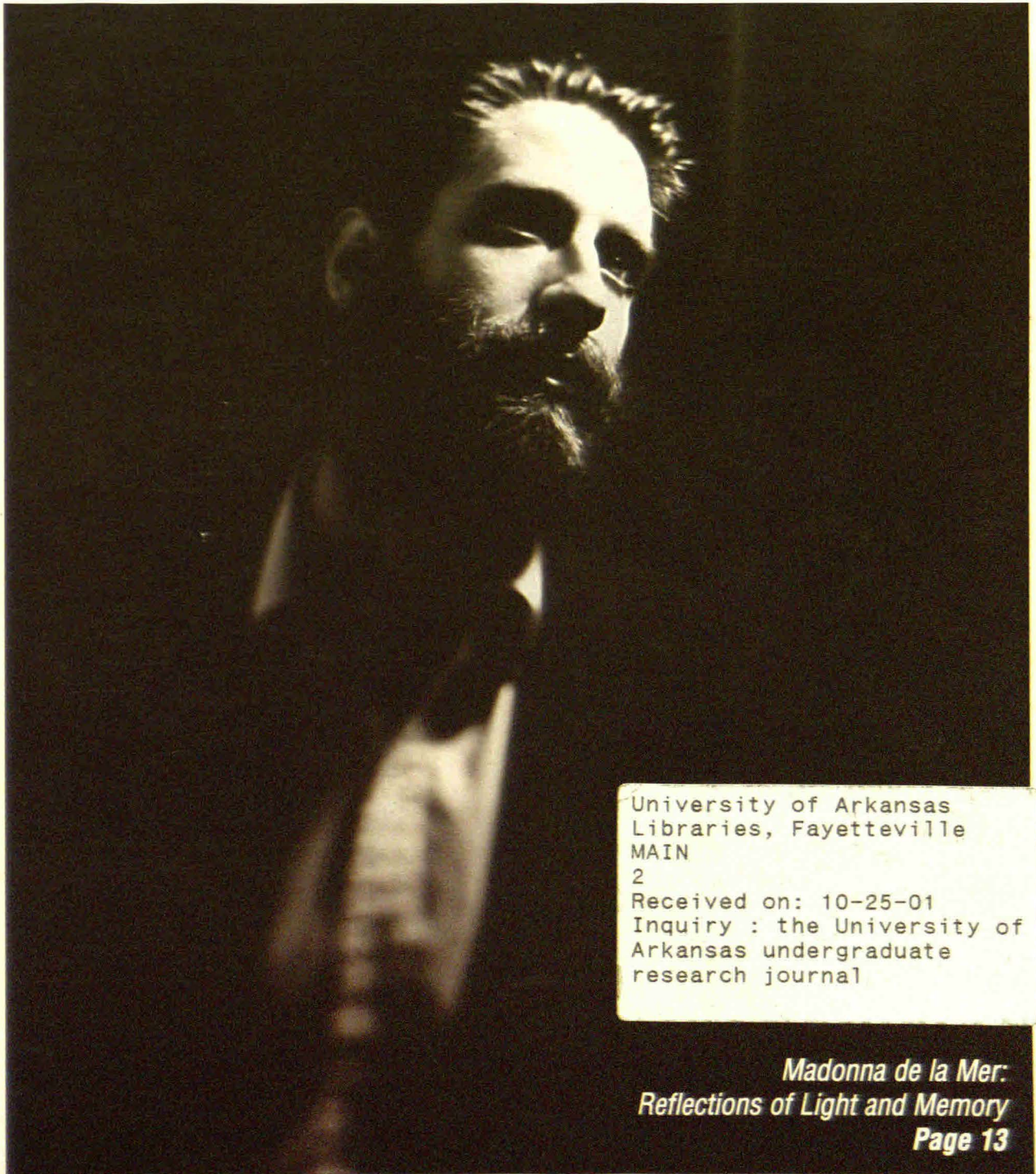
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THE UNIVERSITY OF ARKANSAS
UNDERGRADUATE RESEARCH JOURNAL

INQUIRY

Fall 2001



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Reflections of Light and Memory*
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Undergraduate Research Journal
Fall, 2001
Message from the Provost

The research process involves keen observation, hypothesis development, measurements, analysis of data, and the determination of conclusions. This process will be increasingly needed by future professionals from business managers who apply statistical and other econometric tools to marketing plans, to teachers who tackle the demands for outcome-based education, to computer and software engineers who must assess the potential value of new materials and algorithms on the rates of digital processing.

At the University of Arkansas (UofA), we believe that the process and results of research (the discovery of facts and concepts) and scholarship (the creative organization, criticism, interpretation, and reinterpretation of facts and concepts) are critical to modern undergraduate education and the talents our graduates will bring to the workplace. The results of research and scholarly efforts--represented in this journal--vividly demonstrate how the UofA is contributing to undergraduate education at its best.

A handwritten signature in black ink, appearing to read "Bob Smith". The signature is fluid and cursive, with the first name "Bob" and last name "Smith" clearly distinguishable.

Bob Smith
Provost and
Vice Chancellor for Academic Affairs

INQUIRY

Undergraduate Research Journal of the
UNIVERSITY OF ARKANSAS, FAYETTEVILLE

Volume 2 - 2001

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FOREWORD

This journal, the second in what is intended to be an annual series, is a project of the Teaching Academy of the University of Arkansas and is testimony to the Academy's belief that a function of good teaching is to encourage good research and creative thinking on the part of the students.

This issue of *Inquiry* records the individual research exploration of sixteen U of A student/faculty mentor pairs during the 2000/2001 academic year. The projects included here are drawn from disciplines across campus and are representative of the quality of research done by the honor students in the various disciplines represented on campus. These sixteen were chosen by *Inquiry's* publication board from nearly sixty abstracts received as a result of a call for papers. They vary in subject, in writing style, and in the manner in which they reference their research sources; but they are uniformly excellent in content. In each case, the paper published herein is a précis of the student's larger research product.

The intent of the journal is to record the depth and breadth of the scholarly activities of the university's best undergraduate students. I believe that it does this. We hope that readers will see that there is no limit to what can be accomplished by the University's best students and teachers working together. I hope you will be as excited as I am with the quality of the work presented here.

Murray Smart, Jr., Editor

University Professor of Architecture, Emeritus

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SECTION I: ARTS AND HUMANITIES
ENGLISH, SPANISH, AND ART

SHAKESPEAREAN DEFERENCE TO FEMALE VIRGIN POWER

by Phyllis Nichols
Department of English
Fulbright College of Arts and Sciences

Faculty Mentor: Joseph Candido
Department of English

Abstract

*This project concerns the ways in which Shakespearean literature becomes translated into political theory. It considers the way Shakespeare captures characteristics of Queen Elizabeth I — portraying her as the era's political icon through his plays. He shows her deference by immortalizing her legacy with strong women characters while limiting them to a level of power beneath her. Using *The Merchant of Venice*, *The Tempest*, and *Othello*, the Moor of Venice — plays juxtaposing elements of gender, race, and orthodoxy — the paper shows behavioral patterns linking the plays' patriarchs to King Henry VIII. Shylock, Prospero, and Brabantio each operate in the role of commanding patriarch, though Brabantio is the only Venetian noble with any real power. The first two daughters, Jessica and Miranda, manipulate their fathers and their places in society in order to reap the society's benefits. Shakespeare created these daughters in equally convincing resemblances to Queen Elizabeth. On the other hand, Brabantio's daughter, Desdemona, shows the fallacy associated with neither respecting the orthodoxy nor finding the right loophole for change. Many critics argue that women who rose to power during this era did not advance the women's movement. Instead, they only served as substitutes in the event that their male counterparts could not rule. My findings do not dispute this. However, in interpreting Shakespeare, it is more beneficial to note the larger picture — women are being taught ways to rise to equality and power with men.*

This project concerns Shakespeare, particularly how he captures characteristics of the Virgin Queen Elizabeth I in an attempt to portray her as a political icon through his plays. He shows deference to her, not only by immortalizing her legacy with strong women characters, but also in limiting them to a level of power beneath her. Using three examples - *The Merchant of Venice*, *The Tempest*, and *Othello*, the Moor of Venice - that juxtapose elements of gender, race, and orthodoxy, the paper shows a behavioral pattern linking the plays' patriarchs to King

Henry VIII. It also shows how Shakespeare created the daughters in an equally convincing resemblance to Queen Elizabeth — with the exception of Desdemona, who shows the errors associated with neither respecting the orthodoxy nor finding the right loophole for change.

Elizabeth was just three years old when King Henry had her mother executed. The king was both father and mother to his children. Because he left no male heir, Elizabeth and her half-sister Mary were both given opportunities to rule. Elizabeth controlled England without a spouse, but with the tricks of her father's trade, for 45 years. He had changed the national religion; she changed it back. She ordered the death of her cousin Mary Queen of Scots. In order to sway potential allies and enemies, she used her greatest assets — most important of these was her virginity.

In *The Merchant of Venice*, Portia's father had written into his will a plan, consisting of a riddle and a three thousand ducat suitor fee, by which he could choose her spouse — even after his own death. He intended that the proper fiancé would have both proper finances and the ingenuity to promote future success in business ventures. Two suitors who had the suitor fee answered the riddle incorrectly. Further foiling the plan of Portia's father, a clever young suitor (Bassanio) borrowed the necessary sum from his friend Antonio and answered the riddle correctly. Bassanio planned to repay his loan with the dowry he collected, something that might have made Portia's father turn over in his grave. The plot thickened when Antonio had to borrow the money he lent from his archenemy — Shylock, the Jew. So sure that he could repay the debt, Antonio made a horrendous deal — a pound of flesh upon forfeiture of the loan. Then, before Bassanio could return to repay Antonio, the time to pay the debt expired. Since Shylock would not allow repayment in lieu of flesh, Portia assisted Antonio by assuming a male persona and acting as arbiter, literally coming to Antonio's defense.

Elizabeth respected bonds, such as contracts and marriage, and she required other young women to marry and be respectful of their husbands. Both Shylock and Portia treasured their rings

as symbols of the marriage bond. However, while Portia and her maid forgave the men who gave their rings to the arbiter and "his" assistant (really Portia and her maid in disguise), Shylock was unforgiving of his daughter, Jessica, who stole his ring and traded it for a monkey before marrying a Christian. Critic John Gross pointed out that the monkey is a symbol of lechery, and Jessica's act may have been more symbolic than the play signified.

In assuming these male characteristics, Portia reflected in myriad ways the audience's characterization of Elizabeth. Karl Elze showed how the court scene reinforced the message of laws and bonds. The father's riddle and plan for engagement might have forced an unhappy choice upon Portia. The loan agreement might have been a death sentence for Antonio. However, like Elizabeth's all-encompassing power, Portia was able to consider all of this plus the price Jessica might have paid and compensate for all of them in her case against Shylock.

In *The Tempest*, Derek Traversi contends that Miranda's obedience restores her father's happiness. I agree, but add that like Elizabeth, Miranda is only pretending to be agreeable in order to get what she wants; Prospero is only pretending to restrict her relationship with Ferdinand in order to test its potential for success. Living on the island together, Miranda and Prospero understand each other. Perhaps they are meant to be a reflection of King Henry's affection for his daughters — an affection he did not have for his wives.

In contrast to the previous examples, *Othello, the Moor of Venice* shows the result of not finding the proper loophole before confronting the orthodoxy. Desdemona makes a point to tell her father that she is following her mother's actions by choosing her husband over her father. However, strong Shakespearean women do not turn toward their mothers, those that do tend to die brutally. John Quincy Adams reflected that Desdemona's refusal to follow the higher orders — her father ranked over her new husband — led audiences at the time to consider "the outrage against natural law." Many critics concur with Adams, contending that Desdemona's lack of filial responsibility caused her death. If she had married for power instead — either by deferring to a stronger man, remaining virginal, or by marrying someone weaker and controlling him — she would have had a better chance to grow like the other characters. Although Desdemona married someone with strong military prowess, she chose him based on his stories — based on his soft side. The combination of these errors led to Desdemona's demise.

In the early Renaissance, many kings and nobles gave their daughters a strict set of guidelines to follow — especially in terms of marriage — in order to protect the future of their dynasties. By remaining virginal, Elizabeth creatively challenged the system. This challenge raised questions of propriety and of woman's place. Historically, Elizabeth foresaw the full impact her decisions could have had on her country. Therefore, instead

of allowing other women to follow her example, she persuaded and punished them in order to make them follow the traditional order. In a sense, she became a man in order to rule both men and women. Nevertheless, the question loomed. As Shakespeare's strong female characters and the Virgin Queen continued to support and reflect each other, the ongoing debate of the woman's sphere shifted. A new dialogue was created, one to which the current, male-dominated, society was not ready to respond. As the new dialogue grew, Shakespeare continued to address it with his dramatic reflections of the Queen.

"It serves to remind us," wrote critic Lisa Jardine, "that it is a matter of considerable patriarchal importance for social stability to celebrate brilliant exceptions to the female 'rule' only reluctantly, and then as exceptions" (56). As a ruler, Elizabeth made claim to her inner qualities as a man. Mirroring this, boys portrayed women — sweet victory for the woman who presented herself as a male king. "Woman" was not equated with gender, but rather as "a set of social codes and mannerisms executed by a boy (on-stage)" (Jardine, 131). Elizabeth flipped this equation in her definition of "king," making the position not one of male gender but of male social codes and mannerisms.

The ideology of hereditary leadership is important for gaining equality in political theory: Daughters have nearly always been able to carry on in external spheres like their male counterparts, but it often takes the man's absence to prove it. Jardine points out that "authors ... who have in mind ... prosperous noblewomen are delighted to suggest that the daughters ... should share the new cultural treasures first extended to their brothers" (39). However, Jardine also acknowledges that at the time, the permitted education "conveniently distracted able women from any studies which might have led them to notice... possibilities for emancipation in social and political fields" (52).

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Faculty comments

Joseph Candido, Ms. Nichols' faculty mentor speaks highly of the complexity and sophistication of her project. In his letter to the publications board he says:

I am happy to be able to write in support of Phyllis Nichols's scholarly submission to *Inquiry*. Ms. Nichols has an ambitious project, one which creatively combines her twin interests in literature and political science—the representation of strong women on the Shakespearean stage who must try somehow to find self-realization in the shadow of dominant father figures. Ms. Nichols contends, moreover, that these characters are not merely interesting stage types, but that their stage dilemmas are sharply reflected in contemporary Elizabethan society in the person of the most visible woman of the age—Queen Elizabeth—herself a strong woman who must fashion her own identity as a female political leader in the shadow of perhaps the most dominant father in English history, King Henry VIII. For her main focus, Ms. Nichols has chosen three of the most problematic Shakespearean heroines in the canon, Portia in *The Merchant of Venice*, Miranda in *The Tempest*, and Desdemona in *Othello*. The originality of her project lies not only in its determination to cut across generic distinctions by seeing comedy, tragedy, and romance as linked dramatic enterprises, but in its even more ambitious intention to see contemporary English politics and political ideology through the medium of theatre. Most students would be content with the traditionally arbitrary categories of “art” and “politics” and confine their investigation to either one of these areas as discrete fields of study, but Ms. Nichols rightly refuses to confine herself to such simple schemes. She sets a high bar for herself—one that embraces complexity rather than simplicity—and is committed to clearing it. I believe that her project has the chance to bear real fruit.

Conrad Waligorski of the political sciences department is interested in the political content of Ms. Nichols paper. He makes the following comments:

Ms. Nichols is an outstanding student — thoughtful, hard working, and intellectually alive, with a good, inquisitive mind. She is also articulate and able to grasp complex problems and theoretical claims. Moreover, Ms. Nichols has good sense, fundamental decency and is a fine, considerate person. She is a person who contributes passion for learning and genuine inquisitiveness to her classes. Moreover, she can be relied upon. A conscientious person, she always carries out all assignments and responsibilities that she takes upon herself; she has great determination. I have a very high opinion of her.

Although Ms. Nichols has only completed one course with me -Political Science 2003H, an honors course in

American National Government — she is currently enrolled in Political Science 3933, Contemporary American Political Thought and is doing her usual superb work. She has also regularly kept me apprised of her interests and work. Ms. Nichols' exams and papers in American National Government were intelligently written, and showed insight and understanding, as is reflected in her work to date in her current course with me. She was the class leader in terms of ability, class discussion and commitment to her work. She can focus on the issue under discussion and present evidence to support her conclusions. Her written work and class participation demonstrate initiative, sound perception, and extended reading, making her a delight to have in class. Her class questions and comments are always pertinent and often penetrating. Ms. Nichols will raise questions about anything that is unclear, troubling, or simply something she wants to know more about, yet she always advances relevant points, sticks to the question being discussed, and remains focused on the issues at hand.

I am the out-of-department representative on Ms. Nichols honors thesis on women in Shakespeare. Ms. Nichols' thesis proposal is interdisciplinary and intriguing. Her effort to connect gender and dominance themes in Shakespeare with the emerging republican and early liberal political theory of the late sixteenth and early seventeenth centuries deserves support. Conflicting political ideas dominate this period. The older medieval ideal of one empire and one church has collapsed. The medieval emphasis on contract and natural law is under assault by centralizing monarchies and their apologists for ideas of divine right, ideas that never became dominant in England. Counter arguments, drawing on dawning individualism and evolving notions of individual rights, are developing. Ms. Nichols' thesis unites the most important writer of this period with appreciation that his audiences understood his plays—which generally supported the Tudor view of the world—as more than entertainment, but also, as with the ancient Greeks, commentaries on their world.

CARMEN LAFORET'S NADA: FROM BILDRUNGSROMAN TO WILDER(W)OMAN

by Rosario Nolasco
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Fulbright College of Arts and Sciences

Faculty Mentor: Kay Pritchett
Department of foreign Languages

Abstract

The prize-winning Bildungsroman, or coming-of-age novel, Nada (1944) by the Spanish writer Carmen Laforet, tells the story of eighteen-year-old Andrea, who, in the aftermath of the Spanish Civil War, fulfills her long awaited dream of traveling to Barcelona to study at its University. But the house on Aribau Street, where her relatives live, turns out to be a microcosm of Spanish social ills. It is filled with the spiritual, moral, physical and emotional decadence typical of Spain in the post-Civil War period of the 1940's, hence the title Nada [Nothing]. Thus Andrea arrives at Aribau, having the appearance of, as her uncle Roman describes her, "a disoriented little mouse, but not so unhappy as she looks" [una ratita despistada, pero no tan infeliz como parece]. Though perhaps disoriented, Andrea is not dispossessed, for it is she, as my essay will show, who in the end, not only manages to distance herself from the already mentioned decadence, but also becomes a sort of psychological mother for those who reside at Aribau.

My objectives for this essay are to examine this aspect of Andrea's character, which coupled with the crucial moment of psychological individuation experienced in adolescence, fit nicely into a prototypical structure that has been designated the "wilderwoman." According to Jungian analyst Clarissa Pinkola Estés, "wilderwoman is the health of all women. Without her, women's psychology makes no sense. This wilderwoman is the prototypical woman . . . no matter what culture, no matter what era, no matter what politic, she does not change" (Women Who Run With the Wolves 9-10).

I began with a close reading of Nada in order to discover the salient characteristics of the structure and content of the narrative. Then, with the help of recent feminist approaches to female psychology, I explored my thesis regarding Andrea's psychological strength, discovering that this particular protagonist (from a specific culture, era, and politic) does indeed meet Pinkola Estés' description of the "wilderwoman."

The prize-winning Bildungsroman, or coming-of-age novel, *Nada* (1944) by the Spanish writer Carmen Laforet, tells the story of eighteen-year-old Andrea, who, in the aftermath of the Spanish Civil War, fulfills her long awaited dream of traveling to Barcelona to study at its University. What she finds is "a city she has loved in [her] dreams" (Laforet 7). But the house on Aribau Street, where her relatives live, turns out to be a microcosm of Spanish social ills. It is filled with the spiritual, moral, physical and emotional decadence typical of Spain in the post-Civil War period of the 1940's, hence the title *Nada* [Nothing]. Moreover, Andrea's relatives, being of bourgeois origins, are incapable of confronting their new economic situation, negating the possibility for new avenues. Still, the "deficit" of the people on Aribau Street goes well beyond the economic sphere. This family's moral and psychological deficit is more powerful and dismal than their lack of financial resources, although, superficially, money problems often spark conflicts among the various members of the family.

Thus Andrea arrives at Aribau, having the appearance of, as her uncle Roman describes her, "a disoriented little mouse, but not so unhappy as she looks" [una ratita despistada, pero no tan infeliz como parece]. Andrea might have been disoriented but not dispossessed, for it is she, as my essay will show, who in the end, not only manages to distance herself from the already mentioned deficits, but also becomes a sort of psychological mother for those who reside at Aribau.

Nada is more than a coming-of-age novel. Like many novels written by adolescent females during the Spanish postwar period, it constitutes a lucid account of the struggles women faced as well as their aspirations for personal growth. This narrative "allows the reader an early glimpse of woman's desire . . . [a desire] to achieve some measure of creative and cultural, as well as personal and social, authority" (Ordoñez 33). Thus Andrea's profound desire to gain such "authority" together with her reaching that particular moment in adolescence which "seeks to speak the as-yet-spoken" give Andrea the necessary strength to transcend her circumstances (33). In this process she not only

manages to remain psychologically and spiritually whole, but also extends that wholeness to others.

As Bruce Lincoln points out in his *Emerging from the Chrysalis*, the initial steps in the process of maturation and individuation are recognized as crucial by non-western cultures. His study of women's initiation rituals show how such moments in a young woman's life are celebrated by these groups in an attempt to make women "more creative, more alive, more ontologically real" (Ordoñez 33). In our case, Andrea arrives in Barcelona still encased in a cocoon, but the tremendous shock caused by the circumstances at Aribau accelerates and intensifies her maturation. She rapidly sheds her chrysalis. Remarkably, Andrea's unconscious recognizes this process: "In my dream I saw myself running, stumbling, and suddenly feeling that I was shedding something like a dress or cocoon that tears and falls wrinkled at my feet" (Laforet 177). Thus Andrea emerges ready to confront an "unsuspected truth," to face—without denial—the extreme dysfunctionality of her family.

But what are the hidden primal sources that allow Andrea to move through such a remarkable journey? Jungian analyst Clarissa Pinkola Estés, who has written extensively on the intrinsically intuitive aspect of female psychology, namely the "wild woman archetype," offers an answer: "wilderwoman is the health of all women. Without her, women's psychology makes no sense." The analyst, who herself grew up in a post-war period, shares similar experiences with Andrea: "My generation grew up in a time when women were infantilized . . . [and] kept as fallow gardens . . . but thankfully there was always wild seed which arrived in the wind" (Pinkola Estés 5). This "wild seed" is not geographically nor culturally constrained but rather is universal; accordingly, "wilderwoman is the prototypical woman . . . no matter what culture, no matter what era, no matter what politic, she does not change" (9-10). *Nada's* main protagonist and narrator, Andrea, is that "wild seed" that falls at the doorstep of her relatives' house on Aribau.

Throughout the narration, Andrea demonstrates that time and again she possesses the strength of a wild woman. The use of the word "wild" should not be understood in the modern pejorative sense, but in its original sense meaning "to live a natural life, one in which the creature, has innate integrity and healthy boundaries" (Pinkola Estés 8). From the very beginning she clashes with the degrading conditions she finds at Aribau. Andrea conveys her aversion through her vivid and highly sensorial observations. She specifically says, "my own body, standing on tiptoe amidst brilliant threads of water in that filthy porcelain bathtub, trying not to touch those dirty walls," and she also expresses her desire to keep herself distant, "What a relief to be out of sight of those queer creatures" (Laforet 11).

Such a distinct sensorial ability, made evident time and again throughout the narration, is compatible with the description of the wild woman archetype. Through the senses, this archetype

"sheaths the alpha matrilineal being . . . through sights of great beauty . . . through sounds . . . through the mystique of inspiration" (Pinkola Estés 8). When Andrea is invited to Ena's house for an afternoon of music and wine, she is awed by the passionate singing of Ena's mother. She leaves the house restless, feeling bewildered and unsure as to how to satisfy the persisting desire for beauty that listening to Ena's mother has ignited:

I quickened my pace until I reached the main entrance of the cathedral (Figure 1), and as I looked up at it, I found at last the fulfillment of my wish. As I gazed at the realm of shadows cast by the pious stones, a strength prevailed over me greater than that which wine and music had given me. The cathedral, designed almost in the form of a plant, rose in austere harmony up to the clear Mediterranean sky. Peace, a majestic radiance, emanated from the magnificent architecture. Around its dark outlines loomed the glittering night slowly orbiting it in rhythm with time. For a few moments I let that profound magic permeate me. (Laforet 96-97)

Hence, the "disoriented little mouse," now liberated from her chrysalis and armed with the devices dispensed from her kinship to wilderwoman, becomes a stabilizing influence for her family members and friends, that is, "both friend and mother to all who have lost their way" (Pinkola Estés 9).

When Andrea arrives in Barcelona, she finds a family who collectively suffers from a fragmented psyche. Undoubtedly, the people at Aribau have needed a "mother," one who possesses psychological integrity and healthy boundaries. Both men and women at Aribau have failed to preserve such integrity; they have allowed the trauma of war to creep up and exacerbate weakness. Their economic statuses, appearances, gender inequalities, and even their already damaged egos, fracture their psychological wholeness. All of the above confirms Pinkola Estés' assertion that "when we lose touch with the instinctive psyche, we live in a semi-destroyed state . . . subsumed by the culture or by the intellect or the ego—one's own or those belonging to others" (Pinkola Estés 10).

Consequently, at the time of the narration, the matriarch of the family has been reduced to a mere "grayish blur of a decrepit old woman" (Laforet 9). The grandmother has all her life followed the role, imposed on her by patriarchy, of an "infantilized" grown up woman. She has bestowed privileges onto her male children and has withdrawn the same from her daughters. She has now certainly turned into the dependent child. In spite of her desperate attempts to mother Andrea, it is clear that the roles are reversed. Andrea recalls this experience: "Against my breast I felt her heart beating like that of a little kitten. 'If you wake up scared, my dear, call me,' she said with her quivering voice" (12).

The grandmother's natural successor in the matriarchal line, the eldest daughter, Angustias, is not surprisingly also a victim of the system. To this daughter's credit, she tried to rebel in her youth when she attempted to marry a man beneath her socioeconomic status, but in the end she failed to rise to the challenge. Unable to overcome certain obstacles, she has ended up defeated, frustrated, and disillusioned. Predictably enough, Angustias attempts to regain strength by adopting the role of matriarch over the family, but she fails. Consequently, she tries to impose her "matriarchy" over individuals she suspects have little power, like Andrea or the beggar down the street, both of whom she nags and preaches to, demanding they recognize her "authority." She fails at this too; Andrea soon slips away, refusing to play her game, and the beggar, who has depended on Angustias' charity, has only been putting on a front.

The other two women at Aribau are equally fragmented. Gloria, Juan's wife, is also a child in a woman's body. Completely self-involved, she has immersed herself totally in her tortuous relationship with Juan. Andrea describes Gloria as a woman who possesses a "naïve and stupid vanity." Throughout the novel she repeatedly asks Andrea the same question: "It's true that I am pretty and very young? Isn't it?" Furthermore, in the midst of her justification of Juan's explosions of anger, Gloria contradicts herself: "Juan is very, very good, kid. *Don't you see that he squawks so much and everything?* [italics mine] Well, he is extremely good" (Laforet 28). It seems as though Gloria uses adjectives like "pretty," "young," and "good" to cover up the ugliness that surrounds her. The maid Antonia impresses Andrea even less: "Everything about that woman looked horrible and wretched . . . never has any creature produced such an unpleasant impression on me" (9-10). Antonia, perhaps the extreme example of the psychological destruction noted before, has been not only the victim of postwar culture, but also a victim of her gender and her socioeconomic status, which has made her a prime target for abuse. She has become a victim of Roman's ego as well. He has taken advantage of Antonia's psychological weakness, which she expresses in her servitude and unhealthy loyalty towards him. All the women at Aribau benefit from Andrea's psychological integrity. Andrea is able to assuage the psychological fragmentation in her environment by distancing herself from it or on occasion acting in direct opposition.

Andrea's uncle, Roman, had early on perceived, not only the inner strength, but also the nurturing side of her niece's "wilderwoman." She is the "mother" he needs, one who nurtures his love for music and art: "Say, don't you want to play music today? . . . Do you also paint?" Roman answers these queries like a child bragging about his talents: "I've done a little of everything" and moved to please Andrea with one of his best violin performances. Andrea is able to perceive Roman's enormous artistic talent. She lets him know with a mixture of interest and admiration for his art: "My soul, outstretched like my own clasped hands, would receive the music as parched earth receives



Figure 1. Gaudi's Sagrada Família, Barcelona. Courtesy of the Gaudi and Barcelona Club.

rain. To me, Roman seemed to be a marvelous and unique artist. He would weave into music such pure joy that it transcended the limits of sadness" (Laforet 32). Andrea might have almost saved Roman from his horrible end, his eventual suicide, but Roman could not "transcend the limits of sadness" nor escape the psychological subjugation imposed by his ego, his intellect, and his culture.

Roman's brother Juan, possibly the most tormented soul at Aribau, also benefits from Andrea's mothering care. When Juan, in a fit of rage, goes out to look for Gloria in the red light district of Barcelona, Andrea hurries after him in order to protect him as much from himself as from the world. This is perhaps one of the most significant and moving episodes in which Andrea cares for another. It is also in this episode that the reader realizes how little material resources Andrea has: "I run in pursuit of him as though my life depended on it. . . . Distressed, I thought that if it should occur to him to take a trolley, I wouldn't have the fare to pursue him" (141). She manages to follow Juan from a distance while journeying through "dark and foul-smelling alleys" (143) until he gets into a fight with a drunkard. After the fight, Andrea helps Juan to escape from the police and cares for him: "I took a handkerchief out of his pocket so that he could wipe off

the blood that was dripping on his eye. I tied it on him, and then he leaned on my shoulder" (145). Andrea is no guardian angel sent from heaven. She is just a flesh-and-blood, underfed, eighteen-year-old girl: "I was beginning to feel as tired as I often did during those days. My knees were shaking so much that it was difficult for me to walk. My eyes were filled with tears" (145).

Andrea cares for all of her relatives at Aribau—the grandmother, Angustias, Gloria, Juan, and Roman. All receive, in one way or another and to one degree or another, her care. But Andrea extends her care beyond her family. The novel's third and last part begins with Andrea returning, disillusioned, from a party with her socialite friend and pursuer Pons. She has confronted her reality and has affirmed her desires. It is then that she finds the mother of her best friend Ena waiting for her. All of a sudden, Andrea is made the confidant of a mature woman. Ena's mother opens up completely to Andrea and shares her most intimate feelings with her. Perhaps out of desperation, perhaps because she perceives Andrea's psychological integrity, Ena's mother does confide in her and does allow Andrea to see her at her most vulnerable point: "Her lips were trembling. She realized that she was talking to me, and in trying to control herself, the color of her eyes changed. Then she would close them and let that tumultuous speech overflow like water that breaks through dikes and drags everything along" (191).

After this prelude, Ena's mother starts her detailed narration of her relationship with Andrea's uncle Roman, from first falling in love to the very sad ending of their relationship many years before. Her father tells her that Roman accepted a bribe in exchange for his disappearance from his daughter's life. Andrea is not comfortable hearing these intimate details, but she not only listens, she herself keeps an objective distance: "I was getting embarrassed listening to her. . . . Like youth itself, I was then sour and uncompromising. All the defeat and oppression of that confession repelled me. The fact that that woman would relate her misfortunes aloud almost made me feel sick" (194-195).

Thus Andrea shows with this last episode her capacity to observe and be present before "all the defeat and oppression" without being trapped by it. And still she finds a point of contact between that woman, for whom she feels nothing but aversion, and herself:

There was nothing more to say, since it was easy for me to understand that terminology of blood, pain, and creation that begins with the same physical substance when one is a woman. It was easy to comprehend it knowing that my own body was prepared—as though laden with seeds—for the task of continuing life. Although then everything in me was bitter and incomplete like hope, I understood it. (197)

Andrea understands well the language spoken by Ena's mother, and even though this provokes in Andrea a feeling of bitterness, she accepts the woman's pain as having no remedy. But Andrea also knows the language of female nature, of creativity, of inspiration and intuition provided by the wilderwoman, the part that is also a woman's "physical substance." Andrea intuitively knows that she is prepared, "laden with seeds (wild?)" for whatever may come. Did she "save" anyone at Aribau? Perhaps not. More importantly, rather than saving them, she has saved herself and her wilderwoman from the dangers of the "unsuspected truth." By doing so, she has provided through her narration a bastion of light for generations of wilderwomen to come.

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Rosario Nolasco

Faculty comments

Ms. Nolasco's mentor, Spanish professor Kay Pritchett, finds her critical essay to be insightful and accomplished. She says:

Although for several semesters I have asked students in my Monuments of Spanish Literature class to submit analytical essays, I have yet to encounter a more sophisticated interpretation or a better organized short essay than Rosario Nolasco-Bell's paper on *Nada* submitted last semester. This particular assignment is designed to encourage analysis more than research. Rather than requiring students to spend their time locating and reading criticism, I have chosen instead to have them focus upon reading and interpretation. Rosario's short paper portraying Andrea, the novel's protagonist, as *wilder woman* is striking both for its originality and insight. It moves past the surface reality of the novel and discovers a mechanism for associating this particular text—a product of post-Civil War Spain—with issues of a universal nature. In my estimation, this is a singular accomplishment, difficult even for more experienced readers.

Although, for the most part, in literature classes we tend to focus upon the smaller issues—the details of language, plot construction, and so on—the ultimate goal, the one we perhaps too often fall short of, is to read the text in some especially meaningful way, some manner that not only serves the act of reading but enriches the knowledge and understanding of the reader. Rosario's interpretation of *Nada* attains this level of discernment. She is able to perceive in Andrea the archetype of healing feminine power, the woman who in spite of personal limitations and external hardships is able to journey forth towards wholeness. I find it remarkable that Carmen Laforet, a woman of some twenty years, was able to create such a character as Andrea. I also find it laudable that one of my undergraduates has been able to perceive this significant yet heretofore unrecognized facet of Laforet's young protagonist.

May I add that Ms. Nolasco-Bell is as assiduous in her other assignments as she has been in the writing of this short essay. She shows considerable promise for becoming an accomplished critic of Spanish-language texts.

Steven Bell, the Director of the Latin American Studies Program, stresses Ms. Nolasco's contribution to the area of Spanish literary criticism. He says:

Rosario Nolasco is one of our very top graduating seniors in Spanish, and the work she has done on this project, entitled "Carmen Laforet's *Nothing*: from Bildungsroman to Wilder(w)oman," clearly indicates why. The work Rosario has produced shows a most unusual degree of scholarly maturity and critical

acumen for an undergraduate major. She clearly understands the style and conventions of professional literary criticism; and her piece would I think readily be accepted for presentation at a graduate student conference and publication in a graduate student journal. She proposes to bring a new issue and approach to the scholarship on the highly regarded work of fiction under consideration. Rosario has formulated an original and incisive, interdisciplinary problem and hypothesis involving feminist theory and its historical application, and she has cogently outlined the parameters and variables involved. She also demonstrates clearly the wherewithal to articulate coherently and forcefully the results of her analyses, which promise to make a substantial contribution to this area of Spanish literary criticism.

Historian Bryan McCann is impressed with Ms. Nolasco's understanding of the political nuances dealt with in the novel. He writes:

I want to recommend the inclusion of Rosario Nolasco's essay in the coming issue of *Inquiry*. Rosario offers a subtle critical analysis of Carmen Laforet's *Nada*, truly opening up the novel for the reader and exploring its most significant implications. Rosario has taken on a difficult subject and handled it with expertise; her work is innovative and professional, and would make an excellent contribution to the journal.

Laforet's novel, from 1944, depicts a Spain riven from within, and desperately attempting to conceal its own divisions in the wake of the Spanish Civil War. It is no accident that the novel is set in a middle-class Barcelona home—Barcelona had been by far the most radical of Spanish cities in the early days of the war, experiencing a brief but fervid period of political anarchism and sensual liberation, an ambience in which the character of the young Andrea might have felt completely at home. A split between anarchists and Marxists, followed by the bitter reaction of a conservative merchant sector and the rise of the Falangists under Franco, brought this period to a crashing end. The novel is set in the ensuing period of repression and consolidation of power, and Andrea finds herself in the claustrophobic and hypocritical environment of the bourgeois Aribau family home.

Rosario's reading of this predicament and the ensuing conflicts shows great insight, combining historical and political awareness with sensitive and close attention to the text. Rosario uses Clarissa Pinkola Estes's model of the *wilderwoman*—a kind of ur-female, both primitive and transcendent—to illuminate Andrea's character and her influence on others. Rosario's use of this model is flexible and enlightening, rather than restrictive, resulting in a fine appreciation of the political and sensual dimensions of the novel.

MADONNA DE LA MER: REFLECTIONS OF LIGHT AND MEMORY

By Amjad S. Faur
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Faculty Mentor: Marilyn Nelson
Department of Art

Abstract:

The Pioneers of photography sought to document their lives with a new sense of reality and permanence. The results have persevered throughout photography's brief history as sparse, elegant, honest and strikingly beautiful images. My research uses late nineteenth century and early twentieth century equipment and techniques to document the timeless beauty, which connects us to those old photographs by creating portraits of people, which will deceive and nurture memory. Without our memories, we respond to the present with only survival instincts. Memory is our pool of reference for all experience. Only two basic elements, light and memory, are used as the primary tools in this study. The medium through which these elements are being studied is the only medium in the creative arts in which light is the mark maker: photography. The vivid sharpness found in large format photographs creates a lush and surreal portrayal of time and reality that lends beauty to the nature of this study itself: the perceptions and myths we hold dear to our hearts and minds. The images created for this study portray the vivid lights of both day and night and the illuminated bodies of our species in a suspended dream-like state. They are pictures of people existing in beautiful worlds, which now act as our tangible and visible memory. These photographs, which are to be exhibited at the University of Arkansas in the 2001-2002 academic year, are a portrayal of modern people in a setting and style that erases all traces of date or origin.

The intent of this research is to create a space and reality within photographs that allows the viewer a doorway into a world that is without reference to time, trends or cultural specifics. A world where portraits of faces and bodies exist in an eternal landscape that bears a space in memory and not in time. The completed work will be exhibited so that viewers may absorb and interpret the images included in the study, perhaps taking part of this experience with them or feeling a greater connection to others who have come before them or to their relationship to time itself.

These portraits represent a layering of time, an idea that began to bloom during a visit to Rome, Italy. Being in the presence of such vast layers of time, culture and experience, I became deeply moved by the influence not only of the city but also of the generations of culture which built the Western world. The skeleton of this research is built on dualities: the ambiguity of memory and the literalness of photographs; truth vs. fiction; antiquity and modernity. The pictures included in the study are portraits of people existing in a timeless realm where the photographic process is as sacred as the bodies being photographed. The idea of the photograph contrasting with memory is eloquently stated by Lynda Sexson in *Ordinarily Sacred*:

It was a photograph of a sand sculpture, a reclining madonna with her child in her arms, serenely awaiting the incoming tide. I used to look at the picture, at the woman lying serenely with her child's leg resting on her belly, with the inevitability of the tide that would come over her, already sounding under her bed. Why didn't she try to save the child, I'd think, but then realize-she, like him, is made of sand. This Madonna de la Mer, waiting to dissolve in a tide that had occurred and washed her away long before I or my mother was born, but ironically preserved on pasteboard, made me marvel about the transitory shapes of our eternal desires as much as any eloquence carved from marble.

My project unveils lost time. Like the Madonna de la Mer, the people photographed for this study will be washed away in the sea of time. Yet their bodies, unaffected by sickness, age or death, float in the chemical components of a photograph that will, in time, begin to deteriorate itself. However, this project will preserve the memory of these anonymous beings as they exist now though they appear as though they could have been made one hundred years ago. The figures are an abstraction of time, similar to the abstraction of memory.

The duality of the figure versus its abstraction was investigated early on by photographers such as Alfred Stieglitz

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and Man Ray. They explored figurative transformations within photography with solarized prints and detailed nude studies. Later Ruth Bernhard used foreign textures, such as lace and sand, to paint a new surface on the skin of her models. This research is intended to preserve the classical techniques and craftsmanship established by the pioneers of photography through investigation of early photographic techniques.

Light is important in this project not only as illuminator of the scenes but also as the only mark-maker involved in the creation of the images. Photography exists only through light; it is our modern day memoir. Photography portrays life in an unforgiving moment of truth. Perfect pictorial representation plays a strange game with memory. Whereas memory tells one story, a photograph often tells another. Through the course of this project, the defining differences of each story dissolves in front of the camera. What remains is portraiture born from a moment which will be hidden from the trappings of time or place. Through this research, the original methods of medium and large format photography are re-established as viable and unequaled forms of creativity re-emerging in a digitally enveloped space-age of 1's and 0's. As computers begin their inevitable eclipsing of classical methods, the craft and process of photography



(drawing with light) breathes life into the visual past from which we have come. To shine the light of imagination into the past we have inherited through photographs and memory, while exploring antique and modern creative approaches, will give birth to photographic scenes that are as revealing personally as they are collectively

The instruments used in my research are the tools of photography. The photographs are made using large format cameras to create 5x7 inch and 8x10 inch negatives. As large negatives were used exclusively during the dawn of photography, this technique adds yet another dimension to the past/present amalgamation which lies at the heart of this project. Due to the extraordinarily sharp focus and tiny grain structure in large format negatives, prints of these negatives produce an image which bears an other-worldliness quality. Antique, non-silver processes such as cyanotype, Van Dyke brown, and platinum printing methods were used to retrace the path that has been laid down for modern photography.

Of the materials used in this research, light is the mother — the sole creator. The photographs are lit with a large variety of light sources such as studio lamps, fresnel theatrical lights, candle light and sunlight. These simple but magnificent sources paint the skin of the images. The light creates deep shadows and milky skin tones and opens a luminescent world not unlike that

found in the paintings of Caravaggio in which bodies seamlessly emerge from darkness and are captured by a divine light that throws the space around the figures into an ambiguous realm of darkness and light. The use of these different lighting techniques helps to create a sense of mood and an atmosphere similar to that of Baroque painting or old tintype photographs. Tenebroso, the technique of using severe contrasts of dark and light, is balanced with the smooth and even tones typically found in large format printing. The final effect creates a dreamlike world where time and place are suspended and we are left only with a quiet reflection of ourselves.

The final goal of this research was to create an enormous body of work to be exhibited as a whole so that viewers may walk into the exhibition and feel as though they have stepped into another world. Hopefully, those who see the exhibit can embrace the whispers of the photographs and forget the present momentarily to find a hidden place within themselves in which they can reconnect to generations long since gone. These photographs become portraits of people who represent the timeless, anonymous beauty seen and held by us all. By calling upon one of the uniquely revolutionary forms of visual expression available (large and medium formats), the photographs escape the slick, quick-clicking trappings of digital imaging which are

noticeably dated soon after they are made. Large format photography exists in the same creative realm as puppetry and theater. All are hands-on, extraordinarily challenging forms of creativity. These outlets remind the world of a time when tangible, primitive resources such as wood and clay were the lifeblood of art. The physical relationship of human to medium animates creations, making them that much more a part of ourselves, giving the work a sense of nearness and compassion impossible to find inside of a machine. My research relies on this relationship to weave human experience and human imagination.

Since its discovery, photography has granted mankind the ability to document history as a visual experience. Photography has recorded the thought processes of generations with a new clarity. It is our inevitable connection to old things that attracts us to folklore, or books, or even old photos. This psychological connection is what initially drew me into this project, and it should eventually touch a great number of people in the same fashion. Photographs and their stories are how we will be seen. Memory will no longer be our sole evidence of life lived. It is vital that photography survive in its purest form to act as a storyteller as timeless as our myths.

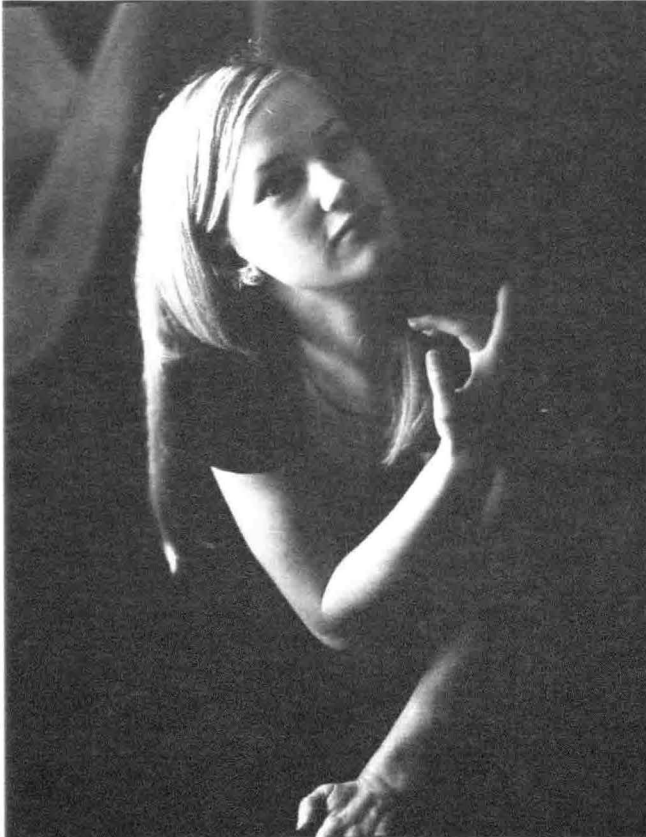
In our disposable culture, photography as a medium for myth-making is invaluable to us now more than ever. The speed of our planet's pace makes it difficult to find clarity within everyday life. It is not only beneficial but also absolutely essential that we take time to close our eyes and remember a part of ourselves so easily clouded by the frustrations of a world passing us by. Popular culture, mass media and computer globalization are quickly changing visions of mythic and universal themes. Popular ideas and portrayals of beauty and self-reflection have become little more than anorexic ideals on an advertisement parade. Neglect of the imagination is becoming a global trend. Perhaps by digging into soils of the past, present and future, it will be possible to see a vision of ourselves as timeless beings once again. Dedication to the preservation of the past and the evolving picture of the future is the beating heart of this project. The final exhibition of this work will be in the University of Arkansas Fine Arts Gallery during January and February of 2002.

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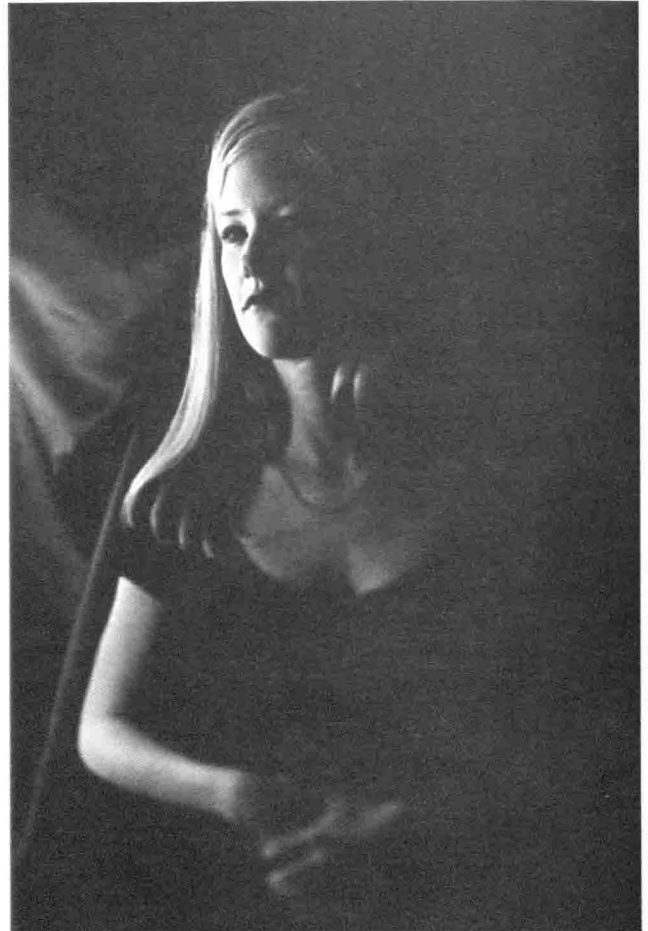


Faculty comments

Marilyn Nelson, Amjad Faur's faculty mentor, describes Mr. Faur's photography in glowing terms:

I am very pleased to recommend Mr. Amjad Faur's research paper, defending his visual creative artwork, for consideration for publication in *Inquiry*, the Journal of Undergraduate Research.

This body of photographic prints, "*Madonna de la Mer (Reflections of Light and Memory)*" is significant for several reasons: First, conceptually, by capturing subject without historical reference or documentation of existing time, Amjad is investigating the 'ambiguity of memory' result'. He is utilizing subject and light to 'create spaces which allow the viewer a doorway into a word which is without reference to time, trends or cultural specifics'. Traditionally, the photograph moves the spectator toward contemplation, a place where the spectator can abandon himself to his associations. Amjad sees this viewing place as an important and necessary contrast to our contemporary society of motion graphics, film, and of viewing the



world from moving vehicles. In those media the eye often has a difficult time grasping a scene before it is immediately replaced with another and the spectator's process of association in viewing Images or scenes is interrupted by their constant, sudden change. These views parallel writings of Walter Benjamin (1892-1940) in his essay, 'The Work of Art In the Age of Mechanical Reproduction' where he contrasts the viewing of art with the viewing of the new genre of film. Second, technically, the exploration and utilization of classical cameras, techniques and craftsmanship established by the pioneers of photography enhances the timeless qualities of his images. This interest has inspired a deeper understanding of the history of photography and the preservation of historical photographic techniques. And third, these photographs have challenged Amjad to expand his research skills and conceptual thinking as an artist. They are of a quality and quantity suitable for solo exhibition purposes and they will increase Amjad's recognition as a serious and dedicated artist. He has already begun to establish an exhibition record, which is unusual for an art student of junior standing. For artists, the exhibition of creative, visual work is equivalent to publishing

written research in other academic areas. However, the written description of his work will increase his opportunities to give conference presentations, to publish, and to apply for grants and visual arts projects.

Amjad is pursuing a Bachelor of Fine Arts degree, with an emphasis in Photography. It is clear that he embodies the qualities of a dedicated student as well as the potential to become a fine photographer. He is an extremely self-motivated individual. He possesses a willingness to explore and problem-solve, to challenge himself, and to accept criticism while maintaining an energetic work ethic. This sustained and concentrated effort to produce an extended series of high quality photographs is ambitious and unusual for an undergraduate art student; it is equivalent to what we would expect of a graduate student. His dedication to and love for the art of photography is evidenced also by his commercial employment within the field.

Amjad's creative research abilities and his performance as an outstanding art student have been acknowledged by the art faculty as a whole. Through portfolio reviews of student work he has received several competitive awards. This year he received the Blanche Elliott Award for Outstanding Junior Art Major, and in 2000, he received the Bedford Camera Award for Outstanding Creative Photography. In 1998 he received the only freshman level award available, the Tom Turpin Award for Outstanding Freshman Art Major. As a result of receiving a scholarship based on his ACT scores, he studied at the Savannah College of Art and Design before entering our program.

As mentor, my advisory role has been to critique the content and formal visual aspects of the work in progress, to encourage critical thinking, and to provide technical criticisms. These meetings help to keep the work focused on project objectives while allowing room for artistic growth. I am fortunate to be working with Amjad and am impressed with his focus, energy and visual interpretations of creative problems.

Larry Swartwood, one of Mr. Faur's studio critics echoes Professor Nelson's sentiments:

Amjad Faur has engaged in a project that is beyond the capabilities of most undergraduate students and which would present a challenge for a mature artist. His project, *"Madonna de la Mer (Reflections of Light and Memory)"*, is a project, which is conceptually, aesthetically and technically well developed. Amjad seeks to find the universal and timeless aspects of visual imagery. Aware that the modern human is bombarded with thousands of images daily—more than individuals in the past may have seen in their entire lives—Amjad seeks to produce images that we can fix and reflect upon.

As a student, Amjad displays those qualities—dedication, motivation and self-discipline—which are important to a serious working artist. At the same time Amjad is willing to listen to criticism, and to grow with that criticism. Amjad has the ability to meld the touch of the poet with the mental discipline of critical thinking. In addition, he has the particular desire that artists have had since they began to paint in caves: to give form to the abstract.

Another of Mr. Faur's studio critics feels much the same way about his work. Joanne Jones says:

I have been monitoring Amjad's work in photography this semester. Amjad is producing work that reflects the intent which he set forth in his grant proposal. He has secured an antique, large format view camera in order to replicate the large negatives used in the early years of photography. The large format provides a negative of high resolution that is contact printed rather than enlarged. The availability of the large negatives allows him to produce prints by print processes developed in the nineteenth century which are very different from those used today. The process he used in taking the photographs—a large view camera—is also special. Working with the large view camera involves a slow, methodical approach that is quite different from today's popular point and shoot or digital methods that record an instant with clarity. Through careful observation and adept control of the camera and subject, Amjad has been able to embody his image with the "timeless, anonymous beauty" that he has specified as his goal. Amjad's stated significance of his study, 'Dedication to the preservation of the past and the evolving picture of the future...', is achieved through the use of the large format camera, the focus on the reality of today, and the vision of establishing myth. I have found Amjad to be a very dedicated and responsible young man, who approaches and embodies his creative work with a passion that is ultimately embraced by the viewer.

FIGURE, IMAGE, AND THE SHAPE OF TIME

IN SHAKESPEARE'S HISTORY PLAYS

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Faculty Mentor: Joseph Candido
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Abstract

Shakespeare began his career as a dramatist by writing the first of a series of plays remarking upon English history from the Middle Ages through the reign of Henry VIII. Most notable of this historic chronicle are the eight plays, or two tetralogies, that dramatize the tumultuous period of civil conflict between 1399 and 1485. Some critics of Shakespeare's tetralogies have argued Shakespeare's intent to produce a single, unified, and providentially-ordered chronicle in which the deposition of Richard II may be viewed as the nascent event for the civil wars that culminated in Tudor accession to the crown. Nevertheless, more recent scholarship has disregarded this notion, preferring instead to view the two tetralogies as separate entities for which there is no compelling evidence that Shakespeare intended a relationship, much less a sweeping thematic narrative spanning eight plays.

However, I suggest that Shakespeare had a Medieval source, the dramatic chronicles of biblical history known as the Corpus Christi plays, from which he may have derived the pattern for connecting together seemingly disparate episodes in history into one richly-textured historiographic body. Through the examination of corresponding scenes from each tetralogy, I demonstrate that Shakespeare's history plays are indebted to the Corpus Christi cycle drama for idea, imagery, and their essential form as an architecture of figural connections. Together, I conclude, these elements impart a greater didactic significance to Shakespeare's history plays and substantiate the conception of Shakespeare's two tetralogies as an important and coherent unit.

England's glorious defeat of the Spanish armada in 1588 and its seeming impenetrability to foreign aggression spawned great nationalist fervor among Elizabethans, among whom was the young playwright Shakespeare, who subsequently devoted a series of plays to English history. Ironically, however, these plays have as their subject the much less auspicious days of England's past. Eight of these history plays, generally grouped

into two tetralogies, are concerned with the period of time between 1399 and 1485, during which England was besieged by the bloody civil conflicts known as the Wars of the Roses. Some scholars, most notably E. M. W. Tillyard, have argued that Shakespeare's two tetralogies of English history may be read as a coherent and providentially-ordered historiography in which the deposition of Richard II results in a long period of civil war that ultimately finds amelioration in Henry Tudor's union of the houses of York and Lancaster and leads to the golden age of Shakespeare's immediate audience. Tillyard cites as evidence for this view three works with which Shakespeare was thoroughly familiar and which, according to Tillyard, provide the "outlines of a pattern"¹ for chronicling providential history: Hall's *The Union of the Two Noble and Illustre Families of Lancaster and York*, Daniel's *The Civil Wars*, and the *Mirror for Magistrates*. However, more recent scholarship has preferred to view the two tetralogies as relatively unrelated chronicles and has disregarded altogether the idea of Divine Providence. Irving Ribner writes that these plays "cannot be conceived of as a single epic unit" and that, furthermore, "the cycle of plays which begins with the deposition of Richard II ... culminates in the glorious victories of Henry V,"² not in Tudor accession to the crown. Similarly, Robert Ornstein contends that the two tetralogies "are too separate and too different from one another to be regarded as the complementary halves of a single oddly constructed panorama of English history."³

I would like to suggest that there is another source from which Shakespeare may have derived a providential pattern for ordering history. The Medieval chronicles of biblical history known as Corpus Christi or mystery plays have long been accepted as one of the many influences upon Shakespeare's art. It is significant, however, that the writers of the Corpus Christi plays, in selecting biblical stories for sequential dramatic representation spanning the real time period between creation and judgment day, chose those Old Testament events that found some correspondence in the New Testament and, therefore, formed a meaningful historical bridge or a relationship in which a greater spiritual truth might be understood. V. A. Kolve

explains this use of patterning as theological *figura*, or the idea of *umbra* and *veritas*, which has as its purpose to connect together seemingly disparate episodes in history and produce "a cycle sequence charged with ... meaning."⁴ My object is to demonstrate that Shakespeare's two historical tetralogies are indebted to the Corpus Christi plays for their form, and that form, as an architecture of figural connections, imparts to Shakespeare's history plays a richer texture and more significant meaning while also substantiating the relationship between the tetralogies. In addition, I wish to show that the history plays are further informed by the Medieval cycle drama in their use of idea and imagery from those plays, which both reinforce the figural structure of the tetralogies and enhance its meaning.

Two significant events in Shakespeare's first tetralogy find a dramatic correspondence in events depicted in *Richard II* and, thus, help to establish a deliberate link with the second tetralogy. The first of these is found in the first scene of the final act of *2 Henry VI*, in which York returns from Ireland, having along the way amassed a large and formidable army. Addressing the audience, he discloses the impetus for his march on England: to remove the king and re-establish Plantagenet rule. However, when confronted by King Henry's messenger, he offers the more palatable excuse of removing a supposed traitor to the crown and swears his allegiance to the king. *Richard II* presents another such ambitious man arriving in England with an army in tow. Bullingbrook claims his return to English soil has no other purpose than to reclaim his lands and title and to rid Richard's court of three traitorous men. And like York, he pledges loyalty to his king on bended knee. However, he sails for England before he is actually stripped of his inheritance, suggesting the ulterior motive of seizing the crown from his inept cousin, Richard II. The *figura* that is York's march on England to claim the throne of England finds in its correspondence to Bullingbrook's march on England a fulfillment that illuminates the latter event in dramatic time. Although Bullingbrook will not confess his genuine motivation, we can look to the earlier dramatic *figura* of York for conformation that Bullingbrook has, like York, intended the crown all along. Thus, by the simple use of Medieval *figura*, we can "read" the later event by seeing it in terms of the former one.

A second and perhaps more dramatic example of *figura* in Shakespeare's history plays lies in the opening scene of *3 Henry VI*, in which York and his men have gained illegal access to Westminster Hall in order to confront King Henry VI, whom they intend to depose. Henry enters the room to find his rebellious Duke of York firmly established upon his throne, a grave insult to Lancastrian authority. In an exchange fraught with tension, Henry demands York's submission but is instead compelled to defend the validity of his kingship. Yet, some sixty years earlier, as Raphael Holinshed reports in his *Chronicles*, this same throne in this very same hall first proved itself contentious.⁵ Then, another Plantagenet and another Lancaster argued who should

be king, a question in which the right of primogeniture was and would forevermore be pitted against the right of might, ability, and conscience. In this earlier scene (in historic rather than dramatic time), however, it is a Lancaster, in the person of Henry Bullingbrook, who has taken possession of the throne and sits on high, and the Plantagenet king, Richard II, who stares up at him with the knowledge that he must either re-establish his claim to the throne or relinquish it forever. The deposition of Richard II in Westminster Hall in the year 1399, in historic time, foreshadows the scene that Shakespeare depicts in the first act of *3 Henry VI*, and its awful veracity is much upon the minds of those who contemplate the right to rule in Westminster Hall in 1461. Thus, when York ascends the throne, his act is the fulfillment of the earlier *figura* or premier event of Lancaster's own ascension.

With the use of *figura* and by selection of parallel scenes, Shakespeare teaches his audience how it might better understand the characters of Bullingbrook and York. In this same way, the authors of the Corpus Christi plays laid a pattern with analogous scenes, intended to direct their audience to a difficult or meaningful insight. Derived from the well-rehearsed liturgy of the church, the *figura* and patterning of the Corpus Christi plays would have been quite familiar to Elizabethans. And as Harry Levin notes, Shakespeare would have had the opportunity to see the mystery cycles first-hand, played much as they had been for 200 years: "Certainly in his youth he must have visited the neighboring cathedral town of Coventry, still a centre for the street performance of Biblical cycles, and watched the pageant representing the Slaughter of the Innocents, where Herod rants in the manner that Hamlet describes."⁶ Thus, we may credit a young Shakespeare with not only the knowledge of figural events but the ability to apply them to his own craft.

This first scene of *3 Henry VI* would also seem to be quite rich in idea and imagery borrowed from the Corpus Christi drama, for we may find within it a neatly constructed correspondence with the first play of each of the Corpus Christi cycles, the Fall of Lucifer. As York would ascend to the throne of England, so Lucifer aspires to the rule of heaven. He therefore assumes the throne of God and, like York, proclaims his right to rule. But, as John D. Cox points out, the right of God to rule heaven and earth in the Corpus Christi play is beyond question, while the right of Henry to the crown of England is not.⁷ In an attempt to maintain his power, Henry asserts his right of primogeniture; however, York's name, Plantagenet, by itself establishes for him an older and stronger claim to power than Henry's. Indeed, Henry's supporters begin to fade as York declares that Henry's grandfather attained the crown, not by conquest, but by rebellion against his king and unlawful usurpation of his office. To this, Henry turns aside to the audience and whispers his defeat. To secure peace, Henry is forced to offer the throne to York upon his death, but this so-called reconciliation of the houses of Lancaster and York plunges England back into a state of war. Thus, the distinction of Lucifer's fall from glory

is imparted to York's ascent to the throne in Westminster Hall. By this, we may understand the fall of the House of York as germinating in an act of hubris, the usurpation of a throne by one, like Lucifer, who feels himself more entitled to it. The correspondence demands that, as York ascends the throne, his fall, and that of his offspring, is determined and imminent in a dramatic mimesis of time in a world that is providentially ordered. But as York will fall, so will Henry in a seemingly retributive act by time and providential justice for the 1399 deposition of Richard II.

Therefore, the true end of England's civil dissension may be found at the end of *Richard III* with Henry Tudor's victory and his subsequent marriage, decisively uniting Lancaster with York. As Shakespeare would have it, and Hall before him, the deposition of Richard II in 1399 and Tudor accession to the crown in 1485 stand as the particular junctures around which the procession of English history may be understood, in what has often been termed England's "salvation" history. However, far from limiting Shakespeare's history plays to simple Tudor propaganda, a larger concept of history and its meaning may be found in a reading that accepts a fall-and-redemption pattern to the long course of historical events depicted and the figural patterning of the *Corpus Christi* plays. Where one event finds its fulfillment or completion in a later event, a dialogue between those two events and between those two episodes in space and time is formed, effecting a dramatic and meaningful abridgment of time itself and blurring the boundaries between past, present, and future. So applied, narrative history, like that of the *Corpus Christi* plays, is made subtly yet richly didactic, broadening its aim beyond the practical application of historical lesson to encompass the meaning of history and time itself. Thus, only such a reading imparts significance to Shakespeare's immediate audience (which must grapple with the import of these events to future time) and grants to Shakespeare a purpose in writing the history plays beyond the mere employment of historical material for dramatic purposes.

Given the heady days of the 1590s, when it may have seemed as though England was invulnerable, Shakespeare's history plays may be understood as a warning. But even as these plays point back to the past, they also point forward to present and future time, offering both a terrifying glimpse of what could occur again and hope for a different shaping of time. Shakespeare achieves a certain middle ground between the Medieval notion of the present as a time for amendment and preparation in order to avoid certain doom, as informs the *Corpus Christi* plays, and the more Renaissance idea of time as a place where man, however mortal, might make his indelible mark upon the universe.⁸ For as certainly as Shakespeare's history plays warn of the imminent doom that will befall England should factious unrest again splinter peace, and advise the attention and diligent response of the Medieval drama, they announce the glory and power that is England's when civil strife is laid to rest. In this way,

Shakespeare offers to his audience a dramatic device for visualizing and monitoring the shape of time to come.

Notes

¹ E. M. W. Tillyard, *Shakespeare's History Plays* (London: Chatto & Windus, 1948) 149.

² Irving Ribner, *The English History Play in the Age of Shakespeare* (Princeton, NJ: Princeton University Press, 1957) 160.

³ Robert Ornstein, *A Kingdom for a Stage* (Cambridge: Harvard University Press, 1972) 31.

⁴ V. A. Kolve, *The Play Called Corpus Christi* (Stanford, CA: Stanford University Press, 1966) 58.

⁵ Richard Hosley, ed., *Shakespeare's Holinshed: An Addition of Holinshed's Chronicles*, by Raphael Holinshed (New York: G. P. Putnam & Sons, 1968) 85.

⁶ Harry Levin, introduction, *The Riverside Shakespeare*, 2nd ed. (Boston: Houghton Mifflin Company, 1997) 19.

⁷ John D. Cox, "3 Henry VI: Dramatic Convention and the Shakespearean History Play," *Comparative Drama* 12 (1978-1979): 50-51.

⁸ Georges Poulet, *Studies in Human Time*, trans. Elliott Coleman (Baltimore: Johns Hopkins Press, 1956) 10.

Faculty comments

Ms. Walker's mentor, Joseph Candido regards her as a "seasoned scholar." He says:

I am delighted to be able to give Susan Walker's scholarly submission to *Inquiry* my highest and most enthusiastic endorsement. Last semester I had the pleasure of watching Susan's project take shape in my senior seminar on Shakespeare's history plays as it grew from the germ of an idea into a mature, sophisticated, and original statement about Shakespeare's indebtedness to the medieval cycle drama. I believe that her work is now worthy of publication in a professional journal. Unlike all the other students in the class who were thoroughly challenged (and sometimes overmatched) by the sheer difficulties of Shakespeare's language, Susan quickly moved past that hurdle to probe beneath the surface of the history plays in a way that led her to consider how these plays might have taken shape in Shakespeare's imagination. She spent a month last summer studying drama in England, and during that time took a trip to York on her own initiative to see some performances of the medieval cycle drama (plays on biblical events) first hand. In my class she soon became fascinated by how closely the staging of some key scenes in Shakespeare's *Henry VI* resembled the sort of staging practices of these older medieval plays, and began wondering if the same cyclical and typological ideas of time and eternity propounded in the cycle plays could in any way be seen as informing Shakespeare's more linear notion of time in the histories. And if it were so that the cycle plays influenced Shakespeare (as she convinced all of us it was,) just what would be the political, moral, and eschatological implications of such a connection for



Susan Walker

our understanding of Shakespeare's notion of historical time? What sorts of ironies, particularly as regards the singularity of human achievement, would arise as a result of seeing a later event as shadowed (often ominously) by an earlier one, and, even more importantly, what *sense* of history does Shakespeare impart, say, to the accomplishments of Henry V by forcing us to see these "heroic deeds" as shadowed by failures in plays *written earlier* but plays that actually deal with *later* historical events? As you can see, this is no territory for a timid or derivative intellect, but Susan entered it with glee and soon mastered it as well as any student, undergraduate or graduate, I've had here at Arkansas in my more than twenty years of teaching. Her conclusions are, quite simply, stunningly original. They force us to reconsider the whole temporal framework of Shakespeare's two great tetralogies of history plays—a question that has dogged critics of these plays from the eighteenth-century onward. In short, Susan has entered a long-standing scholarly argument, and entered it with distinction. I should add that her writing is clear, forceful, and evidential. It gives the impression of the work of a seasoned scholar rather than that of a bright undergraduate. I recommend it for publication in *Inquiry* with great enthusiasm and without reservation. Indeed, I would do the same if I were reviewing it for a top-drawer journal in Shakespeare or Renaissance drama.

English professor, William A. Quinn, describes Ms. Walker as one of the best students he has taught. He comments:

It has been my privilege to have Susan Walker participate in three of my classes: Introduction to World Literature, Part 1; Survey of British Literature, Part 1; and an upper-level /graduate class on Chaucer. In all three classes, Susan was by far the best student. Indeed, I consider Susan Walker to be one of the very best and most promising undergraduates that I have taught in my more than twenty years at the University of Arkansas.

Although I consider these percentiles highly subjective and speculative on my part, I would rank Susan among the top 5% of English majors in terms of her critical acumen and writing skills. I would likewise rank her in the top 1% in terms of her scholarly self-discipline and enthusiastic commitment to mastering the subject. Immediately after reading Susan Walker's first exam, I recruited her to apply for our departmental honors program. She was just as immediately accepted and (I know from the frequent compliments of my colleagues) has flourished as one of our most promising Honors candidates.

Susan is extraordinarily self-disciplined. She has somehow managed in the last two years to excel as both a non-academic employee and a returning student. She actually submitted two "A+" essays for me well before their due dates. I sometimes worry that there's no time for fun or even a good nap in Susan's busy life. But then she assures me of the sheer joy she is having in returning to the university. In conclusion, my overall impression of Susan Walker is that she is a profoundly good as well as an extraordinarily intelligent person—a giver and a caretaker, modest and generous. Everything about Susan Walker suggests that she will be an extremely splendid teacher in the not too distant future.

**SECTION II: SOCIAL SCIENCES
ANTHROPOLOGY, EUROPEAN STUDIES
AND POLITICAL SCIENCE**

ARCHAEOLOGY AND THE PUBLIC: EXPLORING POPULAR MISCONCEPTIONS

by Tamara Rakestraw and Amy Reynolds
Department of Anthropology
Fulbright College of Arts and Sciences

Faculty Mentor: Marcia-Anne Dobres
Department of Anthropology

Abstract

To understand how the public views archaeology and uncover the sources of their perceptions, this paper summarizes the interviews of 58 Fayetteville area high school and college students from the Fall (2000). Using standard ethnographic techniques, including prepared questionnaires and open-ended conversation, we identified several trends in the public's perceptions of archaeology and have developed some hypotheses to account for them. As the Society for American Archaeology has only recently begun to understand, to better educate the general public about archaeology it is important to identify and understand the sources of these misconceptions.

For more than a century, Hollywood, book publishers, advertisers and the American public have been fascinated with archaeology. More recently, archaeology has come to cable television with the introduction of the highly successful "The Discovery Channel" and "The History Channel." In this paper, we focus specifically on issues pertaining to the connection the public creates between archaeologists and dinosaurs, gender biases about archaeology, and public views on the looting of archaeological sites. This paper concludes with reasons why this sort of study is essential to the field of archaeology.

Introduction

The public's misconceptions about archaeology have recently gained the attention of the Society for American Archaeology (SAA). Last February they published a survey entitled "Exploring Perceptions and Attitudes about Archaeology," the first ever research focused on determining the public's general knowledge about archaeology.¹ Unaware of this publication, in the Fall 2000, we conducted our own survey to determine what ideas people had about archaeology. In contrast to the SAA report, our research was specifically aimed at determining what *media* have influenced public perceptions. We specifically focused on the ways popular fiction, movies, and television impacted these views. Understanding the influences

shaping the public's perception of what archaeologists do is absolutely critical to successfully correcting (or at least counteracting) these misconceptions, in order to preserve and protect cultural heritage.

Background

The recent proliferation of television channels that focus on archaeology, such as "The Discovery Channel," "The History Channel," and "The Learning Channel," helps illustrate that archaeology is remarkably marketable and highly profitable for Hollywood. Despite commercial appeal, these television shows often blur the distinction between legitimate archaeology and pseudo-archaeology. These channels frequently show programs that deal with archaeology, mostly hyping the exotic, the unknown, or ancient treasures. For example, "The Discovery Channel" recently aired a show about "the last" Neandertals, which used archaeological information to reconstruct what Neandertal life would have been like in Western Europe (ca. 30,000 years ago). And in 1999, Fox aired the popular "Opening of the Lost Tombs: Live from Egypt" followed by a sequel the following year. PBS also produces shows dealing with archaeology: its "NOVA" series will often focus on archaeological finds. Since the days of silent films, Hollywood movies have also dealt with archaeological topics and they have typically done extremely well at the box office. Examples range from "The Mummy" (both the 1932 and the 1999 versions) to the wildly popular Indiana Jones trilogy, which was the single most well known archaeological movie mentioned by our respondents. The first Indiana Jones movie, "Raiders of the Lost Ark," was ranked 64 on the American Film Institute's list of the best movies of the century.²

Archaeology has proved to be a lucrative topic for novels as well. Numerous fictional books and entire series have employed archaeological themes. Of the best known, Agatha Christie set many of her murder mysteries in the Valley of the Kings; Michael Crichton has written numerous books dealing with archaeology ("Sphere" and "Congo" both have

after we were prodded to define looting for them, ten percent still had difficulty distinguishing between legitimate and legal excavations and clandestine looting. This confusion seems to come from not understanding what looting is, and not understanding the importance of preserving archaeological sites and artifacts *in situ*. While fifty-two percent of our informants knew that it was appropriate to turn over archaeological artifacts they may find to the proper authorities, they did not seem to know who the "proper authorities" were. Sadly, the remaining 48% either did not know what to do with artifacts they might find, or thought that they should (or could) keep or sell them at their own

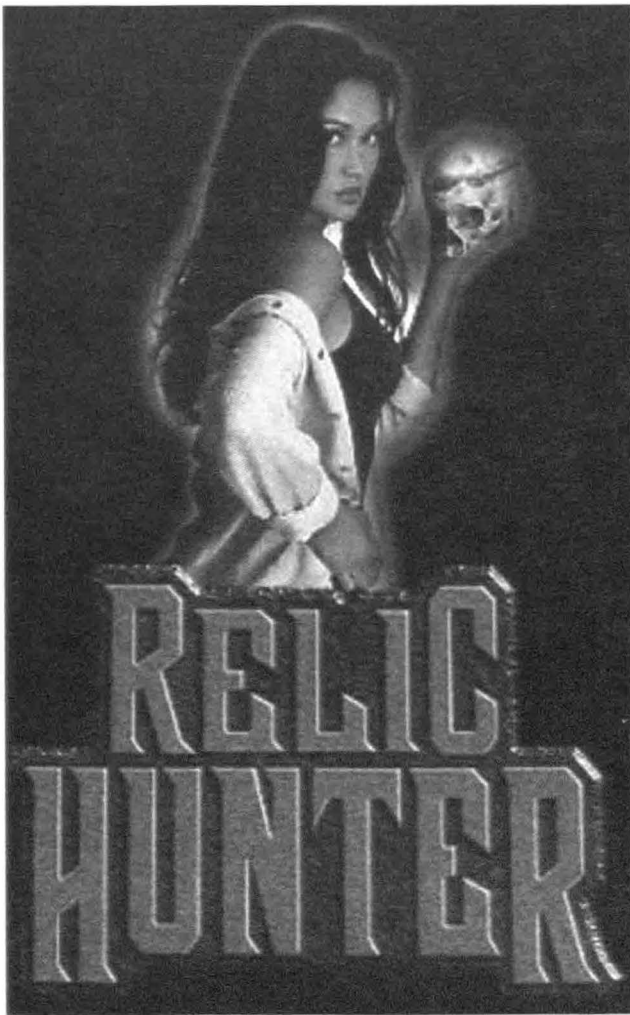


Figure 3. Sydney Fox, the woman archaeologist from "Relic Hunter".

discretion. When we pursued this question by asking if they knew of any laws pertaining to archaeological sites and what they should do if they happened upon artifacts, most said there were "some laws" but did not know any specifics (Figure 6). As well, many self-identified land owners expressed the fear that if their land is known to contain an archaeological site, it will be taken from them.

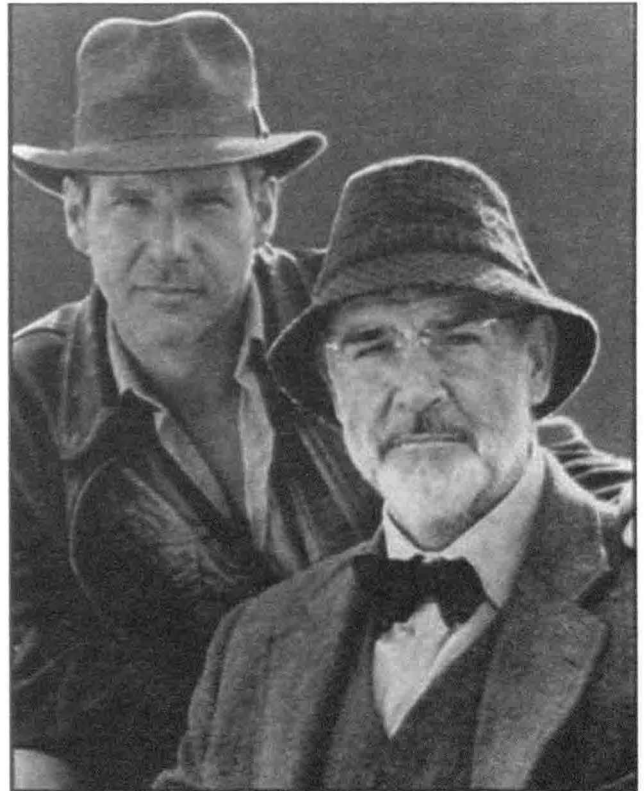


Figure 4. Indiana Jones and his father, the quintessential archaeologists--hairy chested and hairy chinned.

If the Society for American Archaeology and other professional research and educational communities are to have an effective impact on public knowledge of laws designed to protect cultural heritage, this confusion over what looting is, and redressing people's ignorance of their legal responsibilities, are of paramount importance.

Conclusion

This report has brought to light three misconceptions about archaeology: the connection between dinosaurs and archaeology, the gender bias in thinking that the ideal archaeologist is a man, and the confusion about looting and laws that protect cultural heritage. Although surprising and disturbing, our respondents' answers only reflect ideas that are projected by film, television, and fictional media. It is necessary for the public to understand what archaeology really is because:

- the majority of archaeological funding in the United States comes from taxpayer dollars,
- the looting of sites will diminish with further education, and
- the cultural heritage of past civilizations will remain intact and respected.

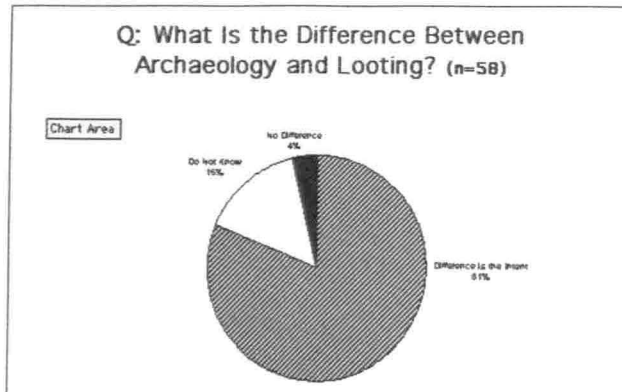


Figure 5. Question: What is the difference between archaeology and looting?

What Should You Do if You Find an Artifact or Archaeological Site? (n=58)

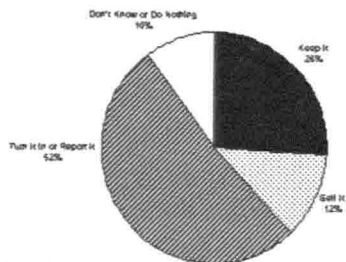


Figure 6. Question: what would you do if you found an archaeological site on your property or found artifacts lying around?

Studies such as this, which identify some of the causes for and sources of the public's misconceptions of archaeology, can provide archaeologists with the awareness necessary to correct or counteract these misconceptions through public outreach and education.

Endnotes:

1 The Harris Survey. "Exploring Public Perceptions and Attitudes about Archaeology." *Society for American Archaeology*: Washington, D.C. 2000.

2 "AFI's 100 Years, 100 Movies." *American Film Institute*. 27 April 2001. <<http://www.afionline.org/100movies/>>.

3 Dixon, Susan L. Archaeologists Do What? Students' Initial Conceptions of Archaeology. Paper presented at the annual meetings of the American Anthropological Association, San Francisco 2000.

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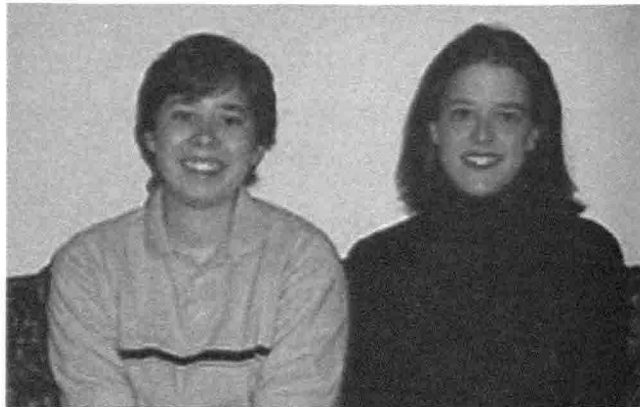
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Tamara Rakeshaw and Amy Reynolds

Faculty comments

Professor Dobres describes the value of her mentees' work as follows:

Tamara Rakestraw and Amy Reynolds describe here the results of a truly significant and original piece of research conducted in the fall of 2000. Their study begins to document (rather than merely assume) how and from where the general public gets its ideas about archaeology. Archaeologists and Hollywood alike have long known that the public is simply fascinated by things very old, by the exotic, the mysterious, and of course by lost treasures and gold-filled tombs. But professional archaeologists have also long lamented that the public is not only woefully ignorant about what archaeologists actually do; they have also recognized that it is these misunderstandings that lead to a cavalier disregard for the preservation of

archaeological sites and the artifacts people may "happen upon." Unfortunately, while archaeologists have long complained about public ignorance of their work, they have never determined the inspiration for these misconceptions, though this is clearly necessary if they are to successfully counteract the most problematic of these notions. Why this should be a matter of serious scholarly concern is two-fold: (1) because tax dollars go to support more than 93% of all archaeology conducted in the US. But more important, (2) where there is ignorance, sites continue to get looted, burials are treated in a shameless and disrespectful way, scientific data is compromised, and cultural heritage is lost forever. Rakestraw and Reynolds provide us an important piece of rigorous scholarship that begins to unravel this puzzle in a manner that makes it worthy of publication in a professional archaeological journal.

The seemingly light-hearted nature of this topic, archaeology and pop culture, should not lead the reader to underestimate its importance. This is an original and impressive study that combines carefully planned and executed field research (ethnographic interviews and a sociological survey) with thoughtful data collection and both statistical and qualitative data analysis. It is no overstatement to say that this work can serve as an exemplar for future studies (which professional archaeologists are only now beginning to undertake in fits and starts).

Tamara and Amy are without question two of the most remarkably self-directed, enthusiastic, engaged, mature, and bright students I've worked with while teaching at the Universities of California-Berkeley, Virginia, and South Carolina. This project began as a mere 30% requirement for a 4000-level course I recently created for the Department of Anthropology, entitled "Archaeology Goes to the Movies." But because Tamara and Amy intuitively understood that the topic was both significant and fun, they pursued it with a degree of enthusiasm, labor, and time investment that I have never seen before. The research was significant in itself, but their results were simply spectacular -- simultaneously sobering, informative, and presented in a remarkably thoughtful and organized manner. Indeed, their in-class presentation simply "wowed" the entire class--most of whom were also Honors and graduate students!

What has especially impressed me about Tamara and Amy is how well they have collaborated on this project--an important skill too few of our students are taught to appreciate. And over the past several months, it's been a joy to watch Tamara's and Amy's personal and scholarly growth. This spring, they gave an extremely professional public presentation of this research to the Anthropology faculty and to the faculty and research staff of the Arkansas Archaeological Survey. While they negotiated some really tough

questions with clarity and insight, they also provided these working archaeologists important information that will prove useful to fulfilling their professional mandate to undertake public education that helps protect and preserve the archaeological heritage of Arkansas.

Anthropology Chairperson Mary Jo Schneider seconds the comments made by Professor Dobres. She says:

What sorts of images does the word "archeology" conjure up? Romantic images of idyllic hunter-gatherers? Fierce Neanderthals who live in caves? Arrow head collectors? Dinosaurs? Although many popular Hollywood movies, television shows, and public broadcasting specials have featured archeologists, does the general public have a realistic image of what archeology is all about?

This is the question posed by undergraduate anthropology majors Tamara Rakestraw and Amy Reynolds. Rakestraw and Reynolds, working under the supervision of Dr. Marcia-Anne Dobres, Visiting Assistant Professor of Anthropology, surveyed a sample of fifty-eight students from the University of Arkansas and Fayetteville High School to learn just what archeology means to young people.

Rakestraw and Reynold's survey results indicate that archeology is not well understood. Nearly one-third of those interviewed believed that the dinosaur-filled movie, "Jurassic Park," was a film about archeology. The authors concluded that in the mind of the public, any professional who "digs" is an archeologist--no matter what is being excavated.

Archeologists are perceived as almost exclusively male, even though in reality, the field of archeology is almost evenly divided between men and women. And, perhaps most disturbing, Rakestraw and Reynold's sample failed to differentiate "looting" from "legitimate archeology."

In this paper, Rakestraw and Reynolds have made a substantial contribution by pointing out the nature of the misconceptions that the general public has about the field of archeology. This is a fine piece of scholarship with important academic and applied implications.

MEDICINE AND HEALTH CARE IN LATER MEDIEVAL EUROPE: HOSPITALS, PUBLIC HEALTH, AND MINORITY MEDICAL PRACTITIONERS IN ENGLISH AND GERMAN CITIES, 1250-1450

by Anna Terry
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Faculty Mentor: Mark Cory
Department of Foreign Languages and Director of European Studies

Abstract

Hospitals and individual caregivers helped meet the physical and psychological needs of medieval people, just as they do today. My overall objective is to explain social and individual responses to disease within the context of Christian theology and the urban community, focusing on England and Germany in the period between 1250 and 1450.

First I investigate social responses to disease, including hospitals and public health ordinances. Christianity mandated the care of the afflicted, yet physical and mental illness was associated with sin and divine punishment. Urban authorities often attempted to deal with plague outbreaks by imposing quarantines and strict regulations on minorities and outsiders. In addition to these more immediate concerns, the experience of plague permeated every aspect of medieval European culture, from the philosophy of health care to artistic representation.

Next I discuss individual encounters with disease, focusing on the ambivalent positions that female and Jewish physicians occupied within the medical profession. Women were perceived as nurturers with natural healing abilities. In spite of restrictions on formal university education, many women trained privately under male physicians. Jewish physicians exerted a considerable influence on the medical profession, even though religious and racial discourse pervaded popular perceptions of their work in the medieval urban community. Yet municipal authorities occasionally engaged the services of Jewish physicians, and Jewish doctors often treated Christian patients. The roles of minority medical practitioners illustrate tolerance as well as prejudice, one aspect of the ambiguity that characterizes medieval views of health care and disease.

Introduction

Health and disease have always been of paramount importance to people, and the goal of medicine remains constant in every place and time: to ease human suffering. Thus the

history of medicine holds lessons not only for the social historian but also for the practicing physician and the public health policymaker as students of human nature and condition. This interdisciplinary study, written from the standpoint of an aspiring physician, seeks to contribute to the humanistic dimension of medicine by helping to integrate it further with its past, illuminating the meaning of health and disease in medieval society while adding depth to current thinking about medicine and public health. This study places various aspects of health and disease within the framework of two major topics, religious beliefs and urban social history. Nowhere do these important aspects of medieval society appear more intertwined than in ideas about health and disease. I have restricted the focus of my research to English and German towns in the time period between 1250 and 1450, grounding these issues in a Western European context.

Hospitals and Public Charity

The first chapter of this study investigates the normal spectrum of disease in urban communities, and the attempts to come to terms with these problems through the endowment of charitable institutions such as hospitals, originally conceived as institutions devoted to the aid of the "sick poor." From the beginning, Christianity mandated the care of the afflicted, and hospitals fulfilled part of this responsibility. Yet Christians also associated physical and mental illness with sin and punishment, and fear of bodily and spiritual contagion tempered the Christian ethic of aiding the poor and sick. In England, the monastic model was especially important to the foundation of hospitals. Because of these ecclesiastical underpinnings, England provides an ideal base for tracing the various legal and moral justifications behind the medieval European hospital. During the course of the Middle Ages, the dispensation of charity in both England and Germany became more of a civic and humanistic goal, in contrast to a Christian communal goal. Hospital charity became more individualized and more fragmented as private citizens gave their resources not to the general poor, but to those they thought were "deserving," or preferentially to specific groups.

Epidemics

The second chapter deals with the extraordinary pressures of epidemics on urban society. Deadly plagues caused dislocation, social upheaval, and sheer human misery. Above all, the Black Death, which began in 1348 and never completely left the European continent until the late 17th century, produced unique cultural and social responses. Overcrowding, poor sanitation, and malnutrition made city dwellers especially vulnerable to plague. The experience of plague resulted in an ever-greater concern with public health in urban areas. In the larger towns of southern and transalpine Germany, for example, there are numerous examples of prohibitions against disposing of waste in the city water supply and selling spoiled fish or meat. Some of these policies metamorphosed into effective public health legislation, and others contributed to negative social attitudes such as anti-Semitism and class envy. Negative and bizarre responses to the Black Death are well documented; the persecution of Jewish communities in the Rhineland provides a grisly example. But the horrors of plague also became a rich outlet for artistic and literary expression, from Boccaccio's *Decameron* to Grünewald's *Isenheim Altarpiece*. In retrospect, the Black Death deeply marked European consciousness for several hundred years, perhaps in much the same way as the Second World War and the Holocaust will mark both European and Jewish identities for centuries to come.

Female and Jewish Medical Practitioners

The final two chapters illustrate examples of individual responses to disease, focusing on the fascinating and ambivalent positions that female and Jewish physicians occupied within the medical profession and the urban social structure. Women were perceived as nurturers with natural healing abilities. Both literary references and archival records of female healers are predominantly positive, even though universities and many medical guilds excluded them in their attempts to gain a professional monopoly. In spite of such restrictions, many female healers learned their trade under male physicians, who were often members of their families. Jewish physicians exerted a considerable influence on the Western medical profession, even though religious and racial discourse pervaded popular perceptions of their work in the medieval urban community. Yet municipal and clerical authorities occasionally engaged the services of Jewish physicians, and Jewish doctors often treated Christian patients. Interestingly, many Jewish healers were also women. The roles of female and Jewish medical practitioners illustrate tolerance as well as prejudice, just one aspect of the ambiguity that characterizes medieval views of health care and disease.

Conclusions

In spite of elaborate attempts to explain plague in naturalistic or theological terms, the illness forever diminished confidence in Western medical tradition, as characterized by the Galenic

theory. Dissatisfaction with the capabilities of medicine helped drive curiosity about the mode of infection, building on the existing rudimentary contagion theory. Intellectual curiosity in many ways threatened the medical establishment, which depended on the synthesis of older ideas rather than the discovery of new ones. Naturalistic explanations, originally motivated by belief in an all-powerful God, led to a more direct concern with the human body and its function. These developments paved the way for the modern scientific and empirical approach to medicine.

Such change was not necessarily progress. In fact, some things about it were very negative. Unfortunately, the institutionalization of public health on the municipal level often went hand in hand with the more negative aspects of social hygiene. Public health developments often degenerated into unfair and restrictive legislation against the unsightly, disease-ridden poor and the Jews, the scapegoats of European society. Even Christian charity in some ways became a reflection of increasing antagonism toward the poor, and a need to control them by means of institutions like hospitals. The original motivations behind public welfare and public health, Christian piety and communal responsibility, sometimes degenerated into hostility toward the very members of society they were supposed to protect. Fear of contamination intertwined with a pious sense of duty affords some of the deepest contradictions in medieval urban society.

During the time period considered, the medical profession in England and Germany progressed from an informal system with only a handful of university-trained practitioners to a profession licensed and regulated by the Church, civic authorities, and independent guilds. The new self-consciousness of the medical profession inevitably led to protectionist tendencies, resulting in attempts to exclude traditional and informal healers. As early as the 12th century, a Salernitan regimen, *Flos medicinae*, had proclaimed: "The unlettered, the empiric, the Jews, the monk, the actor, the barber, the old woman—each pretends to be a doctor, as does the alchemist, the maker of cosmetics, the bathkeeper, the forger, the oculist. While they seek profit, the power of medicine suffers."¹ The gradual process of excluding these unwanted practitioners from the "respectable" profession of medicine took several centuries, but it was one step in the creation of a common licensing system for physicians, a system that we take for granted today. Such a formal system is exclusionary by nature. But ironically, the very system that shut out women and Jewish doctors in the Middle Ages ultimately metamorphosed into something like a meritocracy, accepting the qualified regardless of gender, race, or creed. The development of a uniform education and licensing system for physicians in the Middle Ages helped produce the elevated expectations of medicine that characterize contemporary Western societies.

The informality and deregulation of most health care attests to the great variety of needs and expectations in medieval society. Subject to licensing, regulation, and standardization,

medical practice ultimately became more responsible, and malpractice prosecutions had become commonplace as early as the 14th century.² Between 1250 and 1450, European medical services shifted from the sphere of Christian charity to the domain of the marketplace. On one hand, the medical establishment sought an exclusionary formalization of education and licensing. On the other hand, many potential patients resisted the systematization of their health care options, seeking treatment based on a wide variety of factors—skill and success level, fees, and local availability. If the cure seemed worse than the disease, people did not flinch from finding a theologically questionable doctor, if this offered them some hope of a cure less invasive and painful than those offered by Christian lay physicians and more certain than those promised by the saints.

Medieval charitable institutions, the beginnings of public health, and the contributions of minority medical practitioners came together to shape early modern attitudes toward compassionate care. The gradual shifting of public charity and social responsibility from the Church first to private citizens and then to governments has enabled secular societies to retain a strong ethic of caring for the sick and helpless. The benefaction of hospitals and the existence of charitable organizations are dependent on this ethic, and not exclusively on religion. Ultimately, medieval Christianity helped provide valid foundations for the exercise of charity in a philanthropic context, rather than a dogmatic one. As medieval Christians knew without a doubt, bodily and spiritual welfare are closely intertwined; the best caregivers are those who can provide spiritual strength and comfort in addition to alleviating physical ills. In this study, I have described various attempts to achieve the enduring values of life and health within the framework of medieval society. Such endeavors, both social and individual, delineate the philosophy of ethical caregiving, which is the proper goal of medicine in all times and places.

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¹Quoted in Park, p.76

²Shatzmiller, p.80

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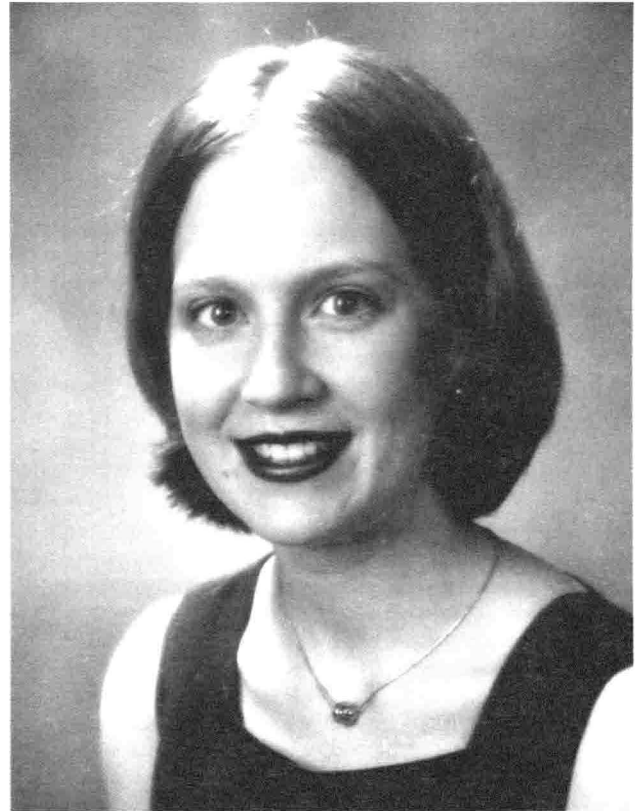
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Anna Terry

Faculty comments

Mark Cory, Professor of German and director of European Studies, functioned as Ms. Terry's faculty mentor for this project. He had high praise for Ms. Terry's work. In his letter of recommendation, he said:

As became clear from her selection this year as a Rhodes Scholar, Anna is an intellectually ambitious, superbly accomplished student. With her years of musical training and her orchestral experience here and abroad, Anna could become a professional musician. With her twin majors in German and European Studies, she could pursue graduate study in either of those fields. For the four and a half years I have known her, however, she has held firmly to her goal of becoming a physician. The article selected last year for the premier issue of *Inquiry* reflects her accomplishments in the BS program in biochemistry central to her pre-med preparation. I have no doubt that she will reach this goal, although she will spend the next two years reading for the M.Phil. in Economic and Social History under the auspices of Oxford's Wellcome Unit for the History of Medicine.

The study abstracted here is preliminary to her course of study at Oxford. Intrigued by public health issues

and by the way late medieval Europe responded to the challenges of ever greater urbanization, she has chosen for her senior honors thesis a consideration of the way early modern attitudes toward compassionate care were shaped by the Church in general, and by the contributions of minority practitioners (women and Jews) in particular. She has both the scientific and humanistic training for an interdisciplinary project of this sort. Her year of study and travel abroad in Europe has given her first-hand experience with the palpable legacy of medieval societies. She can read German source materials in the original. Her record gives every confidence that the product of her undergraduate research will be solid, literate and persuasive. Measured against the enormous pressures exerted in virtually every curriculum towards fragmentation and specialization even at the undergraduate level, the attainment of a genuinely well-rounded education at the highest levels of performance is nothing short of an outstanding intellectual endeavor. Most students at her point in their studies are driven to begin medical school immediately, perhaps because they have set their sights on beginning their careers. Anna's focus is on the quality of her journey, rather than on the punctual arrival at a given destination. The study she proposes

will add great value to her journey, and ultimately to the kind of contribution she makes as a physician. She understands, accepts and acts on the oft-cited wisdom that our best physicians must be more than superb technicians, but rather they must be mature and complex individuals with interests and experiences as varied and filled with highs and lows as those of their patients. I predict that a future biographer will one day reflect on the notable career of Anna Terry, Surgeon General of the United States, and observe that the intellectual reach of her two submissions to *Inquiry* marked the real beginning of a remarkable career.

Lynda Coon, historian and Director of the Humanities Program, had Ms. Terry in several classes. She is equally enthusiastic about Ms. Terry's abilities. In her letter, she commented as follows:

In 1996, Ms. Terry won a prestigious four-year grant (Sturgis Fellowship, Fulbright College, University of Arkansas) for which students compete throughout the South, Midwest, and West. I met Ms. Terry when she was a first-year student in a team-taught, Honors Humanities Project (Fall 1996-Spring 1997). This National Endowment for the Humanities-supported course is a four-semester sequence integrating core courses in world history, world literature, and the visual arts, and only four-year honors scholars with superior ACT scores (above 31) enroll in this interdisciplinary program. The teaching teams for the first and second years agreed that Ms. Terry was the top student in the course—an amazing fact considering that students in this course won all the major University-wide academic awards at the 1999 Honors Banquet. In the Honors Humanities Project, Ms. Terry wrote a number of papers for me, but the one that sticks out in my mind (even though it was completed over three years ago) was her brilliant analysis of the Gothic church of Ste.-Chapelle and its inventive visual re-creation of the most pressing theological (sacred kingship) and militaristic (the Crusades) issues of the period.

More recently (Fall 1999), Ms. Terry enrolled in my upper-level course on late medieval Europe. Again, she was by far the top student in the course (superior to the graduate students!). She never came to class unprepared, and her enthusiasm for the subject matter was so infectious that she often induced more reticent students to join in the dialogue. Her best paper in that particular course involved a detailed analysis of the c.1080 material culture source for the Norman invasion of England, the Bayeux Tapestry. Specifically, in her paper, she argued that Biblical exegesis informed much of the artistic work of the Tapestry. Furthermore, she examined how historical "memory" is continuously re-written by each successive generation, and, that in this case, even only twenty years after the conquest, politics and ideological concerns of the

post-conquest generation were ingeniously interwoven among the obvious "facts" of William I's victory over the Anglo-Saxons. This was a highly sophisticated work—much more the kind of meticulous exegesis I would expect from a graduate student. Furthermore, because Ms. Terry has traveled widely in Europe, she was the only student to have made the pilgrimage to Bayeux to see the Tapestry firsthand.

I find Ms. Terry's Honors Thesis research to be equally impressive. The topic of medical history in the medieval period currently is a hotly contested one, particularly regarding the intersection of magic, philosophy, theology, and medical practice. Furthermore, as Ms. Terry's research indicates, there are many provocative related issues to the academic pursuit of medieval medicine, including the relationship of gender and ethnicity to scientific knowledge (Ms. Terry intends to examine sources that deal with women and medicine as well as Judaism and the urban medical community in Southern German towns, c. 1400-1500 CE). Ms. Terry not only possesses the requisite oral and written skills to carry out a research project that requires a great deal of reading in the German language (she has passed the difficult *Deutsche Sprachprüfung für den Hochschulgang*), she has already proven that she can do top-level academic research at one of the most renowned places in the world for medieval studies, the Institute of Medieval History, Munich. Next year, as a Rhodes Scholar at Oxford's Welcome Unit, Ms. Terry will begin an M. Phil. in Economic and Social History with a sub-field in the Social History of Medicine. A degree from this prestigious program accommodates both Ms. Terry's Humanistic research interests and her career goal to become a practicing physician with a special interest in pain management theory.

WHEN A TREE FALLS IN FAYETTEVILLE DOES IT MAKE A SOUND: THE IMPACT OF ISSUE VOTING ON LOCAL NONPARTISAN ELECTIONS

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Abstract

This research provides an explanation of the impact that high-profile issues can have on local nonpartisan elections. The tree ordinance in Fayetteville sparked a controversy that ignited the community's interest in the race for Mayor. This controversy provides a unique opportunity to measure how issue voting effects elections that have limited information available. The research regarding behavior in local nonpartisan elections is incomplete, because of the challenges this subject provides for political scientist. It is difficult to gauge a voter's choice when the voter's process limited knowledge of the candidates and party affiliation is removed. Generally political scientist view issue voting as requiring a high level of voter sophistication, yet voting behavior at the local level is notable for its lack of sophistication. The purpose of my research is to show that when limited tangible information is available to voters they will base their votes on "easy-issues" such as the tree controversy. This research contributes to theories in the fields of voting behavior, voter sophistication, and issue voting.

Introduction

Issue voting is a topic of extensive research in political science. Some studies argue that issues have little or no impact on voters, citing instead the candidate or party identification. Others argue that the voter compares candidates and chooses the one who differs the least with their point of view. Even among scholars who acknowledge an impact of issues on voter behavior there is disagreement to what this impact implies about the voter's sophistication. The research has been unclear about the impact of issues on the electorate.

The Columbia University studies in the 1940's were some of the first to suggest that there is no relationship between issues and voter behavior. The researchers found that voters often decided which candidate they would vote for before campaigning began and before issues were discussed. This line of research

was supplemented by the authors of *The American Voter* (1956). They showed that on 16 different issues only 18 to 36 percent of the electorate showed sufficient knowledge of the issues. These studies suggest that voters base their decision on non-issue criteria, such as social group, party or candidate. (Niemi and Weisberg 1993)

The perception of issue voting began to change in 1957, when Anthony Downs created a voter behavior model that asserted a rational voter would calculate how much they differ with a candidate on the issues and then vote for the candidate that is closest to their own belief. This was followed by Key's *The Responsible Electorate*, which showed that when clear issue alternatives are present in an election issues could have an impact. Indeed in Nie, Verba, and Petrocik's (1976) *The Changing American Voter* they assert that the public had become more issue-oriented with the rise of the Civil Rights revolution and the Vietnam War. In summary, issues were important to a rational voter when there were clear alternatives available among salient issues.

Hard vs. Easy Issues and Voter Sophistication

After establishing a link between issues and voting, the controversy turned to the character of issue voting. "The common—indeed, universal—view has been that voting choices based on policy concerns are superior to decisions based on party loyalty or candidate image," observed Carmine and Stimson (1980, p. 78). Their complaint was that all issue voting was viewed as inherently good. In *The Two Faces of Issue Voting* they assert that there are two types of issues: hard issues and easy issues. Hard issues are the issues that are "the final result of a sophisticated decision calculus. (p.78)" Easy issues occur "when a particular issue becomes so ingrained over a long period that it structures voters' 'gut responses' to candidates and political parties." The explanation continues, "because gut responses require no conceptual sophistication they should be distributed reasonably evenly in the voting population." Carmine and Stimson continue by showing the difference comparing Desegregation (easy issue) and the Vietnam War (hard issue) and the impact

they had on the 1972 election. They find that people who's vote was determined by their view of desegregation showed no more sophistication than those who used party or candidate to decide, but that those who voted based on the war in Vietnam showed a higher level of sophistication. Carmine and Stimson assert that voters who vote on "easy issues" are not the traditional rational voters. Rather the traditional issue voter was the one who voted on "hard issues."

While there is extensive research on issue voting and the electorate, its focus remains predominately national. The impact of issues on local elections remains largely unexplored. The purpose of my research is to explore the possibility that issues can have an impact on local elections. The case I use is the 2000 election for the mayor of Fayetteville, Arkansas. This case provides a high profile issue in a local election, as well as the absence of partisan affiliations. The issue of the tree ordinance divided the community and caught the attention of the local media. Indeed the events that took place were very dramatic and unusual for this community.

The Tree Controversy

In 1992 Fred Hanna was elected the Mayor of Fayetteville in a close and controversial election. The day before the election an editorial article appeared in the primary local newspaper asking Hanna's leading challenger, Dan Coody, to come forward about the truth of his past. Using a former classmate of Coody, the article accused him of a shady past in Texas, where he dealt drugs and was convicted of a bank robbery. The accusations were false, but the damage was done as Coody lost by just 700 votes the next day. Later Coody won a libel lawsuit against the paper.

Over the next eight years Mayor Hanna governed the city through a time of rapid growth and development. In 1995 he adopted a city tree ordinance; hired a city tree and landscape administrator, and was awarded tree city USA status for the first time in Fayetteville's history. That same year he also oversaw a curbside recycling program that had a 70 percent participation rate in its first year. In 1997 the city was again awarded tree city USA status, as well as the EPA award for environmental excellence. The city again won the EPA award in 1998. Along with these environmental achievements Hanna also oversaw a drop in the crime rate and city taxes; as well as the addition of new schools, fire departments, and a public health and dental center for the poor. In 2000 he almost certainly anticipated he would run for reelection as a strong incumbent candidate.

The 1995 Tree Ordinance that Mayor Hanna had initiated called for the protection of old growth trees (trees larger than 24 inches in diameter) unless development would be otherwise impossible. It also called for a minimum of 15 percent of the canopy to be preserved during development. In an area known as Steele's crossing Argus properties had proposed a plan that

would destroy all but 10 percent of the old growth canopy of the property, putting in danger 51 rare old growth trees that were over a century old. The plan came before the city council on May 2, 1999. A large and vocal group of several hundred citizens were at the meeting, most to oppose the Argus development. The council put the issue to the vote, not allowing an open debate of the issue. The vote ending in a 4-4 tie with Mayor Hanna abstaining from the deciding vote which could have halted the Argus plan. The group became vocal, demanding to be given the right to speak about the issue. Mayor Hanna, along with the four councilmen who voted to allow development left the meeting, leaving behind the crowd and the four dissenting council members.

The reaction was immediate. The next morning at 6 A.M. Mary Lightheart climbed "the old oak tree," chaining herself to a branch. Several lawsuits were brought against the city by citizens, a council member, the Sierra Club, and the League of Women Voters. The events were on local television and the front page of the local papers. Rallies were planned, organizations formed and citizens mobilized. The battle cry became "Remember in November." In early May the November election for mayor already had a defining issue, the trees in Steele's crossing.

The lawsuits were not received well by the courts. One lawsuit filed by the Sierra club citing a federal law that protected a rare bird that lived in the trees was thrown out. Another filed by the Women's League of Voters was accepted on the contingent that they put down 300,000 dollars to compensate Argus if the lawsuit were not won. The League could not raise the money. Still Mary Lightheart sat chained in the trees. Mary Lightheart was a 53-year-old grandmother who, according to herself, had never questioned the law. Soon after she climbed the tree the police set up a blockade, arresting anyone who tried to bring Mary food, medicine, or supplies. In all 30 people were arrested. A rainstorm moved through the area, and Mary stayed in the trees through two weeks of steady rain. Eventually she came down because of a court order brought by her ex-husband. They were in the process of finalizing a divorce, and she was to be held in contempt of court if she failed to appear. She came down from the tree in the middle of the night, three weeks after first climbing up. She appeared at the court proceeding and when the judge ask her where she had been at previous proceedings, she responded, "In my new home." When he ask for an address she responded, "Argus Properties." The next night she was arrested as she made a dash back to "the grandmother tree." As police overtook her a few yards from the tree she fell to the ground, passively resisting arrest. A few days later the trees were cut down.

Still the issue lingered. Over 30 people were tried and sentenced for bringing Lightheart food and medicine. Before Lightheart's trial there was a rally on the Town Square. They had a piece of the "grandmother tree" labeling its rings by corresponding events such as Martin Luther King's assassination, World War I, and the turn of the last century. Julia "Butterfly" Hill, the famous treesitter who spent 18 months in a redwood in

California, gave a speech in front of more than 100 people on a Wednesday at around noon. At the rally were candidates for city council and Mayor, handing out bumper stickers and shaking hands. The election was four months away. The slogan "Remember in November" appeared on the bumper of vehicles, beside a picture of a fallen tree. These were the events that preceded the race for mayor of Fayetteville.

The Mayoral Election

There were six candidates for Mayor in the 2000 election. Mayor Hanna was the incumbent and he owned a local candle shop. Dan Coody was the leading challenger. He was a developer and had remained active in local politics since he lost the race in 1992. He had served as a councilman and been active in many committees in the community. The other contenders were Paula Marinoni, an activist for historical preservation in the community; and Cyrus Young, a sitting councilman who had lost his job with a developer for voting against the development of Steele's crossing in the May 2 vote. The other two candidates were Subroto Lahari, who was an art professor at the University of Arkansas and Mustin (first name only), who was a 19 years old and entered the race to "shake things up around here."

There were several Mayoral forums and debates hosted by the Chamber of Commerce, the League of Women Voters, the Green Party, and the Young Democrats at the University of Arkansas. The debates tended to be long because there were six candidates and the themes would be centered on environmental protection, economic development, water treatment, and the city infrastructure. During this time the other event that brought out the candidates was the cities Autumfest, a festival with rides, crafts, a parade, music and eclectic food. The four leading candidates had a booth at the festival, each offering stickers, pins, and flyers about them selves. Mayor Hanna handed out scented candled and sapling trees at his booth. The tree issue was obviously weighing on his mind. The Sierra club also had a booth at the festival where they officially endorsed Dan Coody for Mayor. Hanna still maintained a large base of support. He was supported by most of the local businesses as well as having the support of the largest local Baptist church of which he was an active member.

On Election Day Hanna publicly predicted he would win with 51 percent of the vote, and avoid a runoff. Coody also was hoping he could get the "50 percent plus just one vote," although he admitted it was unlikely. As the results came in it became obvious there would be a runoff. Coody won the first round with 8,595 votes, followed by Hanna with 7,677. The final percentage was 44% to 39%. The run-off was going to be on November 28. During the three weeks until the election Coody was attacked for being anti-business. The business community attempted to gather votes for Hanna, charging that Coody would ruin the local economy anti-business. Coody's strategy was to make sure that his supporters were aware of the run-off as well as to attempt to

attract the supporters of the other candidates. Both candidates increased spending on television advertisements, while the Coody campaign posted workers at polling stations with signs. On November 28 Coody defeated Mayor Hanna by a count of 7,194 to 4,855.

When the controversy started in May, it was impossible to tell how it would affect the outcome of the election in November. It was questionable if even a high profile issue such as the tree controversy could impact an election on a local level, and also if this issue could maintain momentum from May until November without the help of the national news media. This research is designed to measure the impact of the tree issue on the Fayetteville mayor's race.

Results

Exit surveys were given on Election Day to voters leaving the polling stations to evaluate the impact of the tree issue and the voter's level of sophistication (a complete survey form in the appendix). The author was able to survey 160 people in four different precincts. In the survey I asked for whom they voted, what issue most affected their vote, and specifically if the tree issue had an impact on their vote. I also asked about how often they used various sources for news. There was also a section that included questions to measure general political knowledge.

Of the voters surveyed, 60% indicated that the tree ordinance issue had an impact on their vote (Figure 1). Of those voters who felt the tree issue was important 75% voted for Dan Coody, while only 9.5% voted for Fred Hanna (Figure 2). Among voters who indicated that the tree issue did not impact their vote 46% voted for Mayor Hanna while 25.4% voted for Dan Coody (Figure 3). The voters were asked to choose which issue most affected their decision for mayor. The issues given were water treatment, economic development, environmental protection, city infrastructure, and other (left open-ended). The most given answer was environmental protection with 38%, followed by economic development with 24% and city infrastructure with 19% (Figure 4). Among the voters who were impacted by the tree issue and whom marked environmental protection as the issue that most affected their decision, 85% voted for Dan Coody, while only 15% voted for Fred Hanna (controlled for just Coody and Hanna). However among the voters who were impacted by the tree issue and who marked economic development 91% voted for Mayor Hanna, while only 9% voted for Dan Coody (controlled for Coody and Hanna).

Discussion

One of the main criticisms of issue voting studies is that there is no accurate way to delineate between party voting and issue voting. Critics claim that there is no accurate measure for the affect of partisan affiliation, since the two major political parties in the United States differ on most major issues. One of the

unique features of the Fayetteville election is that it is non-partisan. All six candidates were registered Democrats, and party was not listed on the ballot, so that the voter had no way of distinguishing party affiliation. This is just one of the factors that make the impact of the tree issue so clear. Sixty percent of voters surveyed indicated that the tree issue had an impact on their vote, with eventual winner Dan Coody garnering 75% of those votes. As with most issues, there were two sides. In this election I observed that voters perceived the tree issue as either favoring environmental protection or economic growth, with those emphasizing environmental protection favoring Coody (85%) and those emphasizing economic growth favoring Hanna (91%).

Further support of the impact of the tree issue is shown by the preferences and voting of those that did not indicate an impact. Among those voters, 43.1 % indicated that economic development had the most impact on their voting, followed by 25.9 % that indicated other, while environmental protection and city infrastructure had only 15.5 %. Fred Hanna won overwhelmingly with these voters, posting a 45% to 25% advantage over Dan Coody in the six-way race (Figure 5). These are the numbers more typical of an incumbent mayor. However, based on some of the comments received during the surveying it is possible that much of this group was impacted by the tree issue, but negatively so, and as a result marked "strongly disagree" or "disagree" on the question involving the tree issue. Many of those surveyed who disagreed that the tree issue had an impact on their vote made comments about the "crazy tree woman" referring to Mary Lightheart or referred to that "tree hugging group." In any case Mayor Hanna's strongest support was with those who indicated that they were most concerned with the economic development of the community. Dan Coody's supporters overwhelmingly indicated that they emphasized environmental protection and were mostly impacted by the tree controversy.

Conclusion

Literature concerning issue voting in local elections is rare. This study shows that issue voting can impact local non-partisan elections. In the case of the Fayetteville tree controversy the impact was deeply felt. The next step in this research is to explore the implications that issue voting has on voter sophistication. I also will analyze the voters surveyed to distinguish any correlation between voter sophistication and the tree issue. Also one hypothesis I will test is the possibility that a high profile issue can be used to replace party or ideological preferences in nonpartisan elections.

The contribution of this research is that it strengthens the case for the impact of issue voting. Some research indicates that issue voting occurs most frequently during periods of social turmoil when policy options are relatively distinct from each other, such as was the case in the U.S. during the turbulent 1960s

with civil rights and the Vietnam War (Nie 1976 p. 156-93). Although to a far lesser extent and much smaller in scale, Fayetteville experienced its own version of controversy and it had an impact in the Fayetteville mayoral election. The tree controversy covered the papers, headlined the news, invoked protest and rallies, and mobilized the citizenry. The unique aspects of this study are that it is done in a party vacuum, so that the impact can be shown independent of party bias; and that the study empirically shows an issue impacting a local election. The purpose of this research is to further study the impact of issues on non-partisan elections, as well as to broaden the field of local voting behavior.

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Author's Note

The information for the section about the tree controversy comes from local new papers and television stations, courthouse documents, candidate and news web sites, personal interviews, as well as an active observation of many of the events. The community has been extremely cooperative in helping with the gathering of information for this project (which is greatly appreciated), this includes the candidates, Mrs. Lightheart, observers and participants, court house staff, and the 160 voters who took time to fill out the survey. It does not include the poll workers who ran me off of the polling sites. Also I want to thank the University of Arkansas Political Science Department for all of the support they have given me. I especially want to thank Dr. Shreckhise for his guidance, support, and advice.

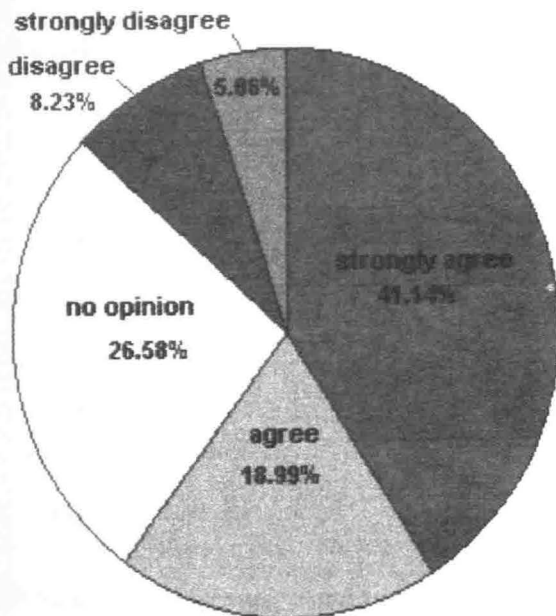


Figure 1: Responses to "The tree ordinance issue had an impact on my voting."

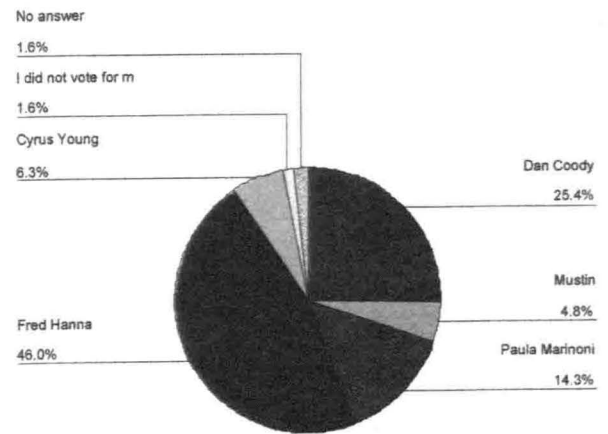


Figure 3: Choice for mayor among voters who indicated the tree issue had no effect on vote.

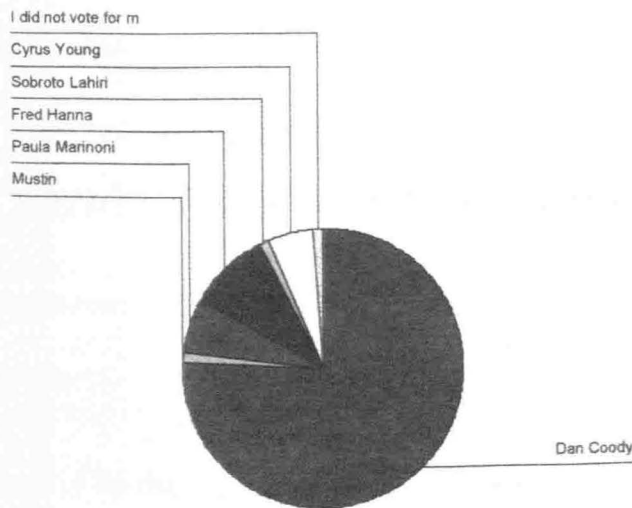


Figure 2: Choice for mayor among voters who were affected by the tree issue.

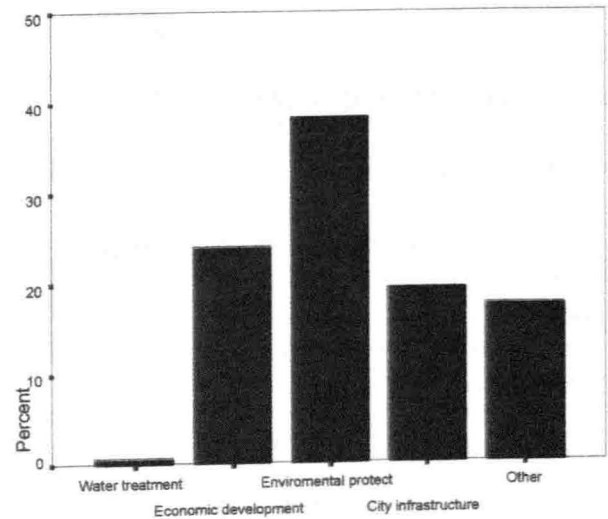


Figure 4: Impact of issue upon voting choice.

Appendix::

Please follow the directions for each question. Your answers will be kept confidential and please feel free to skip any question you do not wish to answer.

1. *Who did you vote for mayor of Fayetteville? (Circle one)*

- a. Dan Coody b. Mustin c. Paula Marinoni d. Fred Hanna e. Sobroto Lahiri
f. Cyrus Young g. I did not vote for mayor

2. *Which of these issues most affected your decision? (Circle one)*

- a. Water Treatment b. Economic development c. Environmental protection
d. City Infrastructure e. Other please specify: _____

3. *In the following questions please circle the response that best represents how you feel about the following statements.*

	Strongly <u>Agree</u>	Agree	Neutral or No Opinion	Disagree
	Strongly <u>Disagree</u>			
The tree ordinance issue had an impact on my voting	1		2 3 4	5
I pay close attention to national news	1	2 3	4	5
I pay close attention to local news	1	2 3	4	5

4. *How many times a week do you use the following for news? (circle one for each type of media)*

	Rarely	1-2 times per week	3-4 times per week	5-6 times per week	7 or more
times per week					
Internet	1	2 3	4 5		
Newspaper	1	2 3	4 5		
Magazines	1	2 3	4 5		
Local TV	1	2 3	4 5		
National TV	1	2 3	4 5		
Other Sources	1	2 3	4 5		

5. *How many times a week do you read the following papers?*

	Rarely	1-2 times per week	3-4 times per week	5-6 times per week	7 or more times per week
Northwest Arkansas Times	1	2 3	4 5		
The Arkansas Democrat Gazette	1	2 3	4 5		
The Morning News	1	2 3	4 5	5	
USA Today	1	2 3	4 5		
The New York Times	1	2 3	4 5		
Other	1	2 3	4 5		

There is a lot of talk these days about what the aims of this country should be for the next ten years. I have here a list of aims that some people feel the country should have for the next ten years. Would you please say which of these you, yourself, would consider the most important long term goals? (Circle one)

1. Maintaining order in the nation
2. Giving the people more say in important government decisions
3. Fighting rising prices
4. Protecting freedom of speech

Which of these would you rank second?:

1. Maintaining order in the nation
2. Giving the people more say in important government decisions
3. Fighting rising prices
4. Protecting freedom of speech

Last, one measure of the success of the news media is how good a job they are doing of informing the public of the government in Washington. The following questions are to determine the quality of the media.

1. Do you happen to know what political position is held by William Rehnquist?
2. Whose responsibility is it to determine if a law is constitutional or not: the President, the Congress or the Supreme Court?
3. How much of a majority is needed to override a presidential veto in the House of Representatives and the Senate?
4. Do you happen to know which party has the most members in the House of Representatives?
5. Would you say that one of the parties is more conservative than the other at the national level? If so which is more conservative?

Please indicate your political preferences:

Strong Republican ____ Republican ____ Independent ____ Strong Democrat ____ Democrat ____

Strong Conservative ____ Conservative ____ Middle of the Road ____ Strong Liberal ____ Liberal ____

Year of Birth: _____ Gender: MALE _____ FEMALE: _____

Using the categories listed below, please indicate your ethnic background.

- | | |
|-------------------------|---------------------------------------|
| ____ 1. NATIVE AMERICAN | ____ 4. HISPANIC ORIGIN |
| ____ 2. ASIATIC ORIGIN | ____ 5. AFRICAN AMERICAN/BLACK |
| ____ 3. CAUCASIAN/WHITE | ____ 6. OTHER (Please Specify): _____ |

Please circle your level of education:

- | | | |
|---------------------|-------------------------|---------------------------------|
| a. Some High School | b. High School Graduate | c. Some College or Trade School |
| d. College Graduate | e. Graduate Degree | |

Faculty comments:

William Schreckhise, Mr. Taylor's faculty mentor had the following comments about His research:

Jon is an exceptional student who is working hard on a unique and important piece of research. I could not have come up with a better topic to study than Jon - the impact of Fayetteville's "Tree Ordinance Controversy" on the November elections. Political scientists largely have ignored local elections as possible areas of study. The field's negligence is simply a product of the unfortunate fact that the bulk of the scholarly attention to the voting behavior of Americans has simply been directed at the national-level with a smidgen of state legislative and gubernatorial races studied here and there. Hence, Jon's thesis will help us to better understand the dynamics of the far more numerous local elections.

Perhaps even more important is the contribution Jon will make to the theory behind elections, in general. In national elections, political scientists have found that a person's political party identification (and NOT their ideological proximity to candidates on issues) is the primary driving force behind how they vote. The importance of the party identification "cue" on a ballot is such that even those who refuse to admit allegiance to one of the parties will, in fact, vote consistently for one party over the other over time. Since an individual's party identification is so important, the vast majority of voters ignore the issues in campaigns even though conventional wisdom might dictate otherwise.

Jon's thesis allows us to explore the possibility that issues may actually affect a local, non-partisan election. Because Fayetteville's mayoral candidates' stances on the *Tree Ordinance Controversy* reveal a clear ideological division, voters could use their positions on local issues as effective replacement cues when deciding for whom to vote. In short, Jon's thesis demonstrates that in this instance that proved to be the case.

I have been impressed by his diligence Jon has shown in the various stages of writing his honor's thesis, regularly coming to my office to seek advice, "touch base," or go over things he has already done. He has given every indication to me that he is very dedicated to sticking to our pre-planned timeline and producing a product on-time and of considerable quality. This is in spite of the fact that the means he is employing to complete the product are quite impressive; he has been utilizing literature that political science students normally do not read until graduate school. Additionally, he has conducted in-depth interviews with local community leaders, and conducted his own exit polling in the November election.

I think Jon's project is both topical, of considerable theoretical import, and is of extraordinary quality.

Janine Parry, one of Mr. Taylor's faculty advisors said of Mr. Taylor's work:

I am familiar with Mr. Taylor's intelligence and work ethic, as well as his knowledge of and interest in politics and political science, because he performed exceptionally in my Introduction to Political Science course two years ago. Since that time, it has been my pleasure to know him as a welcome and regular visitor to my office for advising, graduate school advice, literary exchange, and more!

Mr. Taylor has earned my respect in many ways. Specifically, in the fall semester of 1998 he was one of the first students to really grab notice in my introductory course in political science. From the start, he set "front and center making insightful comments which demonstrated he was keeping abreast of the readings (which were not insubstantial), as well as current news. He also performed extremely well on the three written examinations. In addition, Mr. Taylor produced two research papers on local political events, which were of top-notch quality. Each was a thoroughly-researched and well-organized research effort in which the author displayed analytical ability beyond his years. He performed at this level, incidentally, in spite of the fact that he was simultaneously running competitively for the University of Arkansas's men's cross country team; you would never have known from his impeccable class attendance and regular participation that he was meeting such demands.

Another member of the Political Sciences faculty, Todd Shields, also praised Mr. Taylor's research work:

I am writing to you on behalf of Mr. Jonathan Taylor who is one of our best undergraduate students in the department of political science. Mr. Taylor's undergraduate research is simply outstanding. In fact, Mr. Taylor's paper won the best research paper by an undergraduate student at a recent political science conference, held at Rice University. The conference included students from across the country and the award is quite prestigious. Mr. Taylor's research examines the importance of local political issues on residents' votes for mayor. His evidence indicates that a significant reason for Fred Hannah's recent failed attempt at another term was his stance and decisions regarding the tree ordinances and the development of the Kohl's outlet store on the north side of town. Mr. Taylor's research is important as it indicates that in some instances voters, notorious for not understanding or possessing even the most basic levels of political knowledge, can become quite sophisticated concerning environmental issues at the local level.

OPPOSING SYSTEMS

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Abstract

Costa Rica and Nicaragua, although situated close together in geography, historically and politically are worlds apart. Costa Rica has maintained a stable democracy since 1948, while Nicaragua, rocked by authoritarian rule and then revolution in 1979, is still in an unstable growth period. Each country represents an opposing government system that would have varying effects on the emphasis and influence placed on different social situations in each country. Through studying one social aspect, the women's movement, one is able to examine the positive and negative aspects of each system and prospects for future success of countries under each type of rule.

At the time of revolution in 1948, the Costa Rican government did not put equality of women as one of its main goals, but through time, a consciousness has spread about the need to fight for women's rights. Slowly women have organized to achieve greater equality in many political, economic and social aspects. In Nicaragua, women played an active role in the revolution and one of the objectives of the revolutionary forces, the Sandinistas, was to abolish the discrimination that women have faced for years. Shortly after the revolution, the women's movement was in full force and the effects of this movement are still prevalent throughout the country. In these two neighboring countries, significant advances have been made towards gender equity, but many times these accomplishments are only on the surface and women continue to face discrimination in many private and public social facets.

Throughout the long fight for gender equality in Latin America, women have encountered innumerable political, economic and social obstacles that have hindered the progress of the movement. Underlying these problems is the cultural practice of machismo that has been practiced for hundreds of years in Latin America, including the countries of Costa Rica and Nicaragua. This system, which places "extreme importance on a version of masculinity stressing exaggerated bravado, physical strength and sexual prowess," is a way of structuring power

relations between men and women that emphasizes male dominance and patriarchy (Close 60). Various women's movements in the two countries are working to combat the pervasive influence of machismo in order to establish gender equality within each respective society. Women's organizations often work with the government to combat gender prejudice. The goals and programs of a government are consequently very important determinants of success in achieving gender equality. In addition, political turmoil or stability within the political system can significantly shape how successful women's movement will be within each country.

Two neighboring countries in Central America, Costa Rica and Nicaragua, provide an excellent opportunity for comparison of different approaches to dealing with gender equity. Although situated closely geographically, these two nations are historically and politically worlds apart. Costa Rica has maintained a stable democracy since 1948, while Nicaragua, rocked by authoritarian rule and then revolution in 1979, is still politically turbulent. Through examining one social movement, the women's movement in these two very different countries, we can identify the impact of different forms of government on social development with regard to gender issues.

The institution of democracy after the Costa Rican civil war in 1948, included elements central to the beginnings of an organized women's movement in the country. The government did not establish an organization that had ties to the state but did encourage equalization in other facets. Women were granted the right to vote in the new constitution and the Legislative Assembly recognized women's rights to take part in political institutions. Throughout the next elections, women began to exercise this right to vote and ran in many federal and local elections. Slowly, women began to open doors for the movement, as they became more involved in the political realm.

The National Liberation Party (PLN) actually first began to cultivate the feminist movement by establishing the Secretary for Women's Affairs in order to encourage women voters. Later the PLN created the Women's Action of Social Evolution

(AFES) to incorporate women as a political force throughout different government organizations. Many women's groups emerged from other political parties to combat gender equality since the civil war, but, during the 1980s, the women's movement significantly expanded to reach all sectors of the country.

The main action that promoted gender equality was the introduction of the Bill for Women's True Equality in 1988, which was introduced by First Lady Magarita Penón de Arias and created with the help of the National Center for the Development of Women and Family (CMF). The bill addressed issues concerning political participation, education, violence, social rights, labor right and marriage rights. Many people opposed the passage of this legislation, but these critics only showed the relevance of the need for a change and the presence of discrimination in the country, which invoked a greater desire in the women's movement to fight for equality of women. Under the influence of the First Lady, the women were able to rally to fight the opposition and form more influential organizations within the government.

Other programs aimed at fighting equality were created in response to this movement in the late 1980s and overall, at the end of the decade, over 150 women's organizations were registered with the CMF. The groups all worked to combat the discrimination faced by all women through different facets of society. Through the work of the various organizations, women obtained a more significant influence on government issues to draw attention to the social development of women and respect for human rights in general. The work of these women helped to create a social identity for women to combat the gender inequality in society. Although women had begun to combat the problems through passing legislature and political participation, the organizations still had a long way to go in changing overall cultural attitudes regarding gender equality.

In Nicaragua, a personalistic dictatorship run by the Somoza family governed the country from 1934 until 1979 when, the guerilla group, the Sandinista National Liberation Front (FSLN), led a successful revolution to overthrow this regime. During the revolution many women from various backgrounds came together with the men to fight in combat against this oppressive regime and, in fact, a full 30% of the FSLN's fighting strength was made up of women (Black 324). Women's participation in combat and the importance that the FSLN leaders placed on gender equality served as a catalyst for the Nicaraguan women's movement. In setting up gender equality as a main goal of the revolution, the "Historic Program of the FSLN" states that the Sandinista people's revolution will "abolish the odious discrimination that women have been subjected to compared to man" and will "establish economic, political and cultural equality between woman and man."

Originally, the Association of Women Confronting the National Problem (AMPRONAC), was established, in 1977, to

encourage the participation of women in the resolution of the country's problems, to defend the rights of Nicaraguan women in all sectors and all aspects, and to defend human rights in general (Black 324). After the revolution, in September of 1979, AMPRONAC was transformed into a mass organization for women, the Luisa Espinosa Association of Nicaraguan Women (AMNLAE). AMNLAE was structured around the ideas of the FSLN and worked in close collaboration with the party. At its Constitutive Assembly, in 1981, AMNLAE defined its role as "giving women an organic instrument which would permit them to integrate themselves as a decisive force in the program of the revolution; and moreover, express in an organized manner, both their concerns and their social, economic and cultural aspirations" (Molyneux 147).

AMNLAE was able to play a role in passing various legislative reforms including a law requiring equal pay for men and women and a bill banning the exploitation of women as sex objects in the media. In addition, AMNLAE participated in social reform programs organized by the FSLN to combat illiteracy, health problems, and inadequate housing. The organization was able to demand rights and encourage laws in the economic and political roles of women in society, but many times harsh discrimination still remained at the center of a woman's daily life in the household.

During the fall 1984 presidential campaign, women began to express discontent about AMNLAE and the group's close connection with the FSLN. Even though the government passed many initiatives regarding various social and cultural issues, many outside groups accused the AMNLAE of not addressing the issues of domestic violence, machismo, rape, contraception, and abortion. The organization was able to change different laws to promote gender equality, but now the real struggle was in combating cultural practices that had been inherent in the communities and relationships for hundreds of years. Even though, on paper, in a proclamation or law, women appeared to have equality to men, discrimination and exploitation continued to exist in the work place, overall community and frequently the home and on a daily basis women remained "fundamentally in the same conditions as in the past" (Borge 474).

Both political and economic conditions in Costa Rica played a significant role in shaping progress toward gender equality since the country was able to enact more reforms than many other countries due to its more stable economy and political situation. The work of the First Lady helped to foster the women's movement and aided in provoking the government to take a stand to combat gender discrimination. Government-run programs have contributed to better living conditions and women's organizations, especially in the area of education, have been influential in changing gender stereotypes. However, women's participation in politics in the country remains low and has not been the focus of much government attention. In the social realm, though the Legislative Assembly has passed various

laws to eradicate gender inequality, women in Costa Rica continue to report violence and other problems within the home at alarming levels. Clearly machismo still exists within the country, and is reflected in inequality in the work place and the perpetuation of stereotypical career paths and domestic responsibilities. While overall Costa Rica provides better living conditions for women, the government has had a longer period of stability within which to realize this goal. Relative to the dramatic advances during the Sandinista regime, Costa Rica accomplished less during the time of this study, but the combined changes since 1948, have produced greater gender equality for women in Costa Rica than in neighboring Nicaragua.

Under the Sandinista government, women did enjoy increased educational opportunities, but they did so in the context of greatly declining wages. Also, even though women were able to increase their role in politics and even helped put forth legislation to combat discrimination, women never achieved one of their principal aims, which included a more stable family life. The strong ties binding AMNLAE to the FSLN hindered the development of social programs that directly addressed the domestic issues in gender equality. AMNLAE played a very influential role in the general reform process of the country, but was unable to address various key issues including domestic violence and true political equality. In only one decade, men and women cannot change their consciousness and behavior in the gender system simply through discussion groups, self-help groups or other organizations, but, given the time period, AMNLAE has made significant strides towards gender equality. A social structure rooted in concepts of machismo continued to define social responsibilities, but the role of women in the revolution did help to curb some extreme ideas and helped change gender relations in education, politics, work, and domestic life. The changes in the relationship between men and women were more accepted and more easily carried out since the whole country had been confronted by vast changes through the government.

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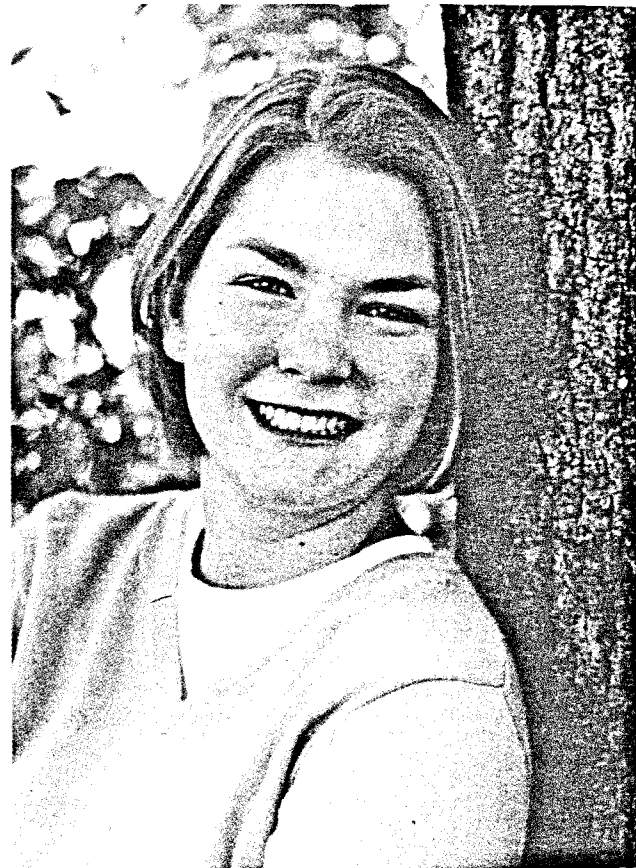
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Faculty comments

Erin Stone received glowing praise for her work from her mentor, Jeffrey Ryan. Perhaps this is to be expected inasmuch as Ms. Stone received the University of Arkansas Alumni Association Award as the outstanding woman graduate of 2001. Professor Ryan comments on her work as follows:

Though I have only known Erin for about one year, I continue to be amazed by the combination of her academic abilities, work ethic, social responsibility and maturity. In my courses, her performance has been uniformly excellent. Our ongoing discussions regarding her academic career in general and various research projects in particular have given me an even clearer indication of her abilities and commitment. Conversations with my colleagues who have had Erin in their classes have further reinforced my very favorable impressions of her abilities. Her professors uniformly evaluate Erin as an outstanding student, with an excellent capacity to assimilate complex ideas and incorporate them into cogent and powerful arguments. Perhaps most impressive to me is her exceptional performance in a study abroad program at the Universidad Nacional in Heredia, Costa Rica. I am personally acquainted with a number of the faculty there and know the courses to be rigorous and



Erin Stone

challenging. Erin's success in such a program, which is among the most highly respected in the region, is yet another indicator of academic excellence.

Her research project is both interesting and important. Though there has been considerable attention given to the status of women in Latin America, I am not familiar with any research that attempts to link regime type with success (or failure) in the area of gender equity. The basic question Erin is asking is whether women fare better under one type of government than another. Despite its apparent simplicity, the implications of this question are profound. If conditions of marginalization and gender inequality persist across alternative regime configurations, then the sources of discrimination may transcend the realm of politics and be more deeply embedded in the social structure. As a consequence, patterns of inequality would likely exhibit a disturbing resilience to the ameliorative efforts of policymakers and citizens alike.

In terms of focus, Erin has chosen two cases in which many variables are held more or less constant (e.g., region, cultural heritage, level of development, etc.) while the key one, regime time, is different. Costa Rica has enjoyed more than fifty years of uninterrupted

democratic government, with an active civil society, progressive social policy and remarkable political stability. Neighboring Nicaragua, by contrast, has suffered calamitous political upheaval and violence over the same time frame, marked most dramatically by the 1979 Sandinista-led revolution, which ended the brutal dictatorship of the Somoza family.

There have been a number of important efforts to explore the struggle for gender equity during and after the Sandinista administration (1979-1990), some of which seek to compare performance on women's rights across various 'revolutionary' contexts (e.g., Nicaragua vs. Cuba). To my knowledge, though, no one has yet developed a comparative framework for examining the issue across 'revolutionary' vs. 'nonrevolutionary' situations. Erin's project is designed to fill this gap, and addresses questions that are not only important in terms of theoretical development, but in social policy terms as well. Are greater gains made in securing women's fights through the incrementalist approach (as in liberal-democratic Costa Rica) or the radical approach (as in revolutionary Nicaragua)? Has more gender equity resulted from a gradual accretion of rights by women or do long-standing patterns of discrimination require some sort of rapid, fundamental break with the past? Or has the marginalization of women in the political, social and economic realms remained largely immune from these alternative approaches to solving the problem?

I think it is indicative of the quality of her project that she was awarded a SILO/SURF undergraduate research fellowship. Another indicator of her intellectual potential is the fact that she has already been accepted for graduate study at both the Bush School of Public Policy and at the University of Texas-Austin with full funding. Personally, I would rate Erin as very much on par with recent students of mine who are currently performing very well in graduate programs at Stanford, Berkeley and Rice.

Impressive as her academic achievements are, what makes Erin truly shine as an individual is her extraordinary commitment to, for lack of a better phrase, 'doing good.' She has served our university, helping to recruit, mentor, and retain fellow students. She has served our community and state, raising funds for breast cancer research and the children's hospital. And she has served our international community both here and abroad. In Northwest Arkansas, she uses her language skills and cultural sensitivity to provide critical assistance to the vulnerable immigrant community in our area. In a remote, impoverished area of rural Peru, Erin helped to build a church, set up an outreach program for local children, and put in place a curriculum allowing the church to offer college-level education. If you want to know the true value of service, ask the frightened Hispanic mother from Springdale how much it meant

to her when Erin helped find health care for her child. Or picture the faces of the humble farmers of Huancayo, when they gather for worship each Sunday in the sanctuary Erin helped build. For Erin, service is not a line on a résumé; it is an obligation and a calling.

Spanish Professor Jason Summers is also extremely complimentary of Ms. Stone's work. In his letter of recommendation he states:

Ms. Stone's research on women's political and social power in Central America is not only a historical study, but can also serve as an excellent predictor of a society's relative success in providing equal opportunities and protections to its members. This research deals with how government and society deal with women in both democratic and revolutionary systems. Particularly interesting is Ms. Stone's point in her thesis proposal that American-style democracy may not provide the best protections for women, nor may purely revolutionary societies, either. The effects of women taking part in social and governmental control of their societies is a benchmark that literary scholars have been considering in the latter part of the 20th century, but without historical studies such as this one, we literary types would have a much more difficult time connecting the texts that we work with to the social realities in which they were produced.

I think that Erin's project will not only serve to document how women were treated in the 20th century, but will also point toward how organized women's movements will continue to have an influence into the 21st century. Democratization, gender roles, and social equity are all aspects that can be linked to this particular study, making it a worthwhile and socially relevant topic in Latin American studies that deserves your support.

As a scholar dealing with gender roles as well as racial issues in Latin America, this research connects with my own work, and I think it is important and should be disseminated. The obvious social concerns relating to Erin's scholarly work are also reflected in her activities outside of the university. She works as an assistant at the Multicultural Center of Northwest Arkansas. Her goals are to work in a non-profit organization that serves the Hispanic community, which again reflects her academic goal of strengthening interest in women's movements in Latin America. Supporting Ms. Stone's work will help establish her as a beginning scholar who I hope can be convinced to continue as a graduate student, because I believe that she would make an excellent addition to the academe.

SECTION III: SCIENCES AND MATHEMATICS

BIOLOGY, CHEMISTRY AND MATHEMATICS

HYDROPHOBIC MATCHING OF SHORT GRAMICIDINS WITH PHOSPHOLIPIDS

by Elizabeth Dunn
Department of Chemistry and Biochemistry
Fulbright College of Arts and Sciences

Mentor: Dr. Roger Koeppel
Department of Chemistry and Biochemistry

Abstract:

Given the highly stochastic nature of larval supply, coral reef fish may often settle in sub-optimal habitats with limited prey. This study examines the foraging and territorial habits of a coral feeding butterflyfish, Chaetodon baronessa, living in two contrasting habitats with markedly different coral prey. In exposed front reef habitats, where coral prey was highly abundant, C. baronessa was highly selective in its choice of prey and aggressively maintained small territories. In contrast, in back-reef habitats where coral prey was scarcer, C. baronessa was more generalist in its choice of prey, and had larger territories that were only weakly defended. The contrasting habits of C. baronessa in different reef habitats are consistent with predictions of optimal foraging theory, in that dietary specialisation and territoriality are reduced to maximise food intake where prey is less abundant.

Introduction

In all living cells, transmembrane proteins "speckle" biological membranes. Some of these structures allow passage of charged particles across the hydrophobic membrane, making possible the concentration and electrical gradients necessary for essential functions such as cell-to-cell communication and life itself. Understanding the membrane channel is therefore essential to understanding the function of the cell. However, membrane-spanning proteins, naturally difficult to isolate and purify because they consist of both hydrophobic and hydrophilic segments, function only in the lipid environment of the membrane and are soluble only in the membrane or organic solvent. In addition, the large size of these proteins complicates their study.

The simpler "model" peptide gramicidin A offers an alternative approach toward understanding transmembrane channels (1). A naturally-produced antibiotic, gramicidin is a peptide consisting of 15 amino acids. Two molecules of gramicidin associate to form a b-helical channel in the membrane, with a pore wide enough to allow passage of cations such as

sodium or potassium (2). This "ion-conducting" channel forms only in membranes; in other environments, gramicidin folds differently, into a non-conducting double stranded form (3) (Figure 1).

Four tryptophans at the end of the peptide are thought to be responsible for channel formation (3). Tryptophan is an amino acid that is most stable when located at the interface between the membrane and the surrounding solution (4). Tryptophans seek the membrane-water interface, burying the remaining, hydrophobic amino acids in the interior of the membrane. Presumably, if this activity generalizes to other channels, then the proportions and placements of tryptophans in the protein sequence vitally influence channel conformation and activity.

The tryptophan-driven folding model predicts that proper gramicidin channel folding is governed both by the relative lengths of the lipids and peptides, and by the tryptophan content of the peptides. Greathouse et al. (5) have varied the length of lipid chains in the membrane to regulate the hydrophobic matching lengths between lipids and peptides. Because the lowest energy conformation requires that the tryptophans remain at the interface, disrupting the matched hydrophobic lengths induces strain upon the conformation. Gramicidin was inserted into membranes containing 6 to 12 carbons per acyl chain. It was found that channels will form only in lipids containing acyl chains with 8 or more carbons. In lipids that are too short for channel formation, a double stranded conformation is observed (5).

This project expands on the previous research by varying the number of tryptophans and the length of the gramicidin peptide itself, in addition to the lipid length, in order to further investigate the effect of hydrophobic matching upon channel conformation. We have synthesized shortened gramicidins of 9, 11, and 13 amino acids, each with 1 or 2 tryptophans (Table 1). We examined the conformations of the molecules in lipids of varying lengths using circular dichroism (CD)¹ spectroscopy, a method of analysis that reveals whether the peptide forms a channel or some other conformation. Based upon our results, conformation does seem to correlate with lipid length.

Materials and Methods

Materials. Amino acids were purchased from Bachem and Advanced Chem Tech. Diacylphosphocholine lipids (Table 2; Figure 2) were from Avanti Polar Lipids, Inc. (Alabaster, AL). Methanol, chloroform, DCM and MtBE (HPLC grade) were from Burdick and Jackson (Muskegon, MI). Water was deionized Millipore Corp. Milli-Q water (Bedford, MA). F-L-Val was from Bachem, Bioscience.

Peptide synthesis. Peptides were synthesized on an Applied Biosystems Model 431 as described in Greathouse et al. (6). Peptides were cleaved from the resin in 1500 μ l of 10% ethanolamine (EA) in DMF for 48 hours at room temperature. Peptides were then filtered and precipitated with MtBE. Peptides were dried under vacuum overnight. Dried peptides were dissolved prior to quantification. Masses of peptides were confirmed by mass spectral analysis (Mass Consortium, San Diego, CA) and purity by high-performance liquid chromatography.

Sample preparation. Peptide/lipid dispersions (1:30 molar ratio) were prepared by suspension of dried peptide in filtered methanol followed by addition of lipid from stock chloroform solutions. The volumes of methanol and chloroform were adjusted to create a 50/50 (v:v) methanol/chloroform solution. The suspensions were dried on a speed vacuum for 1.5 hr and then dried under vacuum 24-72 hr.

Dried peptide/lipid mixtures were resuspended in deionized water, sonicated for approximately 70 min. at 50°C in a Branson W-185 cell disruptor (power level 5) fitted with a Model 431-A cup horn accessory, and incubated for 30 minutes at 50°C. Samples were centrifuged at 14000 rpm for 5-15 minutes at room temperature. The concentration of peptide in the supernatants was determined at 280 nm on a Hewlett Packard 8452A Diode Array spectrophotometer using an extinction coefficient of 5600 $M^{-1}cm^{-1}$ per tryptophan. CD measurements were obtained at room temperature using a Jasco 710A spectrometer. Each spectrum is an average of 8-12 scans from 200-300 nm, with a path length of 0.1 cm.

Results

The conformational dependence of shortened gramicidin analogues on lipid acyl chain length of short-chain phospholipids was investigated. It is known that gA exhibits a dependence on acyl chain length. In lipids longer than C8, gA exhibits a CD spectrum typical of single-stranded channels, with maxima at 220 and 235 nm, and a minimum at 230 nm. In shorter lipids, gA exhibits a CD spectrum typical of non-conducting DS helices such as are observed in organic solvent, with negative peaks at 212 nm and 230 nm (5) (Figure 3).

Both channel and DS conformations were obtained for shortened gramicidin peptides with two tryptophans (Figures 4-6). Trends are presented in figure 7. As can be seen, the 2W 9mer

exhibits the most dependence upon hydrophobic matching; it only forms the channel conformation in one lipid, of intermediate length (C12). The 2W 11mer and 2W 13mer form channels in a wider range of lipids, C8 to C16. The DS conformation is observed in 2W 9mer and 2W 13mer peptides, but not in a predictable pattern. The 2W 9mer forms DS dimers only when lipid is too short for channel formation. The 2W 13mer takes a DS form when lipid is both too short and too long for channel formation. The 2W 11mer does not form a DS structure in any of the lipids tested. No channel-like or DS-like spectra were observed for one-tryptophan peptides. Only varied, atypical spectra were seen (figures not shown).

Discussion

Tryptophan importance. No standard channel or DS spectra were observed for any of the 1W gA analogues in the lipids tested. These CD results indicate that at least two tryptophans are necessary for formation of either standard channel or DS structures. This supports the importance of tryptophan in transmembrane channel folding; one tryptophan is not enough to adequately anchor the peptide in the membrane.

Hydrophobic matching importance. Hydrophobic matching between lipid chain length and the hydrophobic length of the folded peptide was particularly crucial to the folding of the shortest peptide, the 2W 9mer. It was expected that this short peptide would form channels in a range of short lipids; however, this was not the case. The short peptide simply may not form enough hydrogen bonds to stabilize the channel. The slightly longer 2W 11mer and 13mer peptides formed channels in a range of peptides, C8-C16. This is the same range of lipids in which gA forms channels. C8 was a threshold for gA (5); C8 seems to be the critical transition for these shortened gA analogues as well.

The DS conformation, however, does not follow the same pattern as for gA. The 2W 11mer produced no DS dimer spectra. DS formation in the other two 2W peptides varied; DS spectra appeared in lipids either longer or shorter than channel-inducing lipids, with no predictable pattern. The mechanism that determines DS dimer formation remains uncertain.

Non-channel-like and non-DS-like spectra were varied; the conformational behavior of these peptides is complex. The atypical spectra observed for 1W peptides and occasionally for 2W peptides could represent alternate dimeric or monomeric structures (as opposed to the RH $b^{6,3}$ helix of gA). These spectra cannot be compared to typical α -helical and β -sheet spectra of other peptides because of the alternating L,D chirality of gramicidin residues.

This project is aimed toward better understanding of channel protein/membrane interactions and the role of tryptophan and channel length in the folding of these proteins. As the lipid interactions of model systems such as the gramicidin channel are

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Note

Abbreviations: Standard amino acid abbreviations are used. Additional abbreviations are: CD, Circular dichroism; DCM, dichloromethane; MtBE, Methyl *t*-butyl ether; HPLC, high-performance liquid chromatography; DMF, N,N-dimethylformamide; gA, gramicidin A; DS, double stranded; W, tryptophan; RH, right handed.

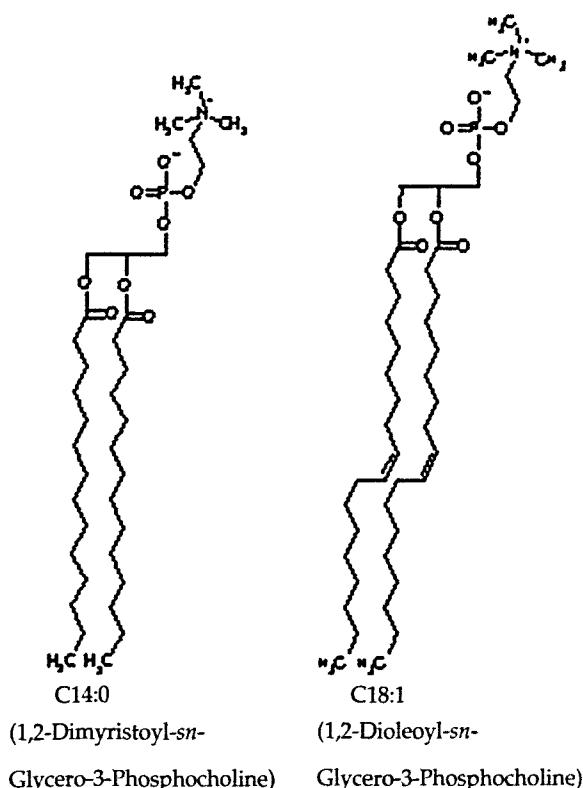


Figure 2. Examples of structures of lipids used for CD and SEC measurements.

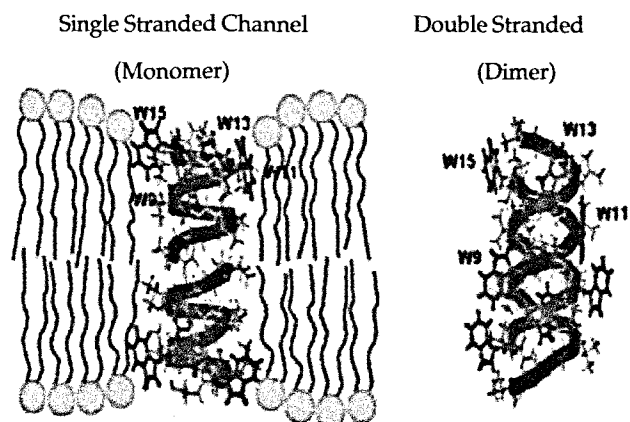


Figure 1. Models of gA in membrane (single stranded channel and in organic solvent (double stranded dimer)).

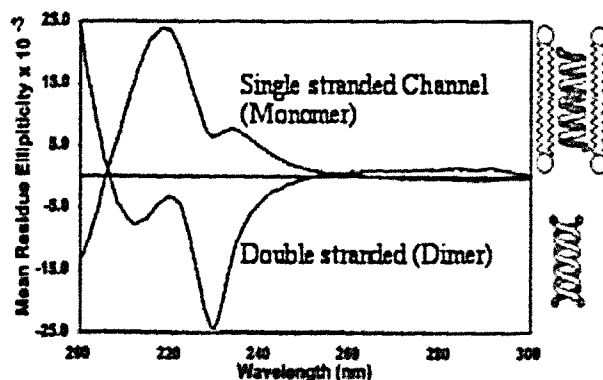


Figure 3. Reference CD spectra of monomeric (channel) and dimeric (double stranded) native gA.

Faculty comments

In his letter of recommendation, Ms. Dunn's mentor, Roger Koeppe writes:

Elizabeth has been productive in the laboratory since the beginning of her sophomore year, and she has done a very nice job of providing a systematic definition of the minimal requirements for the folding of short peptides in the presence of a series of membrane-forming lipids. Her research has served to provide fundamental important new information about the molecular interactions of proteins and lipids and her results make a significant contribution to the future design of molecular "force transducers" that are being developed in my laboratory for the purpose of measuring the energetic requirements for deforming the membranes of living cells of different types. Elizabeth presented her results to a national audience at the Biophysical Society annual meeting in Boston in February 2001.

On the Fayetteville campus, Elizabeth has excelled in "everything." She is one of those rare students of the very highest quality who come along only once or twice in a decade. I would rank her in the top 2% of all students in our department over the. Past twenty years. Elizabeth has been honored with a national Goldwater Fellowship and a National Science Foundation Fellowship for graduate study at Stanford. Her accomplishments in the classroom as well as the laboratory give her unusual status for an undergraduate student at this early stage in her career, and she is highly sought by distinguished graduate programs in cell biology, such as those at Stanford, Duke and Berkeley.

Academically, Elizabeth has a 4.0 GPA and is one of the most outstanding students in any discipline on the Fayetteville campus. In her research on peptide/lipid interactions, Elizabeth has been instrumental at all stages of the experimental design, including the choices of peptides to make and study, the approach to issues of chiral fidelity during the synthesis, and the methods (circular dichroism spectroscopy and size-exclusion chromatography) for analyzing the peptide conformations and interactions in a variety of lipid bilayer systems. Her approach to research is thoughtful, creative and careful. Her package of skills is complete from experimental design to laboratory technique, record keeping, analysis and importantly the writing of reports, including the first draft of a manuscript.

Elizabeth is well aware of the growing interdisciplinary nature of science. She will combine her knowledge of chemistry, biology and biochemistry as she pursues a program of graduate study in cell and molecular biology. In recommending her for a Howard Hughes Fellowship, I have written that I

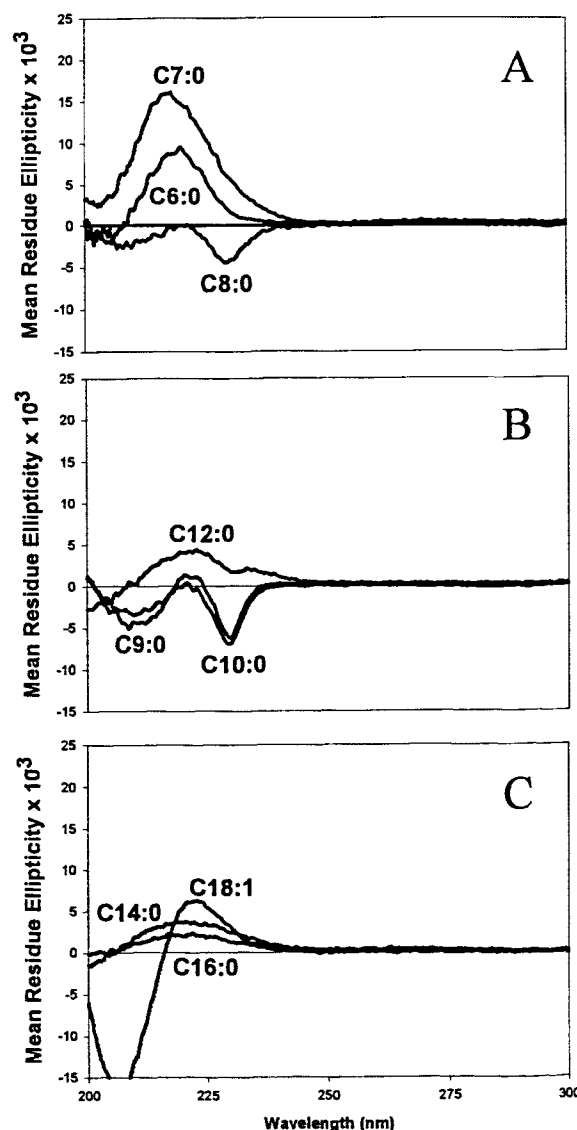


Figure 4. CD spectra of 2W9mer in A) short lipids (C6:0-C8:0), B) intermediate lipids (C9:0-C12:0), C) long lipids (C14:0-C18:1). (Conditions: 1:30 gA:lipid ratio, 0.01-cm path length, room temperature.)

believe her to be the best candidate for a Hughes Fellowship whom I have encountered during twenty-one years of university teaching. This conclusion is based on her scientific understanding, laboratory productivity, and overall accomplishments.

Neil Allison, Ms. Dunn's undergraduate advisor and organic chemistry instructor, had the following things to say about her:

Elizabeth is one of those few students who have an unquenchable thirst for knowledge. In fact, I believe she takes on challenges just for fun. An example of how Elizabeth has used her Sturgis Fellowship from

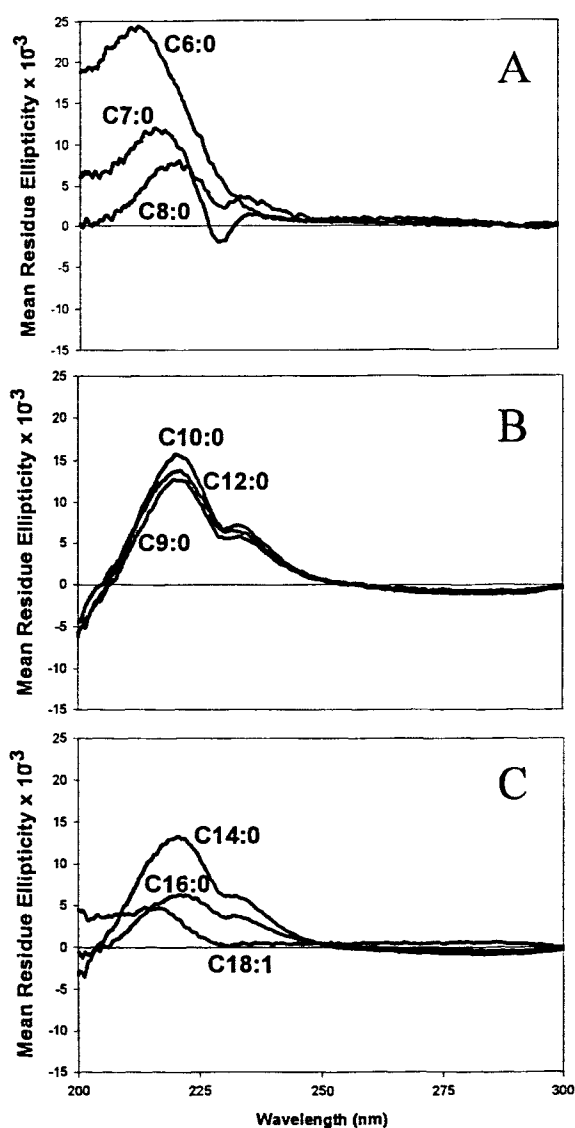


Figure 5. CD spectra of 2W 11mer in A) short lipids (C6:0-C8:0), B) intermediate lipids (C9:0-C12:0), C) long lipids (C14:0-C18:1). Conditions as in Fig. 4.

the Fulbright College to increase her experiences above and beyond most students is indicated the year she spent studying in Great Britain. I believe that her experience there was very valuable not only for the academic challenges it provided but also for allowing her to see how another part of the world operates. Moreover in addition to this year abroad, Elizabeth has been able to handle both biochemistry and a biological science double major on top of this one-year abroad study! In my memory as an advisor over the past nine years, I do not remember a single student that has taken two majors in technical fields. In fact, as seen by her grade point average she has done all of

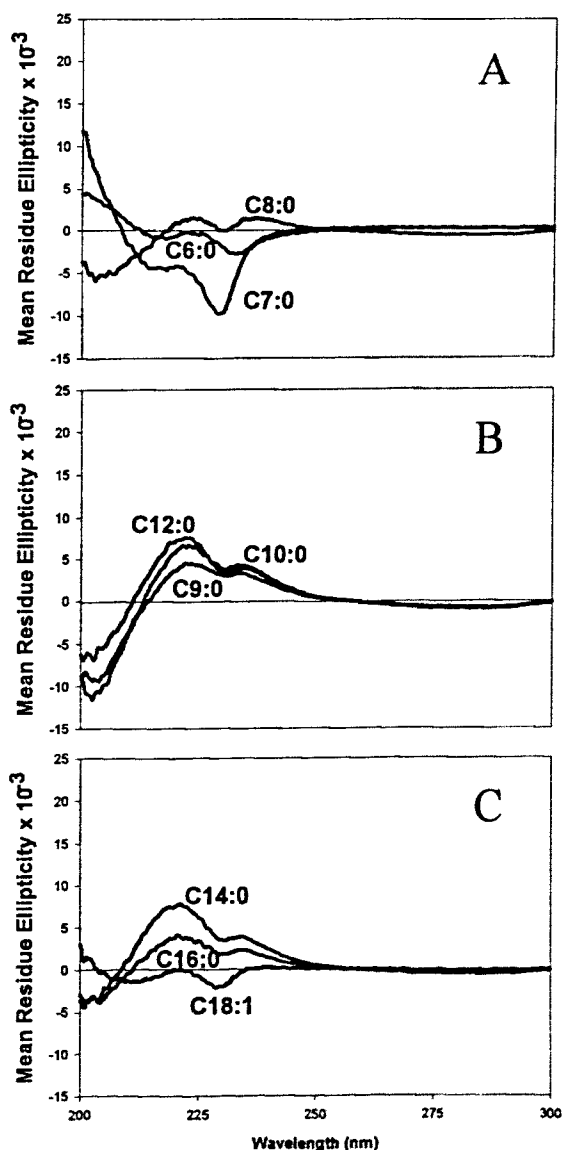


Figure 6. CD spectra of 2W 13mer in A) short lipids (C6:0-C8:0), B) intermediate lipids (C9:0-C12:0), C) long lipids (C14:0-C18:1). Conditions as in Fig. 4.

this with aplomb.

A specific example of Elizabeth's abilities is shown in my classes. She finished with the highest A in the organic chemistry major's laboratory and a very high, solid A in the Organic Chemistry 11 lecture. These were excellent grades in classes that are dominated by the most talented and grade aggressive students (in particular the premedical students) that the University of Arkansas possesses. This is particularly impressive when one considers the other difficult courses that she took at the same time in order to complete her double major in record time. Knowing Elizabeth quite

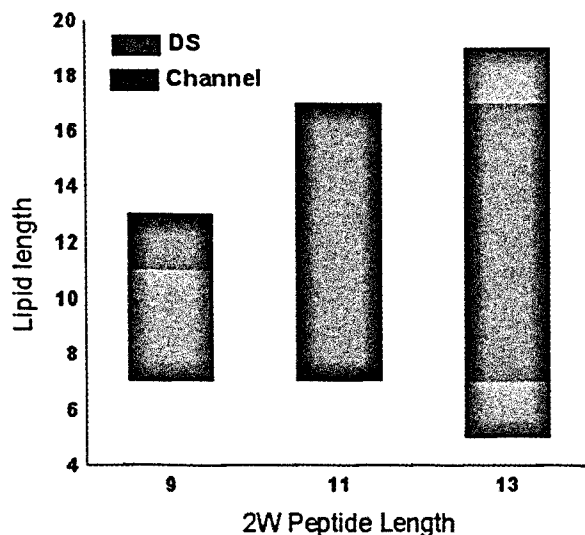


Figure 7. Correlation of length of 2W peptides with lipid length.

well, I can state that it is also very impressive in that the grade appears to be secondary to understanding and learning for Elizabeth (not something that I can say for many of the very high GPA students that I have known).

Over the past 18 years, I've probably written 120 or so letters of recommendation for students with about half of these being for outstanding students. When compared to Elizabeth, however, even the best students that I have written letters for fade somewhat. She is a "First" in my book - a student with all the potential imaginable, coupled with the drive to do great things in the future.

Timothy Kral, who acted as Ms. Dunn's Sturgis Fellowship faculty mentor, made similar comments about her abilities:

I have known Elizabeth for over three years as her teacher and mentor. Elizabeth is a Sturgis Fellow, and each Sturgis Fellow is assigned a faculty mentor. It certainly has been an honor to serve as her mentor. Elizabeth is a delightful individual who is simply brilliant. In my General Microbiology course, she earned an A; however, it wasn't just an A. After four class exams, her average was 100%. I have taught at

Table 2. Lipids Used for CD and SEC Measurements

Abbreviation	Common Name
C6:0	di-Caproyl-PC
C7:0	di-Heptanoyl-PC
C8:0	di-Octanoyl-PC
C9:0	di-Nonanoyl-PC
C10:0	di-Caprl-PC
C12:0	di-Lauroyl-PC
C14:0	di-Myristoyl-PC
C16:0	di-Palmitoyl-PC
C18:0	di-Oleoyle-PC

he University of Arkansas for twenty years and this is the first final average of 100% I have ever had in my classes.

Elizabeth's interests lie in both natural science (biology and chemistry) and mathematics. She is currently working on a research project in biochemistry with Dr. Roger Koeppel dealing with membrane channels and gramicidin. More specifically, she is trying to understand the principles of hydrophobic matching and tryptophan anchoring in biological membranes. Her interest in mathematics is actually slanted toward mathematical biology. She has taken a number of advanced mathematics courses and has attended seminars in our department given by an internationally-renowned scientist dealing with mathematical models and analyses of biological importance.

As a person, Elizabeth is very unassuming and a bit on the shy side. However, she regularly seeks me out with questions about lecture material as well as questions relating to her education or future career. Elizabeth is the type of person who welcomes a challenge. Whatever she undertakes, she does extremely well.

Table 1. Sequences of shortened gA analogues with reduced numbers of tryptophans.

PEPTIDES	SEQUENCES ³
Grammidin A	f-Val-Gly-Ala- <u>Leu</u> -Ala- <u>Val</u> - <u>Val</u> - <u>Val</u> - Trp - <u>Leu</u> - Trp - <u>Leu</u> - Trp - <u>Leu</u> - Trp -ea
1W 9mer	f-Val- <u>Ala</u> -Ala- <u>Val</u> -Val- <u>Val</u> -Ala- <u>Leu</u> - Trp -ea
1W 11mer	f-Val- <u>Ala</u> -Ala- <u>Val</u> -Val- <u>Val</u> -Ala- <u>Leu</u> -Ala- <u>Leu</u> - Trp -ea
1W 13mer	f-Val- <u>Ala</u> -Ala- <u>Ala</u> -Ala- <u>Val</u> -Val- <u>Val</u> -Ala- <u>Leu</u> -Ala- <u>Leu</u> - Trp -ea
2W 9mer	f-Val- <u>Ala</u> -Ala- <u>Val</u> -Val- <u>Val</u> - Trp - <u>Leu</u> - Trp -ea
2W 11mer	f-Val- <u>Ala</u> -Ala- <u>Val</u> -Val- <u>Val</u> -Ala- <u>Leu</u> - Trp - <u>Leu</u> - Trp -ea
2W 13mer	f-Val- <u>Ala</u> -Ala- <u>Ala</u> -Ala- <u>Val</u> -Val- <u>Val</u> -Ala- <u>Leu</u> - Trp - <u>Leu</u> - Trp -ea

*f=formyl

ea=ethanolamine

D-amino acids underlined

D,L-amino acids *italicized*

DIET AND TERRITORY SIZE OF BUTTERFLYFISH IN HABITATS WITH VARYING CORAL COVER AND COMPOSITION

by Michael Berumen
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Faculty Mentor: Raj V. Kilambi
Department of Biological Sciences

Abstract:

*Given the highly stochastic nature of larval supply, coral reef fish may often settle in sub-optimal habitats with limited prey. This study examines the foraging and territorial habits of a coral feeding butterflyfish, *Chaetodon baronessa*, living in two contrasting habitats with markedly different coral prey. In exposed front reef habitats, where coral prey was highly abundant, *C. baronessa* was highly selective in its choice of prey and aggressively maintained small territories. In contrast, in back-reef habitats where coral prey was scarcer, *C. baronessa* was more generalist in its choice of prey, and had larger territories that were only weakly defended. The contrasting habits of *C. baronessa* in different reef habitats are consistent with predictions of optimal foraging theory, in that dietary specialisation and territoriality are reduced to maximise food intake where prey is less abundant.*

Introduction

Prey acquisition is fundamental to the biology and ecology of all living organisms. Life must be fueled by energy, and any organism's acquisition of the energy is often variable. Species are sometimes presented with a wide range of resources, and in natural settings, consumers are rarely limited to one prey type or foraging location. Assuming that animals have some choice in what they are consuming, these choices are likely to have widely varied consequences (Vincent *et al.*, 1996). Foraging behaviour potentially has far-reaching implications for the well-being and general evolutionary 'fitness' of an animal (Hughes, 1980; Pyke, 1984).

In many groups of consumers, we see a great deal of diversity in morphological and behavioral variations in foraging strategies (Hughes, 1980; Pyke, 1984). Increased diversity within a sympatric group often leads to a corresponding increase in the specialization of individual species with respect to food acquisition (Robinson and Wilson, 1998). In some animals, specialization becomes evolved to an extreme level, with associations very near to obligatory symbiosis.

In some cases, foragers must choose the principal components of their diet or the primary foraging location (Werner and Hall, 1974, Vincent *et al.*, 1996). If we equate dietary breadth to specialisation, then consumers should be specialists when resources are abundant and more generalist when resources are scarce (Werner and Hall, 1974; Pyke, 1984). Optimal foraging theory predicts that a consumer should also specialise on that resource which yields the highest returns (in terms of energy) (Robinson and Wilson, 1998). Thus we would expect a specialist to exclusively consume the optimal resource when it is sufficiently available (Chesson, 1983). In some cases the most profitable prey type is not abundant, and searching to find this prey requires more energy than is returned in its acquisition (Ritchie, 1998). In such cases, it is a trade-off between energy expended to acquire prey and energy gained through consumption of the prey (Vincent *et al.*, 1996). In some situations, it may be more beneficial for a consumer to be a generalist. OFT predicts that animals should be specialists and consume the most profitable food when it is sufficiently available to ultimately return more energy than other prey (Pyke, 1984).

In some situations, it also becomes most profitable for individuals to defend a particular resource, however it may not always be economically viable for an animal to aggressively defend a territory (*sensu* Brown, 1964; Hixon, 1980; Tricas, 1989). In cases where preferred resources occur in dense patches, animals may find it most profitable to defend a concentrated resource from other competitors. If resources are limited and the animal must cover a wide area to forage, it is then not feasible to expend a large amount of energy defending this large patchy resource (Ritchie, 1998). In areas where resources are highly abundant, it may be profitable to aggressively defend a small territory rich in resources.

Territoriality has been related to dietary specialisation in some species. In some pomacentrids, dietary preferences changed with territory size. Due to increased availability of preferred resources, herbivorous damselfish fed in a more selective manner (Jones and Norman, 1986). In this case, the authors suggested

that food supply was a consequence of territory size rather than a determining factor. However, many studies have attributed territory size to the availability of resources (eg, Irons, 1989; Tricas, 1989, Righton *et al.*, 1998).

Maintenance of a territory must occur in a manner that restricts competitor access. Aggressiveness in a foraging context is predicted to increase in a similar fashion as territoriality. If resources are abundant enough, then individuals need not compete aggressively. However, as resource availability decreases, dense patches of prey may elicit exaggerated aggressive behaviour in a territorial fashion. As aggressive behaviour requires a significant expenditure of energy, this may actually not be a beneficial strategy in situations where energy returns from the aggressive behaviour are insufficient to support the energy expended. These complex trade-offs are thus far usually examined in theoretical and mathematical modelling contexts, as accurate measurement of variables such as those listed above are near impossible to obtain (Vincent *et al.*, 1996; Ritchie, 1998; Robinson and Wilson, 1998).

The triangular butterflyfish, *Chaetodon baronessa*, offers the opportunity to study consequences of foraging behaviour as it exhibits variability in both dietary preference as well as territory maintenance. It can also be observed in a natural setting, allowing for a better understanding of the fishes' natural behaviours.

Methods

This study was conducted between January and April 2000, at Lizard Island (14°40'S, 145°27'E), on the northern Great Barrier Reef, Australia. The foraging behaviour of *Chaetodon baronessa* was studied at each of four sites; South Island, Coconut Beach, Osprey Islet, and Corner Beach. The four sites were purposely chosen to reflect differences in total coral cover as well as differences in coral composition. South Island and Coconut Beach were situated on the south-east side of Lizard Island and directly exposed to the prevailing South East Trade winds whereas Osprey Islet and Coconut Beach were on the north-west side of the island and relatively sheltered. At exposed sites (South Island and Coconut Beach) hard coral cover was in excess of 50% and dominated by the tabular coral, *Acropora hyacinthus*. In contrast, hard coral cover at sheltered sites (Corner Beach and Osprey Islet) was typically less than 15% and soft corals (family *Alcyonacea*) dominated the reef benthos.

The dietary composition of butterflyfish was assessed during feeding observations, in which replicate fish were followed at a distance of approximately one meter, which minimised disturbance of the fish's natural behaviour following Reese (1975). Whilst observing fish, the number of bites taken from each different coral species and other benthic substrates was recorded. Scleractinian corals on which butterflyfish were seen to feed were identified to species, but other substrates were categorised to one of seven general categories (Table 1)

The optimal duration for feeding observations was determined during an initial pilot study, in which ten replicate fish from both South Island and Osprey Islet were observed for a total of 10 minutes. During these ten-minute observations both the cumulative number of different species and cumulative number of bites consumed were recorded at 1-minute intervals. The optimal duration for feeding observations was then determined based on the minimum period necessary to adequately assess dietary composition and also maximize precision in estimates of feeding rates. In all cases, there was no significant increase in number of different prey species consumed after three minutes of observation. Moreover, precision in estimates of feeding rates was relatively uniform for all periods greater than two minutes. Consequently, all subsequent feeding observations were conducted for three minutes.

A total of 50 replicate fish were each observed for three minutes at every site (South Island, Coconut Beach, Osprey Islet and Corner Beach) to assess dietary composition. The proportional use of the main coral species was then compared to their availability at each site, to assess the selectivity of butterflyfish. Selectivity was determined using selection functions following Manly *et al.* (1993). The availability of coral species was assessed using replicate 10m line-intercept transects, and categories used in the identification of benthic taxa were the same as those used to assess dietary composition of butterflyfish.

To test how aggressively butterflyfish defended their home range against conspecifics, interactions of all butterflyfish were recorded in all observations. Interactions were grouped into two categories, first a "chase" when the observed fish chased away another fish, and secondly, a "chased" category when the individual was chased by another fish. (Data is taken from the 200 individual feeding observations). For all fish observed, incidents were recorded when the subject either chased another fish or was chased. The species of the fish interacted with was also recorded.

In an initial pilot study, fish were observed for a total of 30 minutes to assess territory size. The position of individual butterflyfish was recorded at 45-second intervals. The cumulative home range was then calculated after 7.5, 15, 22.5, and 30 minutes. Analysis of 12 replicate fish in this manner showed no significant difference in territory size after 15 minutes at either site. Consequently, all territory observations were conducted for 15 minutes.

To assess home range of *C. baronessa*, fish were monitored for 15-minute periods. Territory observations were made using several (8-10) metal washers flagged with colored tape. These washers were dropped and moved to fit the boundary of the fish's movement. After 15 minutes, the position of the washers was recorded and measured in a two-dimensional coordinate system. The area of the territory was then calculated using the greatest polygon to fit the recorded boundaries.

Table 1. Benthic categories used in assessing the dietary composition of butterflyfish and measuring prey availability at Lizard Island.**Hard Coral Categories:**

<i>Acropora aspera</i>	<i>Diploastrea heliopora</i>	<i>Montipora hispida</i>
<i>Acropora cytherea</i>	<i>Echinopora lamellosa</i>	<i>Montipora hoffmeisteri</i>
<i>Acropora digitifera</i>	<i>Echinopora mammiformis</i>	<i>Montipora monasteriata</i>
<i>Acropora donei</i>	<i>Favia favius</i>	<i>Montipora venosa</i>
<i>Acropora florida</i>	<i>Favia lizardensis</i>	<i>Montipora verrucosa</i>
<i>Acropora formosa</i>	<i>Favia pallida</i>	<i>Other Montipora spp.</i>
<i>Acropora gemmifera</i>	<i>Favia speciosa</i>	<i>Pavona maldivensis</i>
<i>Acropora grandis</i>	<i>Favia stelligera</i>	<i>Platygyra daedalea</i>
<i>Acropora humilis</i>	<i>Favites abdita</i>	<i>Platygyra sinensis</i>
<i>Acropora hyacinthus</i>	<i>Favites halicora</i>	<i>Platygyra verweyi</i>
<i>Acropora intermedia</i>	<i>Fungia simplex</i>	<i>Pocillopora damicornis</i>
<i>Acropora loripes</i>	<i>Fungiidae</i>	<i>Pocillopora eudouxi</i>
<i>Acropora millepora</i>	<i>Galaxea astreata</i>	<i>Pocillopora meandrina</i>
<i>Acropora monticulosa</i>	<i>Galaxea fascicularis</i>	<i>Pocillopora verrucosa</i>
<i>Acropora nasuta</i>	<i>Goniastrea retiformis</i>	<i>Porites lobata</i>
<i>Acropora robusta</i>	<i>Hydnophora exesa</i>	<i>Other Porites spp.</i>
<i>Acropora sarmentosa</i>	<i>Hydnophora microconos</i>	<i>Povona varians</i>
<i>Acropora secale</i>	<i>Isopora cuneata</i>	<i>Psammacora contigua</i>
<i>Acropora selago</i>	<i>Isopora palifera</i>	<i>Psammacora digitata</i>
<i>Acropora valida</i>	<i>Leptastrea transversa</i>	<i>Sandalitha robusta</i>
<i>Astreopora myriophthalma</i>	<i>Leptoria phrygia</i>	<i>Seriatopora hystrix</i>
<i>Coelosera mayeri</i>	<i>Lobophyllia hemprichii</i>	<i>Stylophora pistillata</i>
<i>Cyphastrea spp.</i>	<i>Montastrea spp.</i>	<i>Symphyllia recta</i>
<i>Dendronepthea spp.</i>	<i>Montipora efflorescens</i>	<i>Turbinaria spp.</i>

Other categories:

<i>Feather hydroid</i>	<i>Non-Coralline Hard Substrate</i>	<i>Sarcophyta spp.</i>
<i>Lobophyta spp.</i>	<i>Sand</i>	<i>Sinularia spp.</i>

Results

Dietary Composition & Electivity

At South Island, *C. baronessa* included 7 main categories of prey, while using 12 main categories at Coconut Beach (Figure 1). However, it was clear that *C. baronessa* had a diet primarily consisting of *A. hyacinthus* at both sites. At Corner Beach, *C. baronessa* used 11 prey categories with a shift to include *Pocillopora damicornis*, but there was no dominant prey choice. At Osprey Islet, 10 main categories were used; however, there was still no single dominant prey choice. The two most common prey categories were *P. damicornis* and *A. florida* (Figure 1).

Electivity indices indicate that *C. baronessa* uses *A. hyacinthus* at exposed sites (South Island and Coconut Beach) in a greater proportion than its availability (Figure 1). No other

coral was selectively eaten at either site. At Corner Beach, *C. baronessa* selectively consumed *P. damicornis*, *A. florida*, and *Galaxea* spp.; however, total consumption of these corals was not as exaggerated as *A. hyacinthus* at South Island and Coconut Beach. At Osprey Islet, only *P. damicornis* and *Coeloseris* spp. were selectively eaten.

Aggression

C. baronessa was observed to chase fish 32 times at exposed sites (South Island and Coconut Beach) while only chasing fish 10 times at sheltered sites (Osprey Islet and Corner Beach). Data are taken from the 200 feeding observations.

Territory Size

A total of 69 territories were measured. Mean territory size varied at different sites for *C. baronessa* (Figure 2). Mean

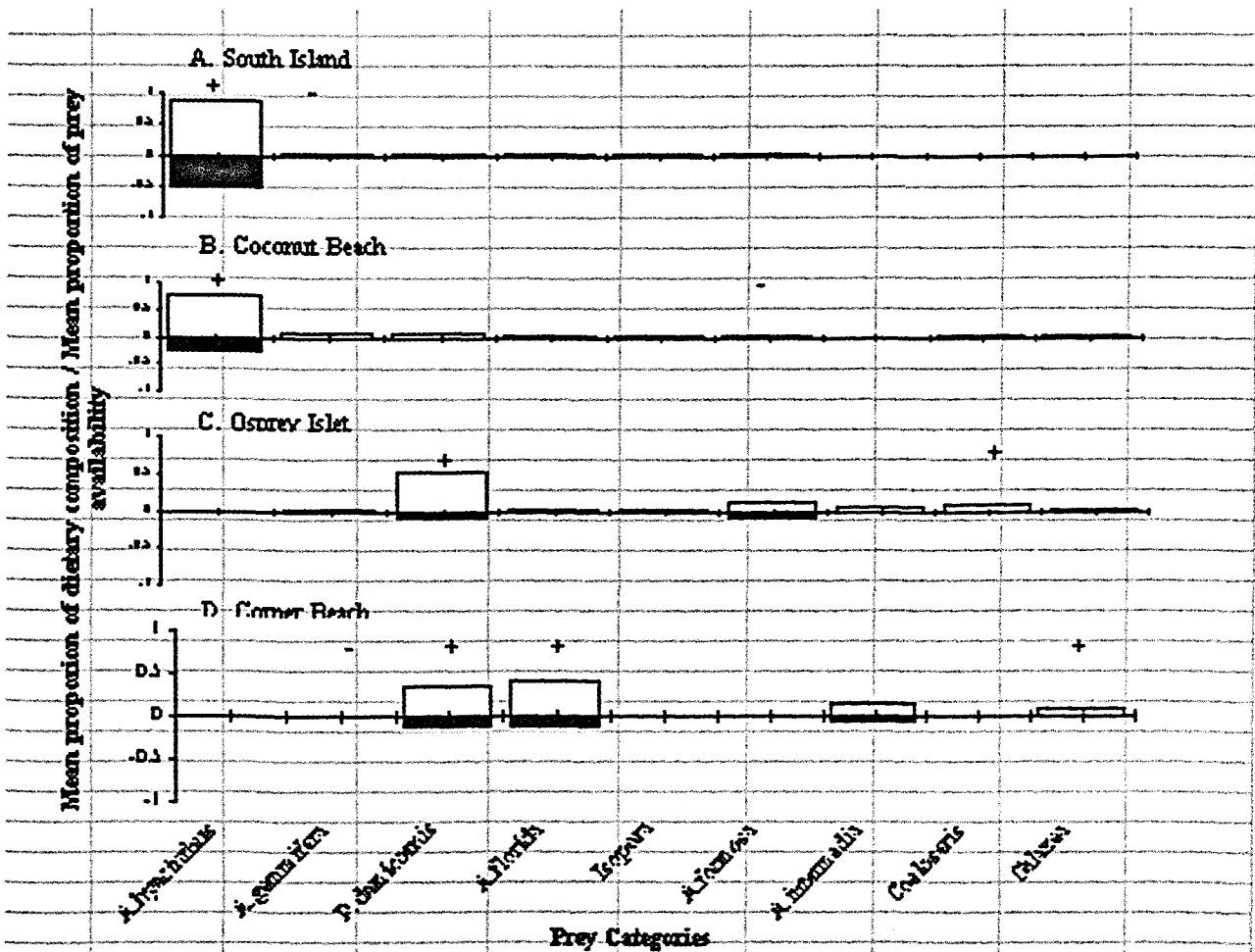


Figure 1. Electivity results for selected prey categories used by *C. baronessa* at four locations at Lizard Island. Positive values (white bars) are proportion of dietary composition based on total number of bites (ie., 1=100%). Negative values (grey bars) are proportion of availability based on total hard coral prey available. "+" symbols indicate taxa which were used significantly more than expected from their availability while "-" indicates significant avoidance of a particular prey category. Data are from three minute feeding observations (n=50).

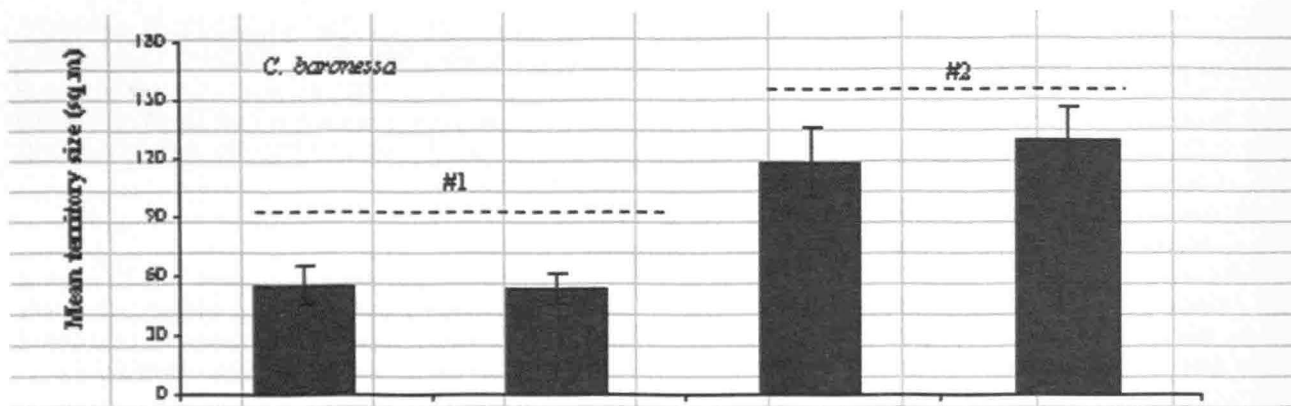


Figure 2. Mean territory size for butterflyfish from four locations at Lizard Island. Values are means and standard errors of estimates of foraging area (sq.m.) from replicate fifteen minute observations. ($n=10$). dotted lines indicate homogeneous subsets identified by Tukey's HSD post hoc test.

territory size at South Island was $55.3 (\pm 9.3 \text{ S.E.}) \text{ m}^2$ and at Coconut Beach was $53.9 (\pm 7.7 \text{ S.E.}) \text{ m}^2$. Corner Beach and Osprey Islet had mean territory sizes of $112.0 (\pm 17.8 \text{ S.E.}) \text{ m}^2$ and $125.4 (\pm 16.3 \text{ S.E.}) \text{ m}^2$, respectively (Figure 2). ANOVA results for territory size indicate that the difference is significant ($p < .001$) among sites. The two exposed sites were identified as a homogeneous subset post hoc by Tukey's test, as were Corner Beach and Osprey Islet.

Discussion

OFT predicts that when optimal prey is available in sufficient amounts, a consumer should selectively use this resource (Stephens and Krebs, 1986; Robinson and Wilson, 1998). If *A. hyacinthus* is an optimal resource, then *C. baronessa* is an optimal forager, as these results suggest that *C. baronessa* behaves in an optimal manner – specializing when optimal prey is abundant, and generalizing when optimal prey is not available. Other authors have predicted this 'flexibility' in optimal foragers (eg, Levins, 1962, 1968; Lowe-McConnell, 1996; Robinson and Wilson, 1998).

Foraging behavior may have implications in further areas, such as growth, reproduction, and survivorship (Sale, 1980). It is unlikely that diet alone would be responsible for variation in such major characteristics, but it is an important indicator that subtle variations in habitat (and subsequent variations in condition) could have impacts greater than previously expected. Gradients at larger scales have been documented in other characteristics such as abundance, growth, recruitment, and community structure (eg, Ogden and Ebersole, 1981; Done, 1982; Sale, 1984; Bell *et al.*, 1985; Choat and Ackerman, in prep.).

Variation in territory size of *C. baronessa* may also be explained in terms of OFT. Territory size is inversely related to optimal resource availability, while at the same time smaller territories are more aggressively defended. Similar relationships

have been found by other authors and suggest that the resource in question is energetically 'valuable' enough to justify the extra energy expenditure necessary to maintain such rigorous territories (Jones and Norman, 1986; Nakano, 1995; Righton *et al.*, 1998). It is likely that in sheltered sites, aggressively defending small territories is not a beneficial strategy. Perhaps the available prey is of insufficient quality, or perhaps it is an issue of quantity. Larger size of *C. baronessa* territories may be a function of suitable prey availability and basic energetic requirements of the fish (Hixon, 1980; Norman and Jones, 1984; Jones and Norman, 1986; Tricas, 1989; Righton *et al.*, 1998).

In summary, it is apparent that *C. baronessa* shows a difference in dietary preference as well as a difference in territory size. This could be due to a change in the fish's behaviour or due to the availability of prey in varying habitats. Butterflyfish provide an ideal vehicle for testing Optimal Foraging Theory, and further investigation into life history variations and experiments to determine the driving factors behind varying foraging behaviour is necessary to fully realise the implications of these varied behaviours.

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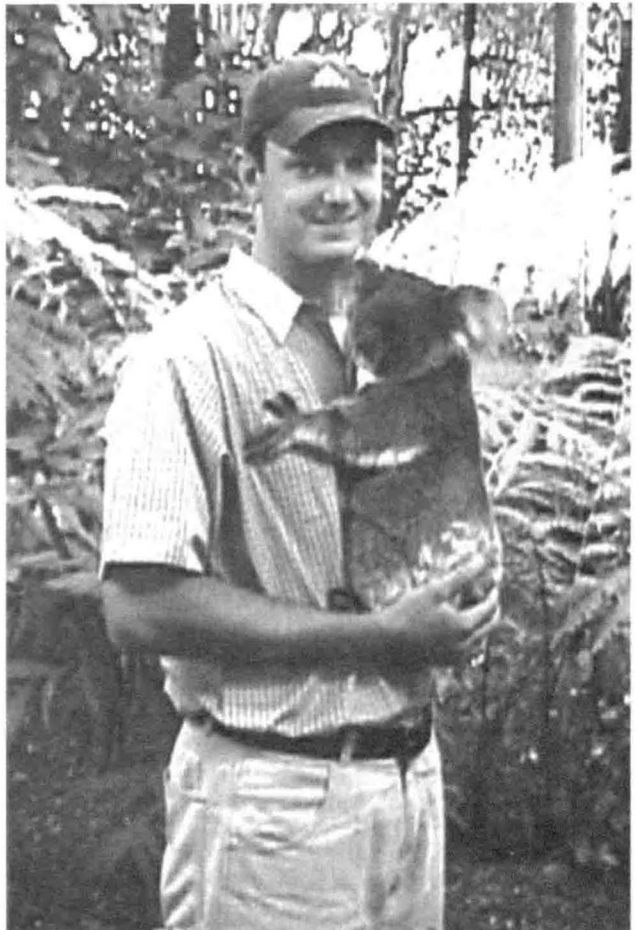
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Faculty comments:

Mr. Berumen's mentor, Raj Kilambi, had this to say about his student's work:

I have known Michael Berumen since he enrolled in my Fish Biology class in the spring of 1999. The main course material centered on fish population dynamics. Throughout the semester, I had the opportunity to get to know Michael in a more personal way. I frequently used his assignments as model examples for the class. He worked with a natural inclination for producing neat and accurate work. He treated seriously even minor homework assignments. It was apparent in our discourse that he appreciated the value of the methods we used to study population dynamics more than most students.



Michael Berumen and friend

In group work, including many of our labs, Michael demonstrated a very diplomatic ability to serve as a leader while openly receiving input from all members. Although sound in his own reasoning and problem-solving abilities, he nevertheless encouraged the whole group to consider the issues at hand and contribute ideas. From personal experience, I know that Michael actively seeks advice from other sources and gladly adopts suggestions for improvement in all manners of affairs.

My first experience with Michael's research abilities came soon with the class term papers. For his paper on various aspects of salmon life history he used original data from Australian journals to compare two populations of the salmon. He displayed a thorough understanding of the material and methods used by the researchers in this field. It is highly uncommon to encounter an undergraduate student with the ability to utilize primary sources and handle data in the manner Michael did, let alone encounter a student in his first year of college with this kind of proficiency.

Our conversations always came back to one subject: marine biology. He regularly would want to know how concepts and methods we studied were applicable in tropical or marine environments. He took the initiative to spend the past year in Australia exploring this new field for him. To obtain a strong foundation in the subject he had only independently studied previously, he enrolled in a full load of upper level classes at James Cook University. Having succeeded in these classes, he then arranged to remain in Australia and conduct independent research for a further 7 months.

Michael has returned an even more mature and developed scientist. I am now serving as his honors thesis advisor. His work demonstrates both a capacity for research and a mastery of his topic which involves foraging theory applied to butterfly fish. Recognition for his efforts has already begun as he has had papers accepted for presentation at two major international conferences, one in Indonesia and one in South Africa.

The research, which he has submitted here, represents only a small portion of his accomplishments. What is presented is quality work. This work is the foundation of his thesis in which he greatly expanded on these ideas. He has been recognized not only at these international conferences, but also by USA Today, which named him to the All-USA Academic Team this year. From the standpoint of someone who has spent a great deal of time in the field of fish biology, fish growth and population dynamics, I am confident in saying that Michael is doing great work here. His contributions are doubtless going to be meaningful and continuing in his field..

Morgan Pratchett, the faculty person who supervised Mr. Berumen's research at James Cook University wrote this about him:

I have known Michael for two years, since he enrolled in a final year Coral Reef Ecology course which I teach at James Cook University, Australia. Michael was clearly amongst the top students in this class, demonstrating an unsurpassable depth of knowledge and commitment to study. Michael was also a very well presented and articulate person, which was why I agreed to supervise him while he undertook a research project for the fulfilment of his honours degree.

During the course of his research project I worked very closely with Michael both as much as a colleague as his mentor, and I came to know him very well. Michael displayed considerable aptitude for scientific research, as he adopted a novel and ingenious approach to the research and completed his proposed project with considerable efficiency and apparent ease. Michael's thesis, which explored the ecological cost of differential prey availability for coral reef

dwelling fish, more than fulfilled the requirements for his honours degree and makes a substantial contribution to the field of foraging theory. Michael's research is leading to several major publications in internationally recognized journals, which would be highly commendable even for students at a Masters of Ph.D. level.

This research has considerable potential to alter the current perception of the role that particular fish play within the dynamics of coral reef ecosystems. I know that Michael had a great deal of difficulty selecting such a small portion of his work to submit to you. His research is broad and encompasses many components, all of which are highly relevant to his topic. I do believe that the piece he has submitted to you is sound and tells a nice story. It mirrors the bigger results which his project has thus far revealed. The research is far from complete, however, and I look forward to participating with Michael in the continued exploration of these areas. His fresh and confident approach to this work convinces me that he will continue to be successful as well.

VOLTAGE GATING OF A MODEL MEMBRANE SPANNING CHANNEL

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Abstract

Channels in cell membranes are important for intercellular communication and especially for the function of the nervous system in higher vertebrates. These channels consist of proteins made from the 20 common amino acids. Channel proteins are embedded into the lipid bilayer membranes of living cells and function by allowing the specific passage of a positively charged material such as sodium or potassium ions across the membrane in response to an external signal. The external signal is either a chemical signal or a voltage that regulates the opening and closing of channels. In an attempt to understand the voltage-dependent opening of channels (gating), we are investigating model membrane-spanning channels whose properties can be regulated by voltage. Our laboratory has developed the only chemically defined model system for which it is currently possible to investigate the structural basis for the voltage gating response at the molecular level. Our window into the gating process involves deuterium magnetic resonance spectroscopy. We use a small model channel system that we label with deuterium (heavy hydrogen) by specific chemical synthesis and then align in liquid-crystalline arrays of hydrated lipid bilayer membranes. The most novel aspect of this research is the ambitious goal of recording magnetic resonance spectra in the presence of a voltage across a stack of oriented, liquid-crystalline membranes. Experiments toward this goal will be described in our article. Accomplishments to date have prepared the way for the voltage-dependent magnetic resonance experiments. To this end, a series of gated and non-gated (control) channel-forming peptides have been designed, synthesized and incorporated into oriented, hydrated lipid/peptides samples. Spectra that define open and closed channel states have been recorded in the absence of a voltage. An important penultimate step has been the successful replacement of the water of hydration by glycerol in preparation for the voltage-dependent spectroscopy.

Introduction

Biological membranes consisting of proteins and lipids are a necessity for life because they separate the cell from the environment. Within each membrane are numerous channels and pumps, which allow the membrane to behave as a selective permeability barrier. Specific chemicals or physical stimuli can excite the channels in cell membranes. Once excited, the channels allow communication across the membrane. With small changes in the transmembrane voltage, it has been found that ion channels may respond by cycling between closed and open states (1), a process known as voltage gating.

The structural basis for gating is a significant unsolved problem in membrane biology. One source of insight into how ions are transported can be obtained from the study of model systems such as gramicidin A. Naturally, gramicidin is not voltage dependent. However, by changing the amino acid sequence, several gramicidin analogues have been engineered to be voltage-dependent (2). One such gramicidin channel was discovered in 1997 (3) and is the first voltage-dependent homodimeric gramicidin channel (4). In the homo-dimeric channel both gramicidin chains feature the same amino acid sequence. The channels lend simplicity for isotope labeling and magnetic resonance (MR) experiments and offer the first realistic possibility of doing structural experiments with a non-zero voltage across aligned membranes. The work completed to date has involved preliminary studies needed to perform voltage experiments.

Native gramicidin has the following sequence of amino acids: Formyl-VGALAVVVWLWLWLW-ethanolamine. The sequence alternates between D and L chirality where the D-amino acids have been underlined. To achieve voltage gating, the formyl-valine in the first position was dropped, making the peptides fourteen amino acids long, and the second and third positions were modified (Figure 1). The second position, referred to as the trigger position, was kept as formyl-glycine (control) or was dimethylated to formyl-Aib to induce gating (Figure 2). The Aib is abnormal because of its two protruding methyl groups. The third position, which we designate as the sensor position,

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was replaced with a deuterium labeled amino acid. Deuterated alanine and valine were chosen because they already appear in the native gA sequence and produce good spectra in oriented samples.

Solid state deuterium MR was used to observe and record the deuterium nuclei using the quadrupole echo sequence (5). Deuterium nuclei produce two signals that are equal in intensity and symmetric about a zero axis. The splitting between the two signals is related to the molecular geometry of the sensor amino acid (6).

Methods

Modified amino acids with either Fmoc or formyl groups were linked together using an Applied Biosystems 431A Peptide Synthesizer. Four analogues of gramicidin A were produced: f-Gly2-L-(Ala3-d4)gA, f-Gly2-L-(Val3-d8)gA, f-Aib2-L-(Ala3-d4)gA, and f-Aib2-L-(Val3-d8)gA. All of the peptides were fourteen amino acids in length with a deuterium labeled amino acid in the third position (Figure 1).

The peptides then need to be oriented and prepared for NMR. Each peptide was mixed with the lipid DMPC in a molar ratio of 4:80 moles. The peptide/lipid mixture was dissolved in a 1mL solution of 95% methanol and 5% deuterium depleted water. The mixture should be applied evenly over 40 glass plates (4.8 x 23 x 0.07 mm) and allowed to dry for 48 hours. When dried, the glass plates are hydrated with deuterium depleted water, stacked together, and sealed in a cuvette. Incubation at 40 C for 72 hours in a heating block allows the peptide molecules to orientate within the lipid bilayer. Once oriented, the samples are ready to be analyzed by solid state deuterium (2H) NMR. Phosphorous (31P) NMR also is used to monitor the alignment of the lipids.

Results and Discussion

The NMR data and spectra will be grouped and discussed according to whether the peptides contained deuterated alanine or deuterated valine. The first peptides to be discussed are those labeled with deuterated alanine.

The control peptide for these experiments was [f-Gly-L-Ala-d4]gA. The NMR spectra in Figure 3 are shown for two sample orientations, with the peptide long axis either parallel ($\theta=0^\circ$) to the magnetic field or perpendicular ($\theta=90^\circ$). Figure 3a illustrates the signal produced by alanine's backbone deuterium (A). It has a splitting of 208 kHz, and the signal produced by the methyl group (B) has a splitting of 33 kHz. Comparing this to Figure 3b, we find that the same peaks are present with half the splitting, characteristic of solid state NMR. The central peaks are due to randomly oriented material and water.

The other peptide labeled with alanine was [f-Aib-L-Ala-d4]gA. Its two spectra are shown as Figure 4a and 4b. Much like the f-Gly spectra, Figure 4a and 4b both illustrate the backbone

deuteron (A) and with almost the same splitting. The difference is in the methyl peaks (B). Figure 4a shows two methyl peaks with a difference of 6 kHz. If these two peaks are both signals from the methyl group, then they should also appear on Figure 4b but with half the peak separation, and they do. The methyl peaks (B) on Figure 4b have a separation of 3 kHz, half of that in Figure 4a. This implies that the bulky methyl groups on the Aib are causing the gramicidin to acquire two different conformations.

The two peptides that are labeled with deuterated valine are [f-Gly-L-Val-d8]gA and [f-Aib-L-Val-d8]gA. Figure 5a and 5b are the [f-Gly-L-Val-d8]gA spectra. Spectra for deuterated valine differ from alanine in that valine has individual deuterons attached to the beta carbon (B) as well as to the alpha carbon (A). There are also two protruding methyl groups (C), whose signals overlap and are compact in the center of the spectra. For Figure 5a and 5b, the individual deuterons, (A) and (B), are present in both; and characteristically, the splittings in Figure 5b are half of those in Figure 5a. The methyl groups (C) are compact in the center and are not resolved into distinct splittings.

Figure 6a and 6b illustrate the other valine labeled peptide, [f-Aib-L-Val-d8]gA. The single deuterons, (A) and (B), in Figure 6a and 6b are present and have almost the same splittings as those in Figure 5. The difference is in the methyl groups. The methyl peaks (C) in both Figure 6a and 6b are more distinct than those in Figure 5 and have a lot more separation. This reinforces what was said earlier. The f-Aib is definitely acting differently than the f-Gly, and it may be causing a second conformation for the gramicidin channel.

For a voltage experiment to be feasible, the water of hydration needs to be replaced with glycerol. Water has a high conductance and the excess heat will deteriorate the lipid and peptide when a voltage is applied (7). Samples with glycerol should not have this effect. A comparison between a water-hydrated and a glycerol-hydrated sample is shown in Figure 7 using the peptide [f-Aib-L-Ala-d4]gA. The two 2H NMR spectra are similar. Each spectrum has multiple peaks with similar quadrupolar splittings. Phosphorous (31P) NMR provides information about the lipid orientation. It is evident from Figure 8b that hydration with glycerol does not disrupt the lipid's orientation. In fact, the unoriented peak is much smaller in the glycerol sample. Glycerol is therefore a feasible alternative for hydrating the samples.

This project has completed all of the preliminary work needed prior to the actual voltage experiments. The information gathered has provided valuable insight and a firm foundation from which to continue. The spectra serve as references for comparison when the voltage experiments are initiated and provide information about the relationship between the labeled deuterons' orientation and the corresponding peak position. The NMR spectra also provide data for preliminary interpretations.

Different conformations and behaviors are already visible between the gramicidin analogues. The peptides containing Aib, for example, are showing evidence of at least two conformations. By following the fate of the deuterium signals from these conformations in the presence of transmembrane voltages of increasing magnitude, future researchers will begin to learn the structural basis for voltage gating.

Abbreviations

NMR	Nuclear Magnetic Resonance
Val (V)	Valine
Gly (G)	Glycine
Ala (A)	Alanine
Leu (L)	Leucine
Trp (W)	Tryptophan
Aib	Aminoisobutyric acid
gA	gramicidin A
HPLC	High Performance Liquid Chromatography
DMPC	dimyristoylphosphatidylcholine (14:0)
DOPC	dioleoylphosphatidylcholine (18:1)

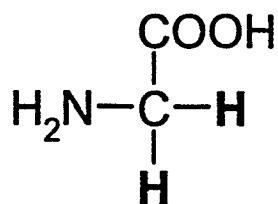
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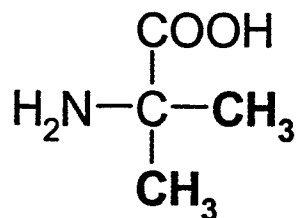
Figure 1: Amino acid sequence for the four synthesized peptides and native gramicin A.

		Sequence														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
#1	a		f-Aib	A	<u>L</u>	A	<u>V</u>	V	<u>V</u>	W	<u>L</u>	W	<u>L</u>	W	<u>L</u>	W
	b		f-G	A	<u>L</u>	A	<u>V</u>	V	<u>V</u>	W	<u>L</u>	W	<u>L</u>	W	<u>L</u>	W
#2	a		f-Aib	V	<u>L</u>	A	<u>V</u>	V	<u>V</u>	W	<u>L</u>	W	<u>L</u>	W	<u>L</u>	W
	b		f-G	V	<u>L</u>	A	<u>V</u>	V	<u>V</u>	W	<u>L</u>	W	<u>L</u>	W	<u>L</u>	W
Native gA		f-V	G	A	<u>L</u>	A	<u>V</u>	V	<u>V</u>	W	<u>L</u>	W	<u>L</u>	W	<u>L</u>	W

Figure 2

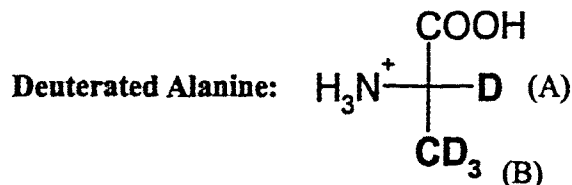
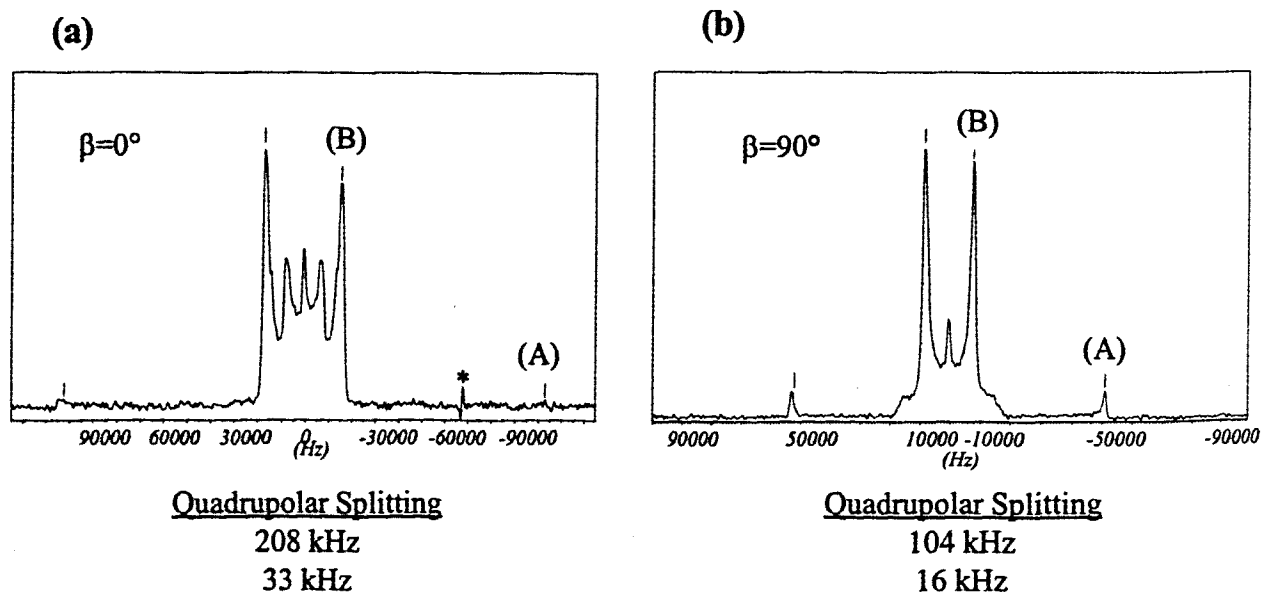


Glycine



Aib (Aminoisobutyric Acid)

Figure 3: [Formyl-Gly-L-Ala-d₄] gA



* Artifact from NMR

Figure 4: [Formyl-Aib-L-Ala-d₄] gA

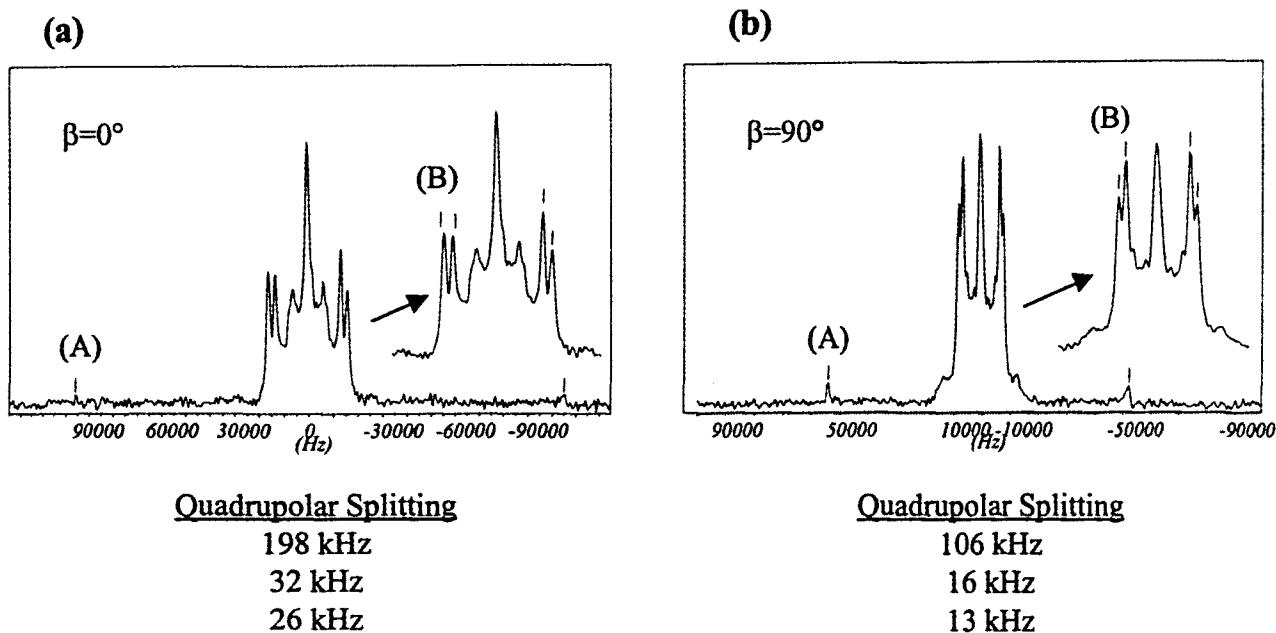


Figure 5: [Formyl-Gly-L-Val-d₃] gA

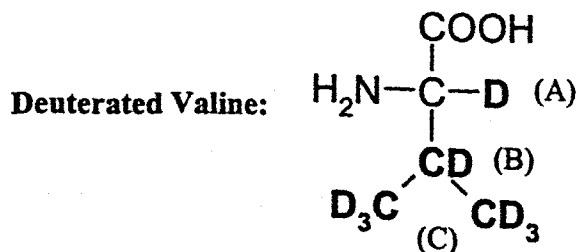
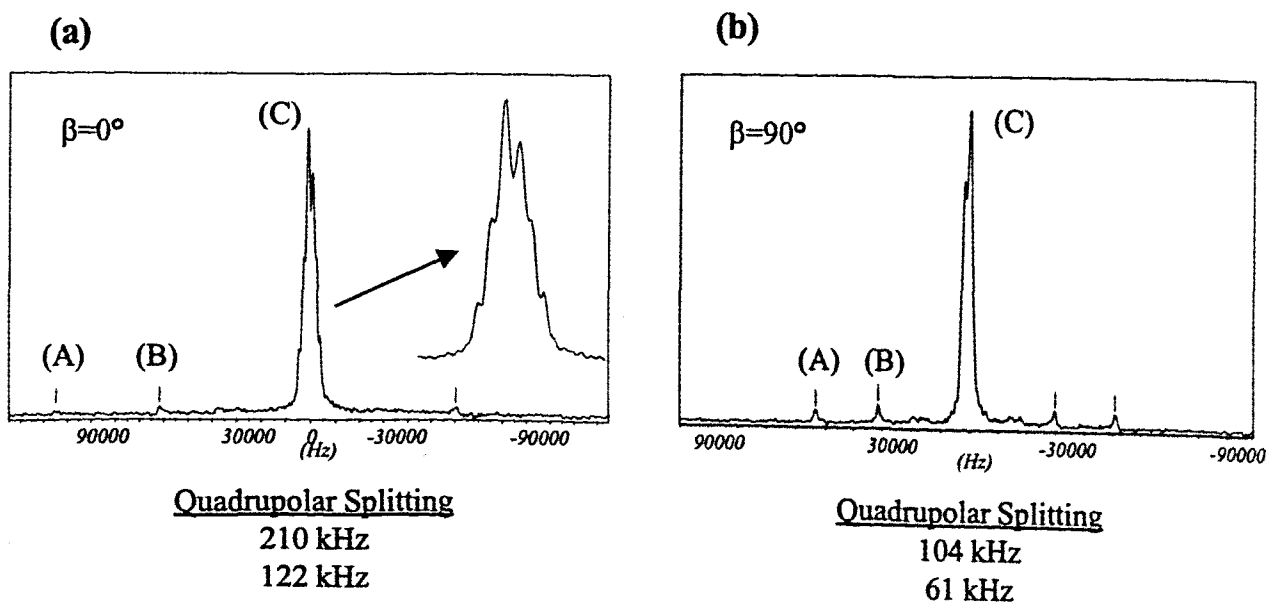
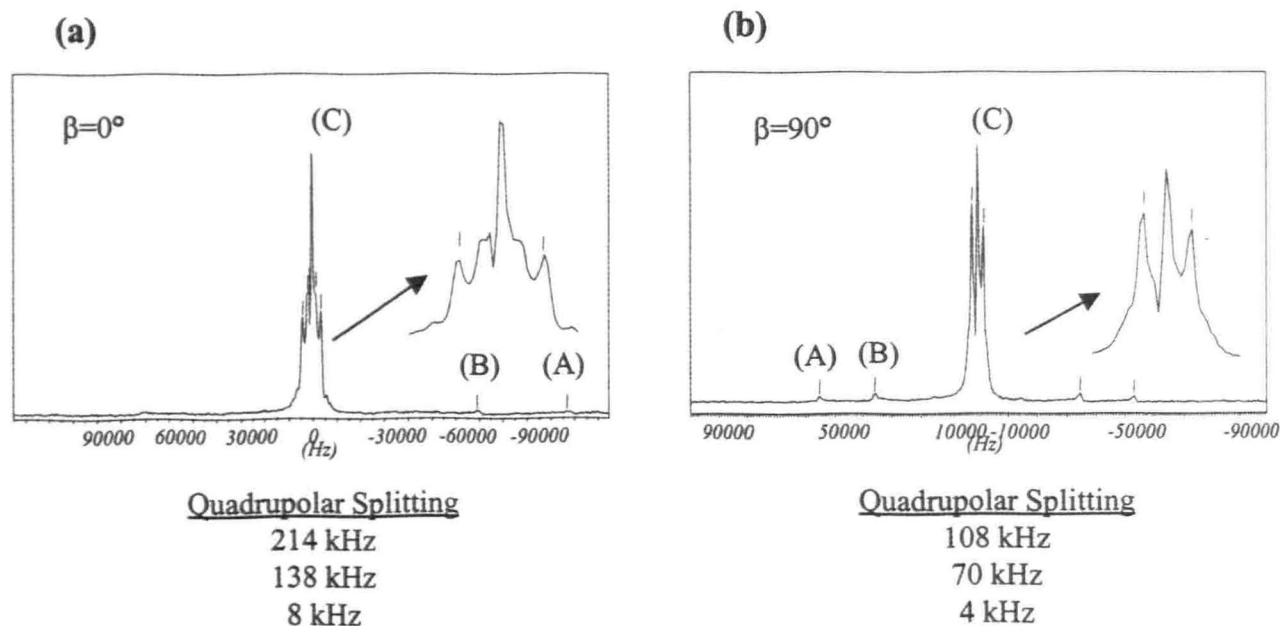


Figure 6: [Formyl-Aib-L-Val-d₈] gA**Faculty comments**

Mr. Miller's mentor, Roger Koeppe, gives him extraordinary credit for contributing significantly to the department's research efforts through his research. He says:

While I have advised many talented undergraduate research students through the years, Eric's project is the most innovative that I have seen by an undergraduate student during my career.

He was awarded a nationally competitive Pfizer Fellowship for this work. Eric has presented his exciting results both at Pfizer headquarters in Groton, Connecticut, in October, 2000, and at the annual national meeting of the Biophysical Society in Boston, Massachusetts, in February, 2001. The foundation that Eric has established has given my laboratory the best possible chance to date for understanding the conformational transitions (i.e., structural rearrangements) that accompany voltage-dependent opening ("gating") of a membrane-spanning channel of known structure at the molecular level. (Since we will not insist on keeping him here following his graduation in May, Eric's fine work will be extended by graduate student Sigrid Schmutzer as part of her Ph.D. thesis.)

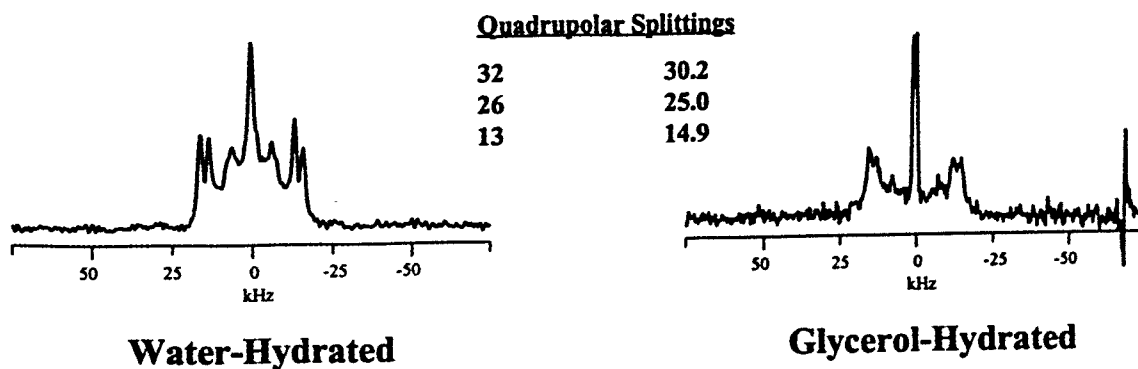
Eric is a delightful, motivated, hard-working and imaginative student. His research project is highly challenging, in both concept and execution. Admittedly, some of the background for Eric's project was in place even before his arrival in our laboratory.



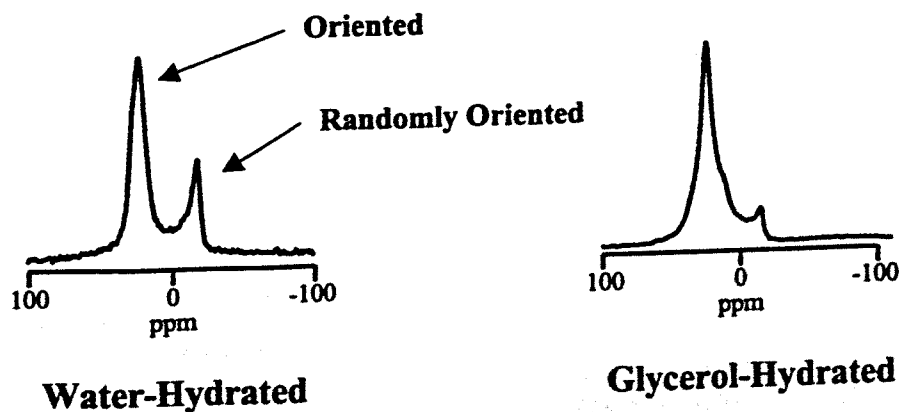
Eric Miller

Figure 7: Comparison of Water-Hydrated versus Glycerol-Hydrated [formyl-Aib-L-Ala-d₄]gA samples using (a) ²H NMR and (b) ³¹P NMR

(a) ²H NMR Spectra



(b) ³¹P NMR Spectra



We had discovered the first gramicidin peptides that gated as homodimers instead of heterodimers, and the observation raised the possibility of characterization by magnetic resonance. But it was Eric who seized this opportunity, developed and synthesized appropriate deuterium-labeled peptides, performed the deuterium magnetic resonance measurements, and turned a phenomenon into an experimental reality. With Eric's very significant progress on sample development and methods development, we are now near the very difficult goal of "voltage-dependent" magnetic resonance experiments (in which an alternating electric field must be established across oriented membranes inside a superconducting magnet).

Our laboratory now occupies a fortunate position. Because of our unique opportunity for characterizing for the first time the molecular details of voltage gating, our laboratory is envied as well as respected within the international biophysics community. I cannot say enough about Eric's contributions to this favorable situation: Without his undergraduate thesis work, we would not be now poised to solve this molecular gating problem. Only Eric's impending graduation (and subsequent graduate study in another prestigious chemistry department) will preclude his seeing the forthcoming voltage-dependent magnetic resonance experiments to their ultimate conclusion. Others will enjoy the benefits of the groundwork that he has prepared and will have the privilege of being coauthors with Eric at the time of publication.

In summary, Eric Miller is imaginative in experimental design and productive in performing experiments in the laboratory. His contributions to our research efforts on voltage-dependent gating of channels have been outstanding.

A member of Mr. Miller's honors committee from the Department of Biological Sciences, C. L. Sagers, is also very complimentary. She says:

I met Eric nearly two years ago in a course I was teaching in evolutionary biology and I now serve as a member of his honor's committee. Eric's honors work focuses on understanding voltage dependence of gramicidin A channels. I now find this project especially engaging (a credit to Eric's teaching skills) even though it is far afield of my research specialty. From my view, Eric is addressing in his undergraduate research a series of weighty questions. The Koeppe lab has found that gramicidin channels may be engineered to be voltage-dependent, and that these may be used as a tool to understand channel gating in non-zero voltage. Eric has made remarkable progress in characterizing these phenomena and has presented a draft of the results to his committee. Through this project, Eric has honed his laboratory and analytical skills, and has proven to be talented as a writer. His successes in his undergraduate research suggest that

Eric has the potential to become an exceptional young scientist.

Beyond his academic accomplishments, Eric is one of the more mature and poised students that I have met on this campus. Interacting with him is always a pleasure and whether the discussion centers on interpreting NMR spectra or the behaviors of Labrador Retrievers, I usually learn a little something.

Donald Bobbitt, chemistry professor and Associate Dean of Fulbright College, also worked with Mr. Miller and shares the views they expressed. He says:

I am writing to offer my strongest recommendation for Mr. Eric Miller in support of his manuscript under consideration for publication in *Inquiry*. I am familiar with Eric's credentials and capabilities through the classroom, and from having served as the Director of the Department of Chemistry and Biochemistry's NSF-supported, 2000 Research Experience for Undergraduates site project. Eric was a participant in that program but raised his own funds through his successful competition for a prestigious Pfizer Undergraduate Research Fellowship.

Eric is a very gifted student; his intellectual abilities clearly place him in the top one percent of students I have observed over the past fifteen years. What truly makes Eric special is that he combines these substantial intellectual capabilities with an exceptional work ethic. He is quick to accept challenges and will work hard to meet them. Further, Eric has a caring and easygoing personality; he is a pleasure to know and work with. I am positive he will be extremely successful at whatever he chooses to do after his graduate work.

As mentioned, during the summer of 2000 Eric participated in the Department's summer research program. Eric, working with Professor Koeppe, accepted a very significant and challenging research problem. At the conclusion of the summer, each student had to write up their results in a journal format, and present their findings in a departmental seminar. Eric's performance on both of these tasks was exceptional. He demonstrated a profound understanding of the problem, and was able to produce meaningful results in only eight weeks. His presentation was clear and focused. I would rate his performance as being similar to that expected of a second year graduate student rather than that of an undergraduate researcher. His research has progressed exceptionally well since that point and I am positive his work will be an important and original contribution to the journal.

AN ANALYSIS OF UNSOLVABLE LINEAR PARTIAL DIFFERENTIAL EQUATIONS OF ORDER ONE

by Laura J. Fields
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Fulbright College of Arts and Sciences

Faculty Mentor: Loredana Lanzani
Department of Mathematics

Abstract

It is difficult to underestimate the importance of differential equations in understanding the physical world. These equations, involving not just simple variables like temperature, speed or mass, but also the derivatives, i.e. the rate of change of these variables, are found in nearly every branch of science. Until the mid 20th century, all such equations were thought to be solvable. This was based on the discovery by Leonard Euler that certain differential equations, called ordinary differential equations (ODEs), are indeed always solvable. While ODEs deal with simple conditions, under which some quantity changes with some other quantity and its derivatives, there are more sophisticated differential equations known as Partial Differential Equations (PDEs), which describe how one quantity changes with respect to two or more other quantities and their derivatives. The hopes of an entire generation of mathematicians were dashed when it was discovered that there exist very simple linear PDEs that are unsolvable – and thus the worst objects that a mathematician could possibly face. It is the goal of this research to present one such example in a form accessible to anyone who has a basic knowledge of differential equations. Understanding of such equations is an extremely important step in developing numerical methods for estimating the extent to which PDEs may not be solvable, thus giving scientists valuable tools in unlocking the secrets of the physical world, many of which are hidden in Partial Differential Equations.

Introduction

Most undergraduate science and engineering majors are familiar with the topic of differential equations. These mathematical objects are found in every branch of science, modeling real-life events such as radioactive decay, population growth, heat flow, stock market fluctuations and much more. The ability to solve a differential equation means being able to predict the behavior of the phenomenon the equation describes, and the more accurately a differential equation models the

phenomenon, the closer the prediction will be to the future outcome. Many times, the number of parameters involved in an accurate description of an event is so large that the functions involved depend on more than just one variable. In this case, the mathematical model involves *partial derivatives* of the unknown function, thus giving rise to *partial differential equations*.

Depending on how the unknown function and its derivatives occur in the mathematical model, one can have different kinds of differential equations. In this work, we are interested in the most elementary type, namely, the so-called *linear differential equations*. Undergraduate students are very familiar with the solution method of linear *ordinary differential equation* (ODE), i.e. models for events depending on just one variable, such as time or temperature. The solution method of linear *partial differential equations* (PDEs) resembles the method for linear ODEs, but only to a certain extent. In the late 1950's, it came as a great surprise to the mathematical world when Hans Lewy showed that there exist very simple but striking examples of linear PDEs of order one which are not solvable. This is in great contrast to the case of linear ODEs.

It is the goal of this research to give an easy to understand presentation of one such example. Although the proof that this equation is unsolvable relies heavily on subtle techniques of complex analysis, we have made every effort to convey the fundamental ideas in a manner accessible to any undergraduate student with a basic familiarity with differential equations.

Classical Methods of Solving Partial Differential Equations

A linear ODE of order one is an equation of the form

$$h'(x) + p(x)h(x) = g(x) \quad (0)$$

where $p(x)$ and $g(x)$ are given functions and $h(x)$ denotes the unknown function (and $h'(x)$ denotes the derivative of h). Under minimal assumptions on the coefficients $p(x)$ and $g(x)$, one can show that all solutions h can be explicitly represented as an integral involving p and g .

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A linear PDE of order one takes the form

$$a(x,y)(fu/fx) + b(x,y)(fu/fy) + c(x,y)u = f(x,y) \quad (1)$$

where, once again, $a(x,y)$, $b(x,y)$, $c(x,y)$ and $f(x,y)$ denote given coefficients, whereas u denotes the unknown function. If a , b , c and f are reasonably smooth real-valued functions, it is possible to show that there is always a change of variables from (x,y) to, say, (ξ,η) , such that with respect to the new variables, (1) takes the equivalent form

$$(fu/f\xi) + c(\xi,\eta)u = f(\xi,\eta) \quad (2)$$

Note that, with respect to the variable ξ , equation (2) is now, formally, just the same as the ODE (0), so that one can solve (2) using methods for Ordinary Differential Equations. However, matters are completely different if one allows at least one of the coefficients of (1) to take complex values, as it may no longer be possible to perform an "ad hoc" change of variables. The next section will examine such an example.

An Example of an Unsolvable Partial Differential Equation

We now consider the following equation:

$$(fu/fx) + ix(fu/fy) = f(x,y) \quad (3)$$

where i denotes the imaginary variable ($i^2 = -1$), and f denotes a function to be suitably constructed as follows. First consider an infinite sequence of points $\{x_n\} = x_1, x_2, x_3, x_4, \dots$ which tend to zero as n goes to infinity. One could, for example think of x_n as $1/n$ or $(1/2)^n$. Now consider a sequence of closed, non-intersecting discs, D_n , each of which is centered at the corresponding points x_n . Since these discs must not intersect one another, their radii must get smaller and smaller as they approach the origin. By using a procedure known as the "convolution integral," we then construct a function $f(x,y)$ such that:

- (a) $f(x,y)$ is an even function of x . That is, $f(x,y) = f(-x,y)$ for all x , regardless of y .
- (b) $f(x,y) = 0$ whenever (x,y) is not in any of the little discs D_n .
- (c) The integral of f is non-zero over each disc D_n .

We now show that for such a choice of the datum f , the equation above is *never* solvable. To begin, we observe that any function, w , can be written as the difference of an even function u^e and an odd function u^o (by odd function, we mean $-u(x,y) = u(-x,y)$; for example, the function ix is odd, since $i(-x) = -(ix)$). Next, by applying the definition of derivative, it is easy to show that the derivative of an odd function is even and the derivative of an even function is odd. Finally, we mention that the product of two even

or two odd functions is even, whereas the product of an even function and an odd function is odd. We now apply all of these facts to the solution $w(x,y)$ with respect to the variable x , i.e. we write w as the sum of an even function of x and an odd function of x (no requirements on y). We obtain

$$w(x,y) = u^e(x,y) + u^o(x,y) \quad (4)$$

This leads to:

$$(fu/fx) + ix(fu/fy)^e = f^e = f \quad (5)$$

where the second equality follows in equation (5) by property (a), and by the observations on even and odd functions mentioned above, we note that if w solves (3), then u^e solves

$$(fu^e/fx) + ix(fu^e/fy) = f(x,y) \quad (6)$$

We now want to show that (5) has no solution u^e with continuous partial derivatives in any little disc centered at the origin. To this end, we begin by supposing, to the contrary, that there is such a solution. We will then show that this would violate property (c) of the definition of f .

Notice, for future use, that an important feature of odd functions is that they must vanish at the origin. Indeed

$$u^o(0,y) = -u^o(-0,y) = -u^o(0,y) \quad (7)$$

And hence:

$$u(0,y) = 0 \quad (8)$$

Now we introduce a substitution of variables in the right half space from (x,y) to (s,y) , namely $s = \sqrt{x}$, such that in the new variables (s,y) equation (6) becomes

$$(fU/fs) + (fU/fy) = F(s,y) \quad (9)$$

Where U and F is obtained from u^o and f via the change of variable; F still satisfies the properties (a)-(c) with respect to a new series of sets, \tilde{D}_n , which are obtained from D_n via the change of variables from s to x . The main advantage in going from (6) to (9) is that this new form of the equation is "more symmetric," i.e. the coefficients of U/fs and U/fy only differ by the constant i rather than the function ix . This fact has a major bearing on the main features of U . Indeed, equation (9) implies that U is now a so-called *analytic function* with respect to the complex variable $s+iy$ in the region where F vanishes, in particular, outside of the \tilde{D}_n 's. The main drawback in going from (5) to (7) is that now U is only defined on the right half-plane, whereas u^o was defined in the whole of the plane. Note that property (6) is preserved under the change of variables. This, together with the fact that U is analytic allows us to apply a famous theorem from Complex Analysis (the "Reflection Principle for Analytic Functions") to conclude that U is actually well defined and analytic on the left half plane as well. Property (8) now forces U to be zero in a little disc centered at the origin (this is another consequence of the

properties of analytic functions, namely the fact that the so-called zero set of an analytic function must be *discrete*). At this point, we apply the famous *Green's Identity*, which, roughly speaking, states that the integral of the derivative of a function over a region is equal to the integral of the function over the boundary of the region. In our particular case, this means that the integral over some disc \bar{I}_n of the function F is zero, contradicting part (c) in the definition of f . Thus, a continuously differentiable solution of (9) and thus of (3) does not exist in any neighborhood of the origin.

Faculty comments

Loredana Lanzani, Ms. Field's project mentor, made the following comments regarding this project:

I have known Laura since January 2000, when she took in my advanced undergraduate Complex Analysis course for Mathematics and Physics majors. Although all the students in the class had been carefully selected and proved to be unusually talented and dedicated, Laura was, by all measures, the very best. I was impressed by the depth of her mathematical reasoning and by her ability to apply the new mathematics notions she had just learned to problems in Physics and Engineering, one of the main goals of this course.

Laura showed so much promise that I thought it might be a good idea to get her involved in an undergraduate research project under my direction. In order to help Laura build the sophisticated mathematics skills she would need for the project, and wishing to protect her from stressful competition against the more mature graduate students, I suggested that she audit the graduate complex analysis course that I was going to teach the next fall. I thought that this might allow Laura to benefit from my lectures on a topic I believed to be too difficult to manage for an undergraduate student. It would also exempt her from having to deal with the difficult weekly homework assignments that I took mostly from the fundamental text, *Complex Analysis*'s by L. Ahlfors—a strenuous but instrumental step in the preparation of our graduate students for the comprehensive exams.

With her typical understated pragmatism, Laura decided, instead, that she might as well register to the course. This was indeed a good decision since Laura turned out to be, once again, among the very best in the class. Laura's excellent talent for mathematics was confirmed one more time. Not only was she not in the least intimidated by her graduate student classmates (and I should add that this was an unusually good and large class), but she often came up with very nice and original ideas for the solution of the homework assignments and in-class test problems. By the end of December Laura was ready to embark on her project, which involved a thorough study of ground-breaking

research papers and a firm grasp of the interplay of two different areas of mathematics: Partial Differential Equations and Complex Analysis. Laura has now achieved a full understanding of all the main points of the proofs in the papers and by now I know her too well to be surprised by her originality, independence and enthusiasm. Yet when I read her manuscript I was amazed by her ability to integrate all the guiding principles of this project into a succinct yet simple and compelling reading. Laura has made this professional-research-level, highly technical and difficult material understandable, indeed enjoyable, by any undergraduate student with a basic knowledge of differential equations and a minimal interest in mathematics and its applications. I would not be surprised if, after reading this paper, more than one student gained refreshed interest and enthusiasm for mathematics.

The challenge of communicating advanced mathematics in a clear yet unthreatening and appealing manner is only too familiar to the professionals in the field, and it is perhaps the main reason why mathematics is often an unpopular subject in our culture. In this respect, I feel that Laura J. Fields has successfully completed the most ambitious project I could hope to expect from an undergraduate student.

William Oliver, vice-chair of the physics department, knows Ms. Fields well and is very complimentary about her research abilities. He says:

I would like to give my highest endorsement of the research project of Ms. Laura J. Fields, a Bachelor of Science Physics and Mathematics. Indeed it is an honor to do so! Ms. Fields holds the prestigious Sturgis Fellowship in our J. William Fulbright College of Arts and Sciences. Two years ago she was selected as the recipient of the Fulbright College Presidential Scholarship. In addition, she was awarded a Stevens Foundation award for academic excellence and most recently a Science Information Liaison Office Student Undergraduate Research Fellowship and the prestigious Barry M. Goldwater Fellowship. Laura is a brilliant young student and a wonderful person, and it is my great privilege to work with her as advisor and research mentor. I am completely confident that she will fulfill her desire to become a successful physicist, and whether she chooses academia or industry, she will be a great role model for women in science.

Ms. Fields had not yet declared a major when she enrolled in the honors section of our department's *University Physics I* course. Midway through the semester she had captured the attention of the professor for the course, who told me she was one of the strongest students that she had seen. I contacted Laura and began a dialog with her about physics in general as well as our programs for undergraduates. To my delight she formally declared a major in physics during the spring of 1999 and I have served as her

departmental advisor since that time.

During the fall semester of 1999, Laura took *University Physics I* and an *Intro to Electronics* course from me. She finished each course at or near the top of the class. She was the most diligent student in the electronics course—a course that requires a large measure of self-motivation and discipline—and she seldom missed any points on the exams. Professor Stewart tells me that she was a delight to have in *University Physics II* and that her honors project was well executed and “refreshingly well written.” I asked my colleague, Dr. Fihpkowski, how Laura did in her first 3000-level course (in *Modern Physics*) and was told that she had a perfect score. Laura has continued to set a standard of excellence in her studies. Academically, Ms. Fields is a superlative student.

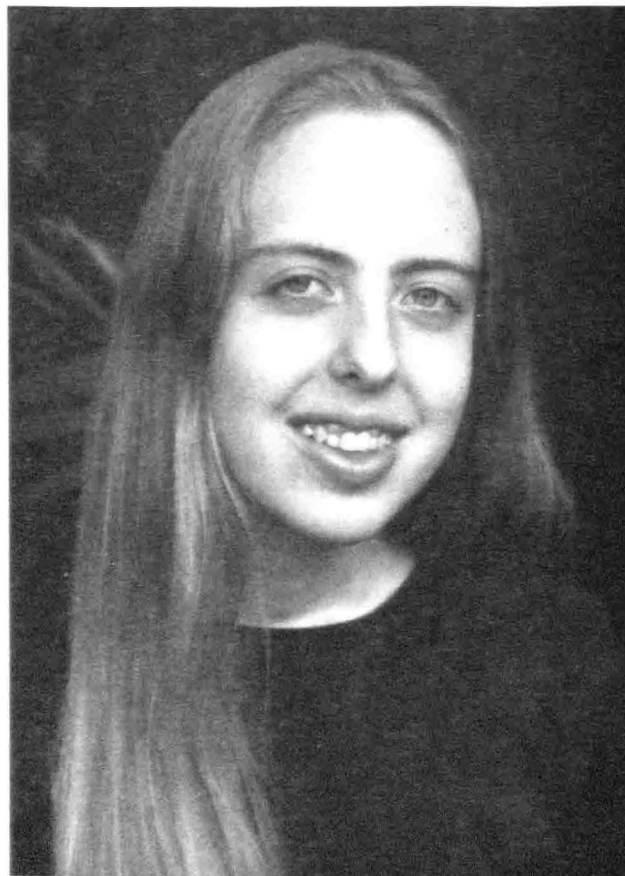
Laura is also a wonderful person to be around. She is always very polite and friendly; she interacts well socially and academically with her peers, and has taken an active role in all aspects of our department’s programs. Currently, she is serving as president of our chapter of the Society of Physics Students. Laura has provided me with invaluable feedback and insightful comments about our department and our courses. This has often been of great help in carrying out my duties as Vice Chair of the department.

Finally, I would like to comment on Laura’s research capabilities and potential. Two summers ago, she participated in a summer NSF-REU program in Alaska on atmospheric physics and her research advisor there had stellar things to say about her. Last summer, she was accepted into all of the REU programs that she applied for, including that at the Smithsonian Astrophysical Observatory at Harvard, which she turned down to accept a summer research position at CERN in Geneva, Switzerland, a world-class research center for particle and nuclear physics. Before going to Geneva, Laura participated in a European Studies tour of Europe sponsored by the Fulbright College. During these two experiences, Laura gained both confidence and valuable experience in traveling and living abroad. She also began to narrow her research interests toward particle astrophysics, although I sense that she is still exploring different areas of physics to some degree.

During the spring of last year, she began an honor’s research project under my direction on a biophysical topic involving light scattering studies of protein denaturation. She was in Little Rock with her family for the break when she contacted me to find out when we could begin. I told her that any time was fine with me and she immediately drove (3.5 hours) to Fayetteville and showed up in my office. To start, I asked her to do a literature search on dynamic light scattering and proteins. Two hours later she returned with over a hundred references, each marked with information as to which library they were in. We

looked them over to choose those most appropriate for our project and the next morning she was in my office with photocopies, asking questions about what she was reading. This is typical of Laura! She is highly motivated, self-disciplined, and has excellent time management skills. In contrast to her peers, her successful SURF/SILO proposal was finished almost two weeks before its deadline last fall. As she has continued on this project, Laura has demonstrated the self-motivation, tenacity, and creativity necessary for successful research. For the first time in my laboratory, we are now measuring reliable diffusivities for proteins in solution as well as protein sizes, all as a result of Laura’s hard work.

From my interactions with Sturgis, Chancellor, and other fellowship awardees and from my experience sitting on many honor’s thesis committees, Laura Fields is ranked with the absolute best of our University’s students.



Laura Fields

INTRACTABILITY AND UNDECIDABILITY IN SMALL SETS OF

WANG TILES

by Adam DeLisse
Department of Mathematics
Fulbright College of Arts and Sciences

Faculty Mentor: Janet C. Woodland
Department of Mathematics

Abstract

Imagine a never-ending checkerboard, red and black squares alternating forever in every direction. Now close your eyes, wait for a second, and open them again. There is still the checkerboard, but is it different? Has somebody moved the checkerboard over two squares? Four squares? One million squares? It still looks the same. This is the nature of periodic tilings. Wang tiles are squares, much like the red and black ones used on a checkerboard, except Wang tiles have colors on their edges instead of on the whole square. Also, Wang tiles can only be put edge-to-edge with each other where these colors are the same. So what's so special about Wang tiles? If you cover the infinite plane with certain sets of Wang tiles, close your eyes, and open them again, you will always be able to tell if it has changed. In these sorts of tilings, there is always something that does not quite overlap when moved any amount in any direction. This is the nature of aperiodic tilings. The smallest known such set of Wang tiles has thirteen tiles. This paper computationally explores sets of six, seven, and eight Wang tiles, looking for the same aperiodic structure.

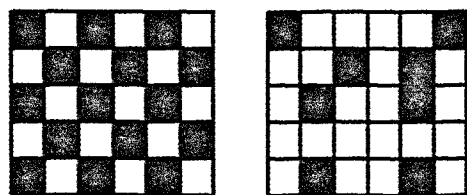


Figure 1. Periodic and non-periodic

To humans, the most important foundation for order is the establishment of patterns. The recognition of patterns is one of the traits that set us apart from the animals. In effect, the fact that we can do mathematics sets us a step above the animal kingdom, for mathematics is the science of patterns. Take, for example, the two patterns shown above (Figure 1). The pattern on the left is highly recognizable as a checkerboard pattern, and we are comfortable with its familiar pattern, even if it were to extend

infinitely. However, the pattern on the right looks somewhat alien and strange because your brain is not instantly able to find a relationship between the squares. In the branch of mathematics known as tilings, we call the pattern on the left a periodic pattern, because we can find an infinite set of translations that leave the tiling unchanged. For example, in the case of the checkerboard, we could move the infinite tiling two squares in any of four directions, and an observer who had not seen the movement would not be able to tell that anything had changed. However, if an infinite extension of the random tiling on the right were moved any distance in any direction, an observer would be able to tell that the tiling had changed, even if they had not seen the actual translation. These sorts of tilings are called non-periodic.

What happens when an infinite extension is not even possible? If I give you a set of tiles, what we call a 'protoset,' could you even tell me if you can use the tiles to tile infinitely, cover the entire Euclidean plane? This problem is known in mathematics as the Domino Problem. Certainly, if I gave you the black and white squares used in the checkerboard (Figure 1), you could tile those forever (I imagine a 1950's diner with an endless floor). This means that the Domino Problem is decidable for certain sets, that is, given certain protosets can easily show that the tiles can cover the plane forever. However, if this is the case for all sets, then each would have a compact fundamental domain, a finite, closed, continuous piece of the plane that contains a single copy of the most basic building block of the infinitely repeating pattern. In the case of the checkerboard, an example of a fundamental domain would be a black square next to a white square, and this pattern covers the infinite plane. However, in 1966, R. Berger gave a protoset of over twenty thousand tiles that admitted a tiling of the plane, yet had no compact fundamental domain, thus, proving that for a general protoset, there could be no algorithm to decide whether the given protoset admits a tiling of the infinite plane. Berger's protoset was the first aperiodic protoset, a set of tiles that does admit a tiling of the plane, yet only gives a non-periodic structure.

In the field of aperiodic tilings, the search continues for aperiodic sets of manageable size, since Berger's twenty-

thousand-tile set was unwieldy even for a computer. Currently, there are different aperiodic protosets having just two tiles by Penrose, Amman, and Goodman-Strauss, but the search for such sets has never been approached systematically. In this paper, what we are looking for is a small set of a certain type of tiles that can only tile non-periodically. For this purpose, we have designed a computer algorithm to take a given set of these certain types of tiles, and in a sense, categorize it. Protosets can be classified into three behaviors: non-tiling, periodic, and aperiodic. The first two categories are decidable under the Domino Problem, that is, we can write a computer algorithm to model the tiles and have an outcome that the protoset either does not tile the infinite plane or has a compact fundamental domain. The third category will, however, confuse the computer algorithm, as it will tile forever, yet the computer will not be able to recognize any distinguishable pattern. A slight variation on the second possibility would be a periodic tiling, but the size of the fundamental domain has a combinatorial complexity vastly more complicated than one would expect given the combinatorial complexity of the protoset itself. Although these fall under the periodic category, they are interesting in that they also might be able to confuse the computer. These types of tilings are called intractable.

The method for construction of aperiodic tilings dealt with in this article is known as Wang tiles. They are unit squares, similar to the ones covering the checkerboard, with the twist that Wang tiles have their edges colored and can only touch other Wang tiles where the colors match. These are the types of tiles that were used in the original aperiodic set of over twenty thousand tiles. Thinking in terms of colored edges, it is very easy to extend the matching rules of Wang tiles to let two edges meet not only where the two colors are the same, such as two red edges meeting, but also where one color is a primary constituent of another, such as red and purple (red + blue) edges meeting. Henceforth, the original definition will be referred to as strict Wang tiles, while the extended definition will be referred to as loose Wang tiles. This extended definition allows for greater flexibility in tiling the plane since it allows for lack of transitivity between tiles. In strict Wang tiles, a red edge could only meet a red edge, so if tiles A, B, and C had red edges, any of those edges could join with either of the other two. However, in loose Wang tiles, tile B might have an orange edge and tile C might have a purple edge, so although tile A's red edge could meet both of them, B and C could not connect at those two edges.

The first and foremost goal of this research is to explore the structure of small sets of loose Wang tiles with a new algorithm for categorizing protosets. We hope to find a small set that confuses the computer algorithm and could therefore be classified as intractable. From a theory by Robinson [2] saying that no aperiodic set has fewer than four tiles, and knowing that the smallest known aperiodic set of Wang tiles has thirteen tiles [3], the algorithm in this paper was applied to protosets of six, seven, and eight loose Wang tiles.

The first problem in computer handling of protosets and tilings are computer representation of the protosets. The easiest way to do this for small protosets is a modification of traditional adjacency matrices. If a protoset has n tiles, then we will have two $n \times n$ Boolean matrices, LRmatrix and UDMatrix, which represent the possible left/right and up/down adjacencies respectively. That way, tile x can be on the left of tile y if $\text{LRmatrix}[x][y]=1$. Notice that this also means tile y can be on the right of tile x . Similarly, we say tile x can go above tile y if $\text{UDMatrix}[x][y]=1$.

Once we have the matrix representation for a protoset, we must find a way to categorize it. A logical approach to determining if a tiling is periodic or not is to search for a fundamental domain. Now, if we look at an infinitely repeating pattern, we can find vectors (a,b) and (c,d) such that every tile is invariant when translated a tiles to the right and b tiles down (c and d respectively). From algebra, we know that the greatest common divisor (gcd) of two numbers is also the smallest positive linear combination of those numbers, so if we were to take $\text{gcd}(a,c)$, that would be the smallest horizontal translation possible where those vectors could give an invariant. Furthermore, we can deduce from algebra that the fundamental domain will have an area of determinant $|(a,b) (c,d)| = (ad-bc)$, so we can conclude that the smallest vertical translation possible that could leave the tiling invariant would be that area divided by the corresponding horizontal translation, or $(ad-bc)/\text{gcd}(a,c)$. So instead of using a protoset to tile the plane and then look for patterns, we can generate fundamental domains using vectors, and see if our protoset can tile the fundamental domain with the rule that the fundamental domain must be able to go next to itself. That means the tiles on the right of the fundamental domain must be able to be adjacent to the tiles on the left of the domain, and likewise for top and bottom. If a protoset successfully tiles our generated fundamental domain, then it has an infinitely repeating pattern with which it can tile the infinite plane, and can therefore be categorized as a periodic protoset. If the protoset does not tile any fundamental domain up to a certain size, then the protoset will be tested to see if it tiles a finite square of the plane. If the protoset cannot even tile the finite square, it certainly cannot tile the infinite plane, and the protoset is categorized as non-tilable. However, if it does tile the finite square, then the protoset has effectively confused the computer since the algorithm can extract no patterns from the tiling. These types of protosets are set aside for human analysis. Only after the human has proved anything about the protoset can it be classified as aperiodic or intractably periodic.

Each of the protoset sizes, six, seven, and eight tiles, was tested for two weeks of computer time, and the results were as we expected to a large degree. As stated earlier, even when we narrow our consideration of matrices around the 25% adjacency pivot, there are still so many that we are only able to scratch the surface. From previous knowledge of aperiodic tilings, we can

generalize that if there is one protoset of a certain size of loose Wang tiles that forces a non-periodic tiling, then it is probably not the only one of that size. We would probably expect there to be around ten such protosets, if there are any at all, so for size six protosets we would have 10 in 2^{72} chances (about one in four thousand million million million) of randomly stumbling upon an intractable or aperiodic protoset. For this reason, our results, which do not even begin to draw near those numbers, are largely what we expect. In two weeks of computer time for each size, the following numbers were generated:

Protoset sizes	# non-tileable protosets	# periodic protosets
6 tiles	11,889,226	8,590,793
7 tiles	5,038,438	4,654,499
8 tiles	4,214,480	5,627,316

The computer found no interesting (aperiodic or intractable) protosets, and this was expected. What also was expected was that the ratio of non-tileable protosets to periodic protosets would decrease for larger sizes since having more tiles allows a greater possibility of tiling the plane.

In conclusion, although we did not uncover any interesting protosets, we did not fully expect to do so. It was merely a hope that the implementation of this categorization algorithm for sets of loose Wang tiles would reveal a previously unknown interesting set. However, we have demonstrated that it is likely that Robinson's theorem can be extended to sets of at least eight Wang tiles, i.e., that at least eight tiles are required for an aperiodic set. The actual lower bound remains an open question.

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Faculty comments

Janet Woodland, Mr. DeLisse's mentor, made the following comments in her letter of support for publication of his work:

I met Adam Delisse in the first semester of his first year at the University of Arkansas, when he was enrolled in my Discrete Mathematics class, and his

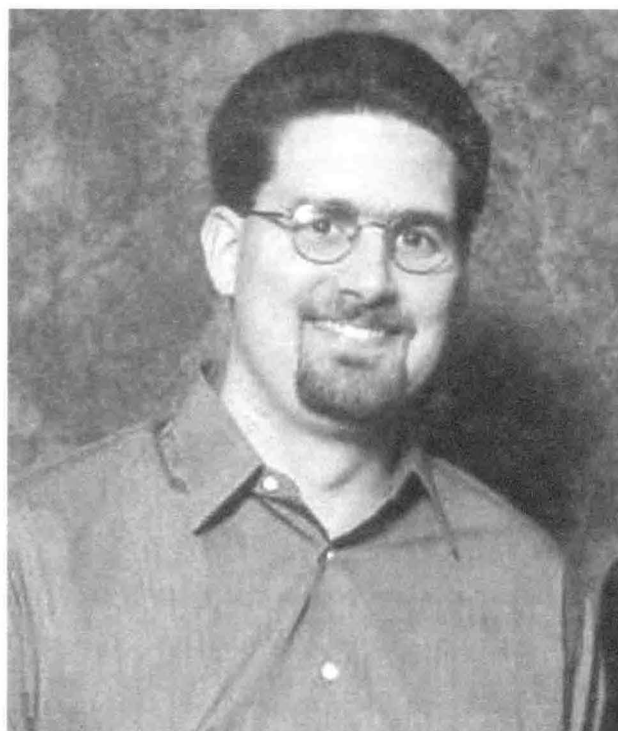


Figure 2. Adam Delisse

academic abilities were immediately evident. This course is a "cornerstone" for the mathematics major, addressing such fundamental concepts as logic, set theory, and combinatorics. Adam was an energetic and alert participant in the class, expressing his comprehension of the course material with unusual clarity. He was particularly talented in recognizing mathematical patterns, and anticipating natural extensions of the course material, and curious about its relationships with other mathematical topics. I was also impressed by the questions Adam asked, in addition to how well he answered mine. His genuine curiosity and attention to detail enabled him to produce some of the most elegant mathematical arguments I have seen from such a young student, and ever since then he has showed the persistence and creativity needed to solve difficult problems.

Though that was the last time Adam took a class with me, we have remained in contact through his continued presence in the department, and his involvement in Pi Mu Epsilon (our undergraduate mathematics society). He has always been one of our best students, and in fact, one of the College's best students, since he is about to complete an Honors degree and has been the recipient of many fellowships including the Sturgis and the Goldwater, and he has presented his work at the regional meeting of the Mathematical Association of America.

This article summarizes the work more fully described in Adam's honors thesis, and combines his chief areas

of interest, mathematics and computer science. The original question Adam addresses was posed by my colleague Dr. Chaim Goodman-Strauss (among the experts in this field), and I have taken on the role of mentor in his absence. The thesis describes Adam's long-term investigation of a certain category of tilings of the plane, with deeper underlying issues such as decidability and intractability. (Kurt Gödel proved in the early 1930s that certain questions *cannot* be answered - that certain statements cannot be *disproved*). The question of how a given set of tiles can cover the plane, and whether or not a given set *must* tile aperiodically, is a major topic of current research in this area of mathematics.

A member of Mr. Delisse's honors thesis committee, Suzanne McCray, Associate Director of Honors Studies in Fulbright College, had this to say about him:

Adam DeLisse, a senior Sturgis Fellow and mathematics major, shines both in and outside his field of study. He chose the Fulbright College of Arts and Sciences Honors Scholars Program, a demanding four-year curriculum pursued by only two percent of the students at the University of Arkansas. Adam also opted to take the Honors Humanities Roots of Culture series of courses. The average ACT score for students who opt for this option is 32 (1400 SAT equivalent). In the third semester, he was the absolute star of the class. The reading load was heavy, and the research project was demanding, Adam's performance was exemplary. His papers were always interesting. He is a thorough researcher and is skeptical when it comes to historical bromides. He always wants to know if the data really supports standard assumptions. There are certainly easier humanities courses to take that will satisfy the requirements, and students in the sciences often opt for them - not Adam. Not only did he choose our most ambitious core curriculum, he also began taking upper-division courses in mathematics as a freshman and is now taking graduate level courses. We expected Adam to do well when we recruited him for our program. We were delighted, when he chose to accept the Sturgis Fellowship. He has been a wonderful member of the Honors community. The Honors students elected him by an overwhelming vote to be the student representative from the sciences on the University Honors Council.

Adam's research abilities are well documented. His research mentor, Professor Chaim Goodman Strauss, is a tough taskmaster, but you could not tell that when talking to him about Adam whom he Praises highly and at length. For two years in a row Adam received a science Information Liaison Office Undergraduate research Fellowship for his work with Strauss on aperiodic tilings. According to Strauss, Adam's presentation of his material at the Mathematical Association of America was very

professional. A previous research project resulted in a newsletter publication for the Society of Actuaries: "Time to Dig Out the Old Dividend Discount Model?" Last year Adam received the nationally competitive Barry Goldwater Scholarship for his outstanding achievements in mathematics and for his commitment to research.

My degrees are in English, and the world of mathematics has always been a mysterious one to me. That is why I approached being on Adam DeLisse's honors thesis committee with some trepidation. Wang tiles meant very little to me. The only comprehensible tile to me was on a floor or in a quilt. But I have had long, interesting conversations with Adam on this topic, and I am genuinely happy that I have served on this committee. On several occasions in talking with Adam, mathematical lights have come on for me.

What Adam is doing is remarkable. As I understand it, no one has approached these tile patterns (or more importantly the possibility of non-patterns) this systematically before. Tile studies are relatively new, originating in the 1960's. According to Adam, scholars have used mathematical theories to prove that nonpatterns do exist with thirteen or more tiles. Adam DeLisse's goal is to demonstrate through the use of computers that even fewer tiles will produce non-patterns. Through his work - he has been able to conclude that eight or fewer tiles will produce patterns to infinity. Intellectually the project is extremely interesting and one day will likely have important practical applications. Finally, Adam DeLisse's work is both interesting and readable.

One of Mr. Delisse's mathematics instructors, Loredana Lanzani, also had high praise for his work, saying:

Adam was a student in my differential equations course during the Fall of 1997, which happened to be my very first semester at the University of Arkansas. It was clear from day one that Adam would define the top of the class. During that semester I often compared my teaching experience at the University of Arkansas with my very fresh memories from Purdue University, where I had had extensive contacts with many science or engineering majors. None of the students I had known in Purdue could even remotely compare to Adam in terms of mathematical ability and rigor, intuition, enthusiasm and curiosity.

Not one lecture went by without Adam being with me or, more often, ahead of me in the presentation. He showed equal enthusiasm both for the theoretical aspects of the subject (in fact, I could tell by his remarks that Adam was consistently able to pin down the details that I had left out in the proofs) and for the many applications to Physics, Statistics and Engineering that we studied. It goes without saying that Adam's written work was exceptional and he

ended up with the best score in the class. (I should add that, later on, I realized that in this class the number of talented students was unusually large). By the end of the semester it was clear to me that Adam would produce an excellent senior thesis in any branch of mathematics.

My expectations have been met beyond my wildest hopes. First of all, the thesis topic, a tiling problem, is a wonderful blend of geometry and combinatorics and perfectly suits Adam's choices for his major (Mathematics) and minor (Computer Science). I was also impressed by the large body of information, both in terms of mathematics and computer programming, that he had to master in order to test the theory on a concrete set of computer simulations. Last but not least, when reading his thesis I was very much impressed by Adam's ability to explain such complex work in a clear, precise and yet entertaining and compelling manner. His frequent comparisons with familiar patterns from everyday life (the checkerboard and the 1950's diner with an endless floor are the first examples I can remember) make sure that non-specialist readers have close at hand very pertinent and concrete examples that they can relate to to help them keep track of the main ideas in his work.

SECTION IV: PROFESSIONAL DISCIPLINES
ENGINEERING, HORTICULTURE AND
LANDSCAPE ARCHITECTURE

A METHOD OF IMPLEMENTING THE INTERLEAVER IN 3G WIRELESS COMMUNICATION SYSTEMS FOR RANDOMIZATION OF BURST ERRORS

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Abstract:

In less than a year or two, third generation (3G) wireless communication systems will be replacing the currently existing second generation (2G) wireless systems and be used worldwide. The 3G systems will have a higher data transfer capacity, which allows for simultaneous data, voice, and video transfer (e.g., multimedia applications) while most of 2G systems only allow for low-rate data and voice transfer. The wireless communications industry has set standards for 3G, which detail various operations of the technology. It should be noted that the 3G standards outline only the different operations and not the processes for the production of these operations. The research presented addresses a method of production of the interleaver operation for randomization of burst errors.

In this paper, the details of the interleaver are described and a novel method to implement the interleaving operation in a 3G system, called Universal Mobile Telecommunication Systems (UMTS) is presented. The implementation was aided by a sophisticated tool from Cadence, "Signal Processing Workstation" (SPW), which was used in both the design and testing of the interleaver. Of the two interleavers in UMTS standards, the first interleaver is the focus of this research. However, this research would be applicable to the second interleaver.

Introduction:

The research presented discusses a method in the design and testing of the first interleaver operation in the Universal Mobile Telecommunication Systems (UMTS) third generation (3G) wireless technology standard. The research was done for the Wireless Communications Research Group (WCRG) of the University of Arkansas. The design and testing was aided by the Cadence software tool "Signal Processing Workstation" (SPW). SPW uses a graphical interface to allow users to build floating-point and fixed-point digital circuitry. Graphical representations of important digital blocks (such as memory, logic, and math blocks) in SPW expedite design of a digital system. To understand

the design of the interleaver operation presented, it is first important to understand the basic reason for the need of the interleaver in wireless communications. The transmission of data signals through a transmission channel (air in this case) is subject to random disturbances. These disturbances can cause random errors in the data being transmitted. Through a process called channel encoding, the random errors can be compensated for before sending the signal by attaching additional information about the original data to the end of the original data. After the signal, along with its random errors, is received by the receiver, the additional information sent with the original data is decoded (the inversion of encoding) to correct the random errors.

Unfortunately, the transmission of a signal in air is also subject to burst errors. Burst errors occur in response to a fading transmission channel, where a fading channel develops from a rapid change in the distance between the base station and mobile handset (in most cases, this is a cell phone). The problem with burst errors is that they cannot be corrected with encoding techniques alone. However, in the interleaving process, the burst errors can be converted to random errors, known as randomization, by interleaving before transmission and then deinterleaving after reception of the signal. The burst errors can then be corrected by channel encoding/decoding.

The interleaver operation:

Interleaving is a process in which the bits that compose a digital signal are reordered before transmission of the signal to compensate for the effects of burst errors resulting during signal propagation of the transmission channel. The type of bit reordering is determined by the standard of the communication system. In a typical interleaver, the bits are written into a memory block in sequential order, and then read out of the memory block in a different order. One way of thinking of the typical interleaver is to think of a matrix representation of the memory block. The bits are first written into the memory row by row (starting at the top), and after filling up the memory, the columns of the matrix are then permuted. Permutation is a reordering of objects. One

permutation of the sequence of numbers {0, 1, 2, 3} might be {0, 2, 1, 3}. In this case, the set {0, 2, 1, 3} is said to be a permuted sequence of the original sequence. In general, for a sequence of n numbers there are $n! = n(n-1)(n-2)\dots(2)(1)$ different permutations of that sequence. Thus, when the columns in the interleaver are permuted, the order in which they appear in the matrix changes. The output signal of the interleaver is then fabricated by reading the permuted matrix column by column (from the left) (see Figure 1). At this point, the signal is said to be interleaved.

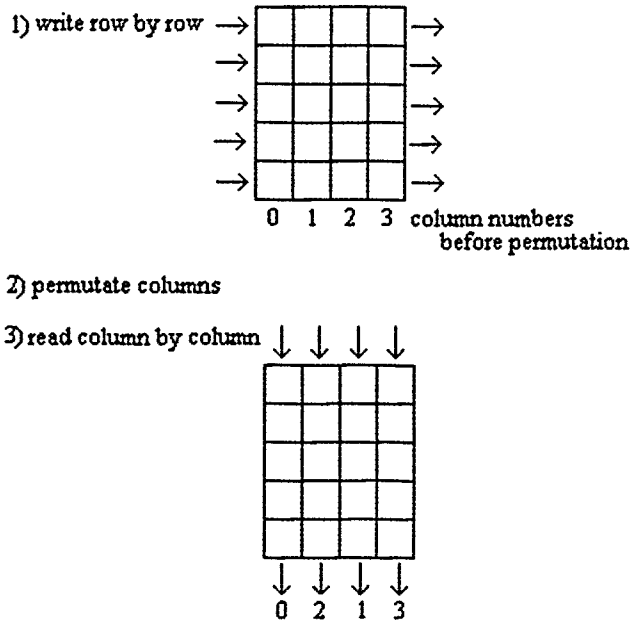


Figure 1. Example of the three steps needed to generate the ideal permuted data sequence.

Several parameters are needed to successfully interleave. The first of these is the number of bits in the data signal, commonly referred to as the length of the signal. The length of the signal must always be known because the amount of memory allocated should be the same as the length of the signal. The number of columns and the type of column permutation must also be known. This research used parameters specified by the UMTS 3G standard.

Design:

The interleaver's basic algorithmic architecture was designed to meet the specifications outlined in the UMTS standards. The design of the interleaver can be broken down into five sections: memory allocation, writing to memory, column permutation, reading from memory, and changing read/write states. As explained above, the interleaver reorders the bits of a data signal. For practical reasons, the number of bits must be finite. Also, the number of bits must be small, often less than a thousand (for reasons beyond the scope of this paper). The number of bits needed to transmit a second's worth of voice

signal is approximately seventy thousand bits. Therefore, the transmission of a data signal is processed in small intervals. The time it takes to transmit these small intervals is called the transmission time interval (TTI). The TTI is measured in milliseconds (ms) and is given as a parameter in the UMTS standard. The number of bits in one TTI is a small portion of the number of bits in the total data signal. Consequently, a certain number of TTI's must be processed in a communication system in order to deliver the whole data signal. The number of bits in a TTI will be denoted as L . In the UMTS standard, the TTI has possible values of 10ms, 20ms, 40ms, and 80ms. For this research, the different TTI's will correspond with the values of $TTI\#$, which are 0, 1, 2, and 3 (for example, if the TTI is 40 ms, $TTI\#$ will be 2). The total number of columns, col_total , needed in the memory of the interleaver is dependent on the TTI of the system. The number of columns for a $TTI\#$ of 0, 1, 2, and 3 is 1, 2, 4, and 8 columns, respectively. The permutation column sequence for the different number of columns, as specified by the UMTS standard, is {0}, {0, 1}, {0, 2, 1, 3}, and {0, 4, 2, 6, 1, 5, 3, 7}, respectively. The permutation sequence for a particular value of $TTI\#$ will be denoted by $P_{TTI\#}$. Also, a value in a permutation sequence will be denoted by s_n , where n is the n th value in the sequence starting with zero (for example, the value of s_6 in P_3 is 3). The total number of rows, row_total , needed in the memory is just L divided by col_total .

A delay in data signal is usually unwanted in a communication system. For instance, a delay in hearing a voice on a cell phone would be irritating to the listener. A continuous data signal should be kept in order to avoid pauses, or delays, in the reception of the signal. Hence, when processing multiple TTI's, there should be no delays between the different TTI's at the output of the interleaver. These delays were avoided by using two different random access memory (RAM) blocks, MEM1 and MEM2 (see Figure 2).

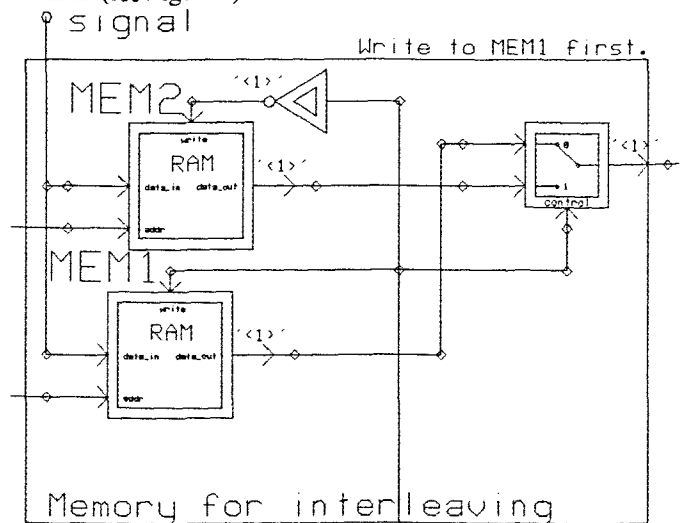


Figure 2. (A snapshot from the final design). Two RAM blocks, MEM1 and MEM2, are used for the first interleaver memory allocation.

During one TTI, L bits (the number of bits in a TTI) are being read from MEM1 and sent to the output on the interleaver. While this is going on, the next L bits from the input of the interleaver are being written into MEM2. On the next TTI, MEM1 is being written into, while MEM2 is being read from.

This pattern continues, where the read/write processes alternate among MEM1 and MEM2 on each subsequent TTI. Thus, a two-block memory allocation was implemented to maintain a continuous output data signal with no delay between adjacent input TTI's.

A memory block in SPW has an unspecified number of memory locations inside the block in which a single bit of information can be stored. For this research, the total number of locations for each of MEM1 and MEM2 is L . Each location in the memory has its address specified in decimal value, with the first location as value zero and the last location as value $L-1$. To write to a location in the memory, the appropriate address value must be inputted into the address input pin of the memory. In the design, the appropriate address value, when writing to either MEM1 or MEM2, was generated by one counter, denoted CT1 (see Figure 3). A counter is a device which, as indicative of its name, counts in an orderly fashion. The counter CT1 starts at zero and counts by one up to $L-1$. After the counter reaches $L-1$, it rolls back over to zero and starts over again. Every counter has a count output pin. The count output pin outputs the present value of the counter. Using the count output pin of CT1 as the address location for MEM1 and MEM2 during their respective writing cycles, each bit per TTI is loaded in sequential locations in the memory from zero to $L-1$ for a total of L bits. Thus, at the end of a TTI, the location of each bit will have the same order in the memory as the order inputted to the interleaver.

Ideally, after writing the bits per TTI to either MEM1 or MEM2, the columns in the memory must be column-wise permuted. In this design, permutation of the columns is not done directly before reading because that would increase the delay of the data signal to the output. Instead, the permutation step is bypassed and incorporated into the reading step. So, the process of writing to the memory row by row, permutating the columns, and then reading from the memory column by column is shortened to writing to the memory row by row and reading from the memory in a different sequence. This sequence of reading produces the same output as in the ideal case when the columns would be first permuted and then the memory would be read column by column. The problem of generating the correct interleaved output sequence now resides in how the memory should be read.

Reading from MEM1 and MEM2 during their respective reading cycles is accomplished with the use of two counters, CT2 and CT3, four read-only memories (ROM's), and a constant value block. Before going into detail about how the different SPW blocks were used to read from MEM1 and MEM2, the basic

idea behind the method needs to be explained. In the ideal case, the interleaver design is centered about a memory block represented as a row_total by col_total matrix. Each position in the matrix has some address location associated with it. In this research, the memory location addresses are numbered in respect to the input sequence. For instance, memory address 1 contains the first bit of the input sequence and memory address 2 contains the second bit, continuing until the last bit of L bits. From this knowledge, the sequence of address locations that should be read from the memory for proper interleaving can be summarized in an equation. If c_addr represents the current address location that is being read from the memory, then $c_addr = (c_count)(col_total) + s_n$, where c_count is the current count value, col_tot is the total number of columns being used, and s_n is the current column in the column permutation sequence for a particular TTI#. The current count value, c_count , controls when the c_addr changes to its next address location. The current count value is implemented using the counter, CT2 (see Figure 3). Since the read operation is done column by column, the maximum number of CT2 should match the total number of memory locations per column, which is the total number of rows. In this case, the maximum value of CT2 is simply row_total . For a TTI# of 2 and L of 20 bits, the sequence of c_addr is { 0, 4, 8, 12, 16, 2, 6, 10, 14, 18, 1, 5, 9, 13, 17, 3, 7, 11, 15}. Now, the hardware can be implemented by using the guidance of the c_addr equation. In the design, the c_count value is the same as the output count of CT2. Whenever the count of CT2 rolls back over to zero, the next column in the column permutation sequence is counted. Therefore, s_n should be incremented every time c_count becomes zero (excluding the first time c_count is zero) and is done so by using another counter, CT3 (see Figure 3).

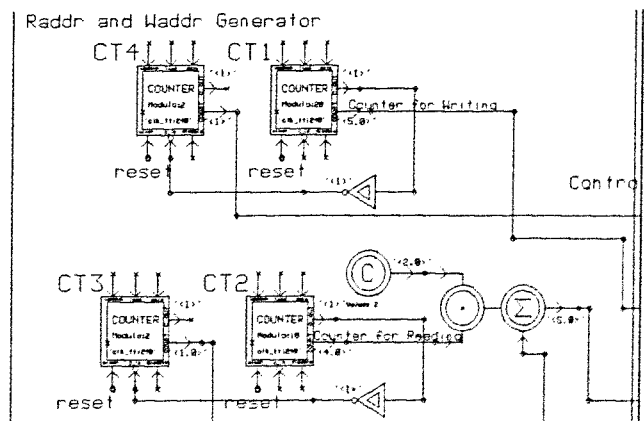


Figure 3. A close up of the four counters in the first interleaver final design (TTI# = 1, $L = 20$).

The four ROM's contain the four different permutation sequences P_0 , P_1 , P_2 , and P_3 , respectively. The permutation sequence in each ROM is generated by reading the memory of

the ROM in sequential address locations (starting with zero). This is accomplished with the counter output of CT3. Thus, CT3 should count only whenever CT2 has reached zero, as stated above. This type of configuration is common with the use of counters (especially when used in the design of clocks) and was easily arranged by using special purpose output and input pins named c_{in} and c_{out} on the SPW counter. Now, whenever value CT2 reaches zero, the value of CT3 increments by one and the next permutation value, s_n , in $P_{TTI\#}$ is outputted by $P_{TTI\#}$'s respective ROM. The col_total is a constant value in the interleaver, and thus, does not change in the operation of the interleaver. Hence, col_total 's value is controlled by an SPW constant block. All necessary values for the c_addr equation have now been developed in the hardware and are ready for the mathematical operations as described in the c_addr equation. SPW has a math block that has three inputs. Two of the three inputs are multiplied by each other and the third is added to the result of that multiplication. This SPW block is used in the design to multiply c_count by col_total and then add s_n to that result to obtain c_addr . The current address, c_addr , becomes the input to MEM1 and MEM2 during their respective read cycles.

The discussion of the design so far has just been for the processing of one TTI. Since an ideal data signal will be composed of many TTI's, the interleaver must accommodate for multiple TTI's. The design of the interleaver must be able to change states from reading MEM1 and writing to MEM2 to writing to MEM1 and reading from MEM2, and vice versa to process more than one TTI. The changing of read/write states in the interleaver is achieved by using an additional counter, CT4 (see Figure 3). CT4 has only two values, zero and one. CT4 is dependent on CT1 like CT3 is dependent on CT2. That is, CT4 is only incremented when CT1 reaches its maximum value of $L-1$. Thus, CT4 changes its value between 1 and 0 after every TTI length of bits. The value of CT4 is used to control several switches. One switch redirects the read/write address locations between MEM1 and MEM2 and changes the read/write state on MEM1 and MEM2 at the same time. Another switch changes the output of the interleaver between the output of MEM1 and the output of MEM2.

All of the necessary operations of the interleaver design are now finished. For the complete view of the design see Figure 4. Testing is the last stage in the completion of the interleaver operation.

Testing:

Testing of the interleaver was done with the Signal Calculator (SC) tool in the SPW software. When testing the interleaver, a data signal of a known number of bits was inputted into the interleaver. The operation of the interleaver was verified by confirming that the SC output of the interleaver matched the

hand-calculated output for a sufficient number of bits at the beginning and the end of the output signal. SC is a graphical display, which proved to be beneficial when scrolling through a large number of bits.

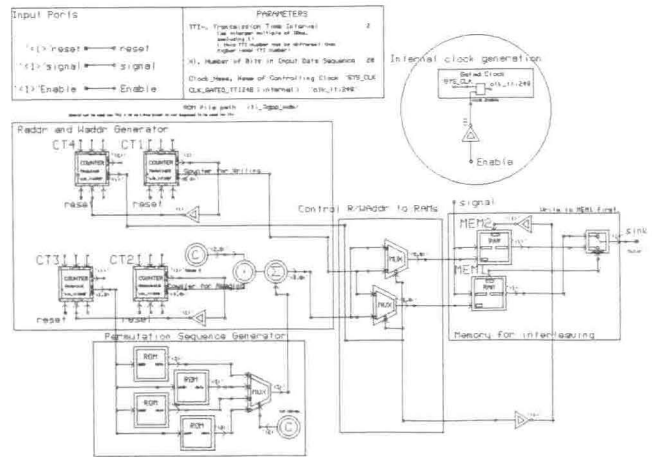


Figure 4. Final design of first interleaver (TTI# = 1, L = 20)

Conclusion:

The testing verified that the final design of the interleaver for randomization of burst errors was correct. The final design was completed after several other designing and testing phases and became part of a much bigger project headed by my mentor. The interleaver was the first design of many other designs for that project. For this reason, the interleaver was the most challenging and problematic of all my designs. The pace and accuracy of my other designs improved from my initial work on the interleaver. Any future designs for the WRCG will without a doubt enjoy the same benefits.

In wireless communication systems, a data signal often has to be processed during various stages of the transmission and reception of the signal. A processed signal can be defined as a signal that has to be analyzed or changed. Whenever a signal has to be processed, it causes a delay in the amount of time it takes the signal to reach its final destination. It is important then that a communication system have sufficiently small delay. The outcome of the research was a functional implementation of the first interleaver under the UTMS standards that avoided delays in between adjacent TTI's and delays in the permutation of the data signal. For this reason, the final design is advantageous to any UTMS 3G technology. This is important since second generation (2G) wireless technology systems will soon be replaced by 3G systems in the next few years. 3G technology is better because it will offer a higher data rate and data capacity, allowing for simultaneous multimedia applications, such as data, voice, and video transfer.

Works Consulted:

3GPP 3G TS 25.201, "Physical layer – general description," Release 99, V3. 1.0, June 2000.

3GPP 3G TS 25.212, "Multiplexing and channel coding," Release 99, V3. 1.0, June 2000.

V.K. Bhargava and I.J. Fair, "Forward Error Correct Coding," *The Communications Handbook*, ed. Jerry D. Gibson. Boca Raton: CRC Press, 1997. 177-178.

A. Paulraj, "Diversity Techniques," *The Communications Handbook*, ed. Jerry D. Gibson. Boca Raton: CRC Press, 1997. 216-217.



Eric Duquette

Faculty comments

Mr. Duquette's faculty mentor, Wookwon Lee, made the following comments about the work:

Eric Duquette's paper describes in a concise manner the fundamentals of the interleaver, which is an essential component in wireless communications, and its implementation using creative control circuitry along with use of memory components. As described in the paper, the core part of the interleaver design was the control circuitry to write and read information data to/from memory components in a timely fashion

in order to transmit data in a noisy radio channel in a form that can be reliably received and decoded at the receiving end. The interleaver also has to accommodate various transmission-time intervals that might be associated with greater complexity for the entire interleaving operation. Eric successfully designed this "might-have-been-complicated" interleaver with an efficient control circuitry by using a few counters for generation of write/read addresses for the memory components.

I found Eric to be an innovative, hard working undergraduate student. He has made excellent contributions to my own research project for the design of a sophisticated transmitter for a European-proposed, wideband Code-Division, Multiple-Access (W-CDMA) system for the next generation wireless terrestrial cellular system designed to provide multimedia services to ordinary cellular phone customers. I am confident that his work on the interleaver described in this paper is the result of creativity and innovation that can rarely be found in an undergraduate student, particularly in one who had little background in the areas of wireless communications when he began the project.

Neil Schmitt was also enthusiastic about Mr. Duquette's work. He said:

It is my pleasure to provide a letter of support on behalf of Mr. Eric Duquette who is submitting some of his undergraduate research work for publication in *Inquiry*, the University of Arkansas undergraduate journal. Eric is a responsible individual who has achieved an impressive academic record in electrical engineering. His quiet unassuming approach to technical challenges belies his tenacious pursuit of solutions that are economically and technically feasible. Eric distinguished himself by becoming the top student in my Digital Signal Processing class - a class most students find very challenging.

I am intimately familiar with the research topic that Eric elected to pursue. It would be very very appropriate for a Master's thesis topic. In spite of not having the academic coursework one would normally assume to be a pre-requisite to attacking this problem, Eric has achieved significant results. His efforts involve state-of-the-art research on a component of a new digital communication system that is destined to replace what is currently in use in the United States and that will be used world-wide as well. His design had to comply with international standards.

EVALUATION OF CHILLING REQUIREMENTS FOR SIX ARKANSAS BLACKBERRY CULTIVARS UTILIZING STEM CUTTINGS

By Dayanee Yazzetti
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Dale Bumpers College of Agricultural, Food and Life Sciences

Faculty Mentor: John R. Clark
Department of Horticulture

Abstract:

Woody perennial plants including blackberries (*Rubus* subgenus *Rubus* Watson) require certain amounts of chilling or rest hours below 7T during the dormant season for successful bud break the following year. Blackberry cultivars developed in Arkansas are being grown in various climates worldwide, and all cultivars need chilling requirement estimates for accurate recommendations of adaptation. Determining chilling requirements using stem cuttings collected from field-grown plants rather than whole plants is a desirable system. We conducted a study to evaluate both artificial- and field-chilling of six cultivars. For the artificial-chilling study, 12-node stem cuttings were collected 2 days after the first killing frost. These were then placed in a moist medium in a walk-in cooler at 30C. At 100-hour chilling intervals, five cuttings of each cultivar were placed under an intermittent mist system. For the field-chilling study, a biophenometer was placed in the field to measure chill, and ten 12-node stem cuttings of each cultivar were collected at 100-hour intervals of chilling up to 1000 hours below 7°C and placed under intermittent mist. For both studies the mist bench was located in a heated greenhouse (min. temperature of 15T), and cuttings were placed according to a completely random design. Budbreak was recorded weekly. Studies were analyzed separately by SAS. Results for Study One, artificial chilling, were inconclusive due to a lack of clear differentiation among the cultivars and their chilling intervals. Study Two, using field-chilling, showed a significant chilling-interval x cultivar interaction. 'Arapaho' appeared to have a chilling requirement of 400 to 500 hours, 'Kiowa' 200 hours, 'Shawnee' 400 to 500 hours, and 'Chickasaw' probably near that of Shawnee. The cultivars Choctaw and Apache did not provide clear chilling-interval differentiation in the study. Our results indicate that the use of stem cuttings receiving field chilling to evaluate chilling requirement of blackberry cultivars has merit and can be a successful method in this research area.

Introduction

Woody perennial plants such as blackberry (*Rubus* subgenus *Rubus*) require certain amounts of chilling or rest during the dormant season for successful budbreak and normal shoot and flower development to occur during the next season. Rest period is defined as the duration that a plant must be exposed to cold temperatures at or below 7°C, while chilling requirement is the amount of cold needed to satisfy that rest period and is species and often cultivar specific (Ryugo, 1998). Failure to meet this requirement results in reduced and erratic budbreak, poor shoot growth, reduced flowering, and reduced fruit yields the next year.

Blackberry cultivars released from the Arkansas Agricultural Experiment Station breeding program include 'Shawnee' (Moore et al., 1985), 'Choctaw' (Moore and Clark, 1989), 'Navaho' (Moore and Clark, 1989), 'Arapaho' (Moore and Clark, 1993), 'Kiowa' (Moore and Clark, 1996), 'Apache' (Clark and Moore, 1999), and 'Chickasaw' (Clark and Moore, 1999). Cultivars developed in Arkansas are being grown worldwide in environments with chilling conditions that differ from the original breeding locale. Chilling-requirement estimates are needed for all cultivars to ensure effective adaptation recommendations. Limited formal research has been performed on chilling requirements of blackberry cultivars. Drake and Clark (2000) reported chilling requirement of Arapaho was 400 to 500 hours and Navaho was 800 to 900 hours using whole plants in a study with controlled artificial chilling of constant 3°C.

In the fall of 2000-2001, we conducted two studies that evaluated the use of stem cuttings to estimate chilling requirements of six blackberry cultivars. The first study (Study One) was conducted to determine the feasibility of using artificial chilling to fulfill chilling requirements of stem cuttings. The objective of Study Two was to determine the feasibility of using blackberry stem cuttings receiving natural chilling to identify chilling requirement.

Material and Methods

Study One: Fifty 12-node, lateral-branch stem cuttings of Apache, Arapaho, Chickasaw, Choctaw, Kiowa, and Shawnee were collected from mature plants located at the University of Arkansas Agricultural Research and Extension Center, Fayetteville, 2 days after the first killing frost of 12 Oct. 2000. The cuttings then were placed in a moist sawdust medium in a walk-in cooler at 3°C. At 100-hour chilling intervals, five cuttings of each cultivar were removed from the cooler and placed under an intermittent mist system in a completely random design. The mist bench was located in a heated greenhouse with a daily minimum temperature of IVC and a daily maximum temperature of 25°C.

Study Two: In order to measure natural field chilling, a biophenometer was placed in the planting to record the number of hours below 70°C. Ten stem cuttings from lateral branches of mature canes of each of the cultivars mentioned above were collected from the field at 100-hour intervals of chilling up to 1000 hours. However, due to a severe ice storm in December 2000, the 900-hour chilling interval cuttings were not taken because of the inability to collect the cuttings. Also, Arapaho cuttings were only collected for 100 to 600 hours of chilling due to a shortage of lateral branches in the planting for this cultivar. Following collecting, the field cuttings were placed in the same greenhouse under an intermittent mist system in a completely random design. For both studies, incandescent lighting was provided to prolong the day length to 16 hours in the greenhouse.

Data collection for both studies consisted of a budbreak count of each cutting of each cultivar weekly for 10 weeks. A bud was considered broken when the first leaf became visible as it unfolded from the bud. Budbreak data after 10 weeks for each study were analyzed separately by SAS (SAS, 1989), and standard errors of the means were calculated.

Results

Study One The data analysis for Study One indicated a significant chilling-interval x cultivar interaction, indicating that the cultivars did not have the same budbreak for all chilling intervals. For 100 to 600 hours, all cultivars except Kiowa had 15% budbreak or less, indicating that chilling differentials did not appear to be delineated using the artificial chilling method (data not shown). Substantial budbreak was experienced at several higher chilling levels (above 600 hours) for Choctaw, Apache, and Shawnee. However, Arapaho had very low budbreak for all the intervals except 900 to 1000 hours; this result contradicts that of Drake and Clark (2000) who estimated Arapaho chilling of 400 to 500 hours. Kiowa behaved differently from all the other cultivars, showing no lower than 20% budbreak across all intervals and increasing up to 70% for the 1000-hour chilling interval. The lack of a comparable finding for Arapaho, as reported before, and the lack of clear differentiation among the

chilling intervals of the cultivars indicated that this method was likely not a reliable method to obtain chilling requirement estimates.

Study Two The chilling-interval x cultivar interaction was significant for this study, indicating that budbreak differed among the cultivars for the various chilling intervals. Arapaho was the only cultivar with a known chilling requirement used in the study, and it had a substantial increase in budbreak between 400 and 500 hours, consistent with the findings of Drake and Clark (2000) (Fig. 1). This finding was very important because it shows that this method of chilling-requirement determination appeared to be successful for this cultivar. Kiowa had substantial budbreak at 200 hours, and at most other chilling intervals (Fig. 2). A reduction in budbreak occurred at 300 hours for Kiowa, because the death of several cuttings collected for this chilling interval contributed to the low budbreak value. A substantial budbreak reduction was noted for Kiowa at the 800 and 1000 hour intervals, likely due to winter injury sustained from extreme low temperature (-16.7°C) during this chilling interval. Based on these findings, it appears that Kiowa has the lowest chilling requirement of the Arkansas cultivars, and it may be as low as 200 hours.

Field observations of Choctaw in more subtropical climates of the world have shown it to have a lower chilling requirement than other Arkansas cultivars released prior to 1989 (J.N. Moore, personal communication). In Study Two, Choctaw showed no budbreak until 400 hours, with higher budbreak at other chilling intervals (data not shown). Budbreak never exceeded 32% for Choctaw at any interval, however, which was a lower percentage than most other cultivars produced. We conclude that data were inconclusive in substantiating the low chilling observations for Choctaw reported previously. Shawnee has been the most widely grown Arkansas blackberry cultivar, with widespread planting of this cultivar in the southern U.S. Evidence of lack of chill has not been reported (J.N. Moore, personal communication). In our study, Shawnee appeared to have a chilling requirement of 400 to 500 hours due to the greatly increased budbreak between these two intervals (Fig. 3). Since most southern states receive this amount or more of chilling, one would expect a cultivar not to experience chilling-requirement shortfalls at this chilling level. The chilling requirements seen in our data support this observation. The two newest Arkansas cultivars, Apache and Chickasaw, have no chilling observations available. Chickasaw had its highest budbreak of 50% at 700 hours, a major increase in budbreak compared to the lowest chilling intervals (data not shown). It had increased budbreak at 400 to 600 hours also compared to the lower chilling intervals also. This suggests Chickasaw probably has a chilling requirement near that of Shawnee, or possibly slightly higher. Budbreak did not remain as high for Chickasaw at 800- and 1000-hour chilling intervals, which again might be due to winter injury of some buds. Finally, Apache had low budbreak at all chilling intervals, with the highest budbreak level at 800 hours of 20% (data not shown). It

was anticipated that Apache would have a chilling requirement near to that of Navaho (800 to 900 hours as found by Drake and Clark, 2000), as Navaho is one of its parents. Due to the low budbreak at all intervals, we feel our results are inconclusive in estimating chill requirement for Apache.

Discussion

The major objective of our studies was to determine if the use of stem cuttings would be successful in differentiating chilling requirements different blackberry cultivars. Stem cuttings are much easier to use for chilling requirement determinations because as they can be collected from field-grown plants and forced to budbreak after collection. Conversely, using whole plants for this type of research requires that potted plants be grown for a season prior to exposure to chilling and then be used for budbreak measurements after chilling-treatment intervals are provided. This is a much more labor intensive and expensive process. Also, before or near the release of a new cultivar there are often a very limited number of plants available, and having whole plants to use in a chilling determination study is usually not possible.

The use of artificial chilling on blackberry stem cuttings (Study One) was deemed unsuccessful in our study due to the lack of differentiation among most cultivars and the low budbreak at all of the lower chilling intervals except for Kiowa. This could be due to several reasons. It is possible that the cuttings were collected prior to the onset of the dormancy period of the plants. When dormancy actually begins is always a question, and we are not aware of an absolute way to know this. Our collection was based on the occurrence of the first killing frost on 12 Oct. 2000, which we hoped would be the beginning of dormancy or the rest period. However, if the plants were not physiologically in or near dormancy at this time, this could have affected the subsequent ability of the plant to show response to chilling (to satisfy the chilling or rest-period requirement) and this could have contributed to our inconclusive results. Also, the collected plant material may require attachment to an entire plant under normal circumstances to allow the measurement of chilling to fulfill the rest period, and this may have been disrupted when the stem cuttings were removed from the plant. Whether the reasons are those discussed here or the results were due to other causes, we feel that artificial chilling of stem cuttings was not a reliable method to measure chilling requirements of different blackberry cultivars.

Conversely, the field-chilling study (Study Two) provided results that we feel allowed the differentiation of chilling requirements of most cultivars. Previous research by Drake and Clark (2000) showed a difference between two Arkansas cultivars in chilling requirements, and field observations in areas of low chill also indicated cultivar chilling- requirement differences. Our first noteworthy finding - that of a similar estimate of

chilling response of (i.e. 400 to 500 hours) for Arapaho stem cuttings exposed to field chilling compared to that found by Drake and Clark (2000) using whole plants - provided confidence in the stein-cutting method we used.

A very apparent additional finding in Study Two was the unusual budbreak at a low chilling level for Kiowa. This cultivar was released in 1996, and as yet has not been planted as widely as Shawnee, Choctaw, or Arapaho. Therefore, growers and researchers have not reported as yet on its chilling response. During the testing of Kiowa prior to its release, Moore and Clark (1996) observed that it had earlier spring budbreak compared to Shawnee and Choctaw, and this characteristic of Kiowa might reflect either a lower chilling requirement or a lower heat requirement for bud development. Our data support the idea that this characteristic could be due to a lower chilling requirement, as our study did not measure differential heat requirement conditions. Additionally, one reason that no chilling concerns have been observed by early evaluators of Kiowa may be due to the fact that it has produced good budbreak in all areas in which it has been grown (both low and high chill locations) due to its low chilling requirement. We conclude that 'Kiowa' likely has the lowest chilling requirement of all cultivars tested in our study.

We expected a low chilling-requirement response for Choctaw based on field observations of its reliable budbreak in locations of low chill. Our data were disappointing as we observed rather low budbreak at all chilling intervals, and therefore the differentiation of these intervals was not reliable. Reasons for this were not clear but could include the possibility of cold injury to buds during the study or could be related to a sufficient heat requirement to begin growth. Choctaw has been observed to be the least hardy (most susceptible to winter injury) of the Arkansas cultivars (J.N. Moore, personal communication), and it is possible some bud injury occurred early in the fall of this study period. However, bud injury was not evaluated at collection. The heat requirements for growth to begin have not been measured for any Arkansas blackberry cultivars, thus it is not possible to speculate if this variable was involved in our study, as the environment in which the cuttings were forced was thought to be warm enough to contribute to budbreak for all cultivars.

The Shawnee response was very much as expected, since a chilling requirement of 400 to 600 hours was suspected for this cultivar based on field performance. Our finding of a requirement of 400 to 500 hours fell within this expected range, and the budbreak levels were among the highest of all cultivars after these chilling treatments. This result provided further confidence in our method.

Finally, the results for Chickasaw indicate that it likely has a similar chilling requirement to that of Shawnee or possibly slightly higher. Further research and observation should be done on this cultivar to substantiate the chilling requirement of this

new cultivar. Apache, with budbreak below 20% at all intervals, needs further investigation to determine its chilling requirement. Why differentiation of chilling estimates was not achieved in our study with this cultivar is not understood, as we were not aware of any limitations of this cultivar, such as winter injury of buds prior to collection, heat requirements, or other factors.

In conclusion, our results indicate that for the majority of the cultivars evaluated in our study, the use of stem cuttings receiving field chilling was a successful method of chilling requirement determination. We suggest that this investigation be repeated to verify this conclusion, and that bud viability of cultivars be determined prior to forcing to verify that winter injury does not contribute to reduced budbreak. Additionally, with other fruit crops, including peaches (*Prunus persica* Batsch.), it has been reported that different temperatures contribute to efficiency of chilling-requirement fulfillment (Richardson *et al.*, 1974). With peaches, temperatures between 7 and 0°C provided the most efficient chilling, while temperatures below 0°C contributed to little chilling-requirement fulfillment. The chilling efficiency of various temperature ranges should also be investigated in blackberries to determine if a similar response is involved.

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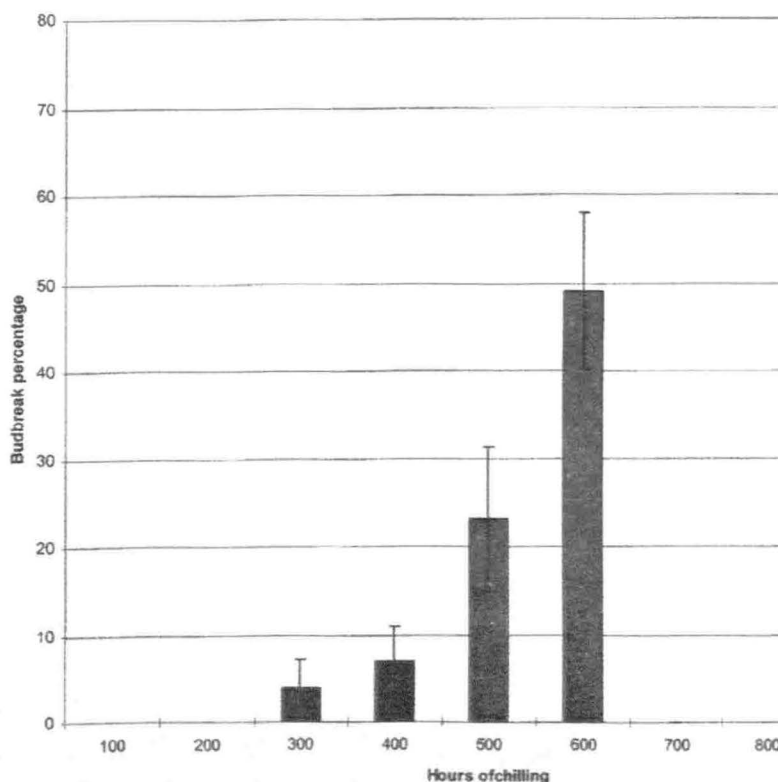


Fig. 1. Budbreak of Arapaho blackberry after 10 weeks of forcing in a heated greenhouse following 100 through 1000 hours of chilling, below 7°C.

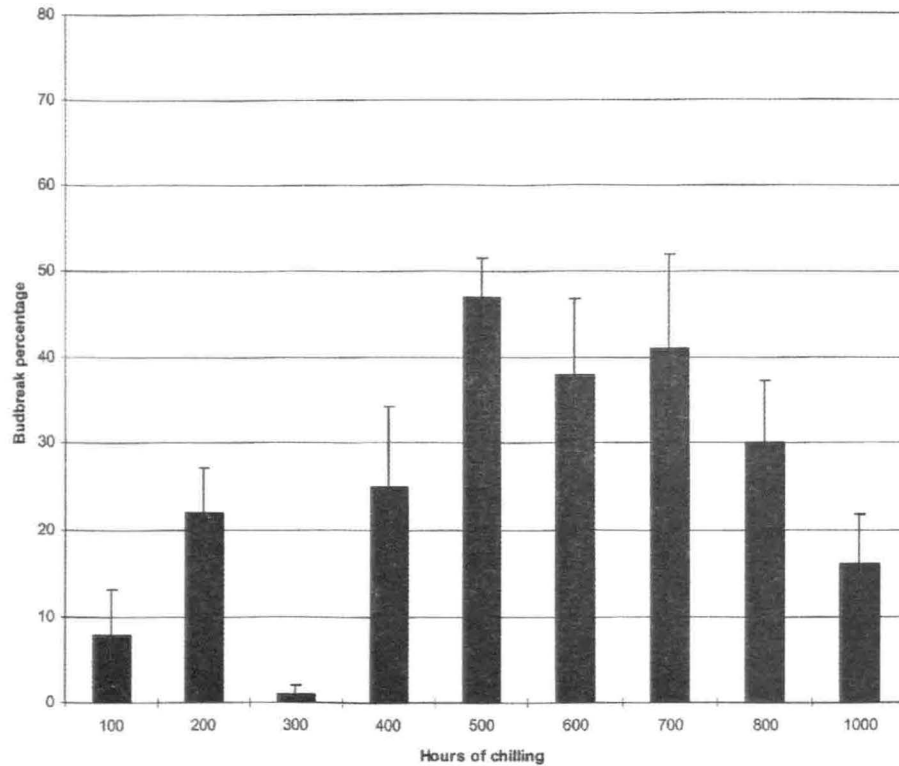


Fig. 2. Budbreak of Kiowa blackberry after 10 weeks of forcing in a heated greenhouse following 100 through 1000 hours of chilling, below 7°C.

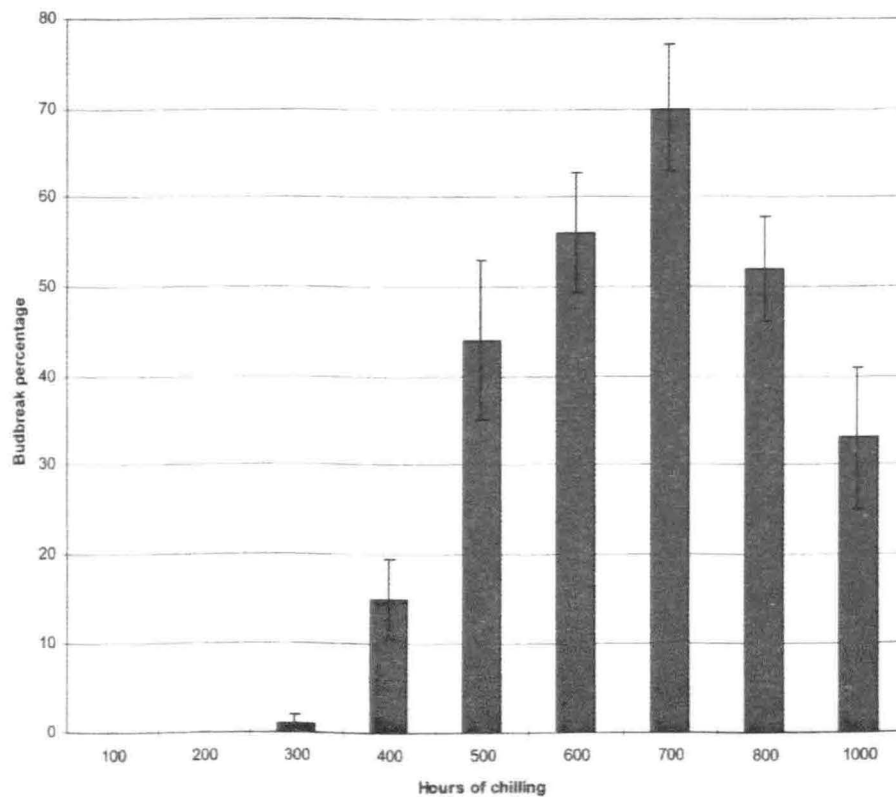


Fig. 3. Budbreak of Shawnee blackberry after 10 weeks of forcing in a heated greenhouse following 100 through 1000 hours of chilling, below 7°C.

Faculty Comments:

Ms. Yazzetti's project mentor, John Clark, said in his recommendation:

I am writing in support of Dayanee Yazzetti in her submission of a manuscript on blackberry chilling for *Inquiry*. I was Dayanee's special problem advisor for this study and I can attest that she did a fine job with the study. Work on the project began last October, and extended until just before spring break. Her findings provided some interesting and new data on the topic of chill requirements for blackberries in both methodology and cultivar aspects of this topic. Additionally she has presented part of the results of her work at a regional meeting of the American Society for Horticultural Science (placing first in her competition), and here on campus at the Gamma Sigma Delta Student Presentation Competition (placing second). Thus I deem her project a success in all its aspects.

Dave Hensley, Professor and Head of the Department of Horticulture, in recommending the inclusion of Ms. Yazzetti's paper in this journal made the following comments:

The work is of high quality, is relevant in the field, and is publishable in one of our discipline's journals. Ms. Yazzetti has already received an award for presenting the work at a professional conference. The manuscript has been reviewed positively by various horticulture faculty. I think Dayanee Yazzetti would well represent the research activities of undergraduates in agriculture and urge you to give her serious consideration.

FOCUS HOPE: A POCKET PARK STUDY, DETROIT, MI

By Jennifer Luks
Department of Landscape Architecture
School of Architecture

Faculty Mentor: Judy Brittenum
Faculty Consultants: Mary Comstock, Mark Boyer
Department of Landscape Architecture

Abstract:

"People do not use city open space just because it is there and because city planners or designers wish they would."

Jane Jacobs, *The Death and Life of Great American Cities*

Urban parks were, and sometimes still are, thought of as sanctuaries from the surrounding city. Large green areas were historically set aside in cities or on the outside of cities to be used as parks, but, until recently, no great effort was made to provide more intimate spaces in individual neighborhoods. In the urban environment today, parks may also be perceived as places of potential crime and danger. A park, depending on its location and users, may be a place that is avoided and thought of by nearby residents and passersby as an eyesore rather than an asset. Lewis Mumford said of park design, "It is not by a mere quantitative increase in the present park facilities, but by a comprehensive change in the whole pattern of life that we shall realize the full social function of open spaces."

The location of this study was Detroit, Michigan, a city notoriously plagued by the effects of poverty, high crime rates, overcrowding, and neglect. On July 23, 1967 one of the most devastating civil disturbances occurred in Detroit. At the end of the rioting a few days later, 43 people were dead, thousands were injured and arrested, and \$100 million in property had been destroyed by fire and looting.

After the 1967 Detroit riot, former president Lyndon B. Johnson appointed a committee to investigate the causes of the riots. The committee recommended four areas as the focus of action to improve the daily life struggles endured by people who participated in these riots. The four areas were: employment, education, the welfare system, and housing. Although this report was quite extensive, it was not exhaustive. It did not include one major component of a city, which has unfortunately been overlooked in the design of many of America's cities, and that is the incorporation of open space.

What is a Pocket Park?

Pocket park is the term used to refer to "parks in densely built locations occupying interstitial space between buildings and bounded by sidewalks and walls of existing buildings" (Goldsteen p. 12). A pocket park is usually one to three city lots in size and is typically located in a dense urban area. There are three basic locations for pocket parks: corner lots, midblock lots, and through-the-block lots.

Pocket parks have a range of functions and purposes which depend upon their location and their user groups. A pocket park may serve a business district, a community center, or a residential neighborhood. A pocket park may be a place for workers to eat lunch, a play area for children, a backyard in dense residential neighborhoods, or a community garden. A pocket park may consist of hard surfaces, green surfaces, or a combination of both. They may be plazas with trees for shade, gardens, or playgrounds.

The Focus: HOPE Campus

Focus: HOPE is a forty-acre campus located along Oakman Boulevard and Fenkel Avenue between Linwood Avenue and Woodrow Wilson Avenue in Detroit (see figure 1). Highland Park, an independent city surrounded by Detroit, is located east of Focus: HOPE at the terminus of Oakman Boulevard.

Focus: HOPE is located in an industrial zone. Adjacent to Focus: HOPE are low density residential areas. Oakman Boulevard, which passes through the Focus: HOPE area, is designated as public and private open space corridor. The closest primary community retail/service center in the area is in the city of Highland Park, a few blocks east of Focus: HOPE. The Focus: HOPE campus is divided by the John Lodge Freeway, a freeway extension that runs under Oakman Boulevard. There is also an abandoned railway spur that separates parts of Focus: HOPE from each other.

As Focus: HOPE has developed and grown over the years it has started to evolve into what appears and functions much like

a university or college campus. Focus: HOPE has many of the same features of a campus: teaching facilities, administrative offices, employment areas, and in the near future, residential units. In the years to come, Focus: HOPE will continue to grow and expand. This expansion can continue the way it has in the past, with various buildings and vacant lots being purchased as they become available, however, it is clear at this time that Focus: HOPE would benefit tremendously if the area they currently occupy in Detroit were to be treated as a campus, the Focus: HOPE campus. This would allow Focus: HOPE to be viewed as a whole unit. As a campus, Focus: HOPE would become a community, and the communities around Focus: HOPE would become part of the greater community of Focus: HOPE.

The Focus: HOPE campus currently consists of 20 buildings, several parking lots, and a few vacant lots. If and when buildings and land near Focus: HOPE become available, they can be purchased, and the campus can expand. There are several buildings along Linwood Avenue and Fenkel Avenue that appear as though they may be vacant or in need of renovation. There are also several vacant lots in the area. The purchase and/or reuse of some of these buildings and vacant lots would improve the overall image of the area and allow Focus: HOPE to continue to evolve and expand.

Demographics

The residential areas surrounding Focus: HOPE are predominately African American (98% black and 2% white). The median age of these residential areas is 34. The median household income is \$11,929, and the average household income is \$18,547. The education levels are low; 42% of the population has no high school diploma, 66% have no college education and 85% have no college degree. The unemployment rate is 33%, which is well above the national percentage of 3.9% (based on 1990 census data). The residential areas surrounding Focus: HOPE are comprised of 3,387 housing units. Of the total housing units 10% are vacant, 43% are owner occupied and 47% of the housing units are rental units.

From this data it can be surmised that the residents of this area of Detroit have a lower level of education and; therefore, lower levels of income, and a higher rate of unemployment. The people who live in these residential areas can greatly benefit from an organization such as Focus: HOPE, that provides people with educational as well as employment opportunities.

Another key point to be taken from the demographic data is the predominance of a black population working and living in this area. Just as Focus: HOPE has a story to tell, so do the people of the local African American community.

Creating a Sense of Place

"The power of place...the power of ordinary urban

landscapes to nurture citizens' public memory, to encompass shared time in the form of shared territory." (Hayden p.9)

A public park or plaza is shared territory and can help to give a neighborhood, community, or campus a distinguishable and recognizable sense of place. It is important to recognize and embrace the culture and heritage of the people living in a particular area. In order for a park or plaza to have a sense of place the people must feel a connection to that particular park or plaza so that space may become a place rather than merely a space. Places have history and meaning. In order to give identity and meaning to a place, it is important to embrace, reflect and celebrate the history, experiences and culture of the people who occupy a place and of the place itself.

To embrace the heritage of the African-American community one might look at the art of John Biggers and the poetry of Maya Angelou. In the artwork of John Biggers one can see delightful mosaics of geometric patterns, deep solemn colors, the heart and soul of the African-American traditions and culture, and a portrait of the human experience.

Details

As one looks at the details, patterns, and symbols found at Focus: HOPE, they begin to form their own network of geometric patterns. This network of geometric patterns can be assembled into a mosaic similar to those found in the artwork of John Biggers. From the repetition of the diamond shape found in the architectural details of several buildings owned by Focus: HOPE to the symbol of Focus: HOPE (two hands reaching out to each other, one black and one white, enclosed by a circle, a shape without hierarchy), Focus: HOPE contains many geometric shapes, which when put together can make their own mosaic of geometric pattern. The repetition of patterns throughout the Focus: HOPE campus would help to strengthen the identity of Focus: HOPE and aide in creating a sense of place.

Overall Concept: *Reflecting upon the past, celebrating the future.*

Focus: HOPE is a place with a story to tell, a story that needs to be told. The overall concept for the Focus: HOPE campus involves interpreting that story. The story of Focus: HOPE is one of overcoming adversity through a series of events and experiences. Focus: HOPE came out of a very dark period in Detroit's history and gave people hope for a better tomorrow. To understand the importance and value of Focus: HOPE the past must be remembered in order to celebrate the future.

The overall campus plan.

Focus: Hope is currently divided into three zones (see figure2). Zone A is the main zone of activity. This zone contains the administrative offices and educational/training facilities. Zone B is the future residential area, and Zone C is the manufacturing zone. Zone B is separated from Zone A & C by

the John Lodge Freeway, and Zone C is separated from Zone A & B by the Conrail Spur Railroad Line.

The three zones of the Focus: HOPE campus can be linked together by converting the abandoned railroad tracks into a recreational trail. Linking the three zones together with a recreational trail would help to create a unified campus instead of having three separate zones of the campus. A recreational trail would not only link the separate zones of the Focus: HOPE campus together but would help to link Focus: HOPE to other businesses and residents in the area.

There are several opportunities for the abandoned railroad tracks that separate Zone A from Zone B. The tracks could be converted into a recreational trail. This trail would be approximately a one mile loop and could be used for running, bicycling, and walking. Converting the railroad tracks into a recreational trail would link the three zones of Focus: HOPE together, link the communities surrounding Focus: HOPE to the campus, and provide a connection from Focus: HOPE to other parts of Detroit.

The railroad track area presents another opportunity, a potential location for a retention pond, and thus, an additional service and amenity for the site. The overwhelming amounts of impervious surfaces in and around the Focus: HOPE area have few places for rainfall to go. As a result, rainwater has collected in the area between the two sets of railroad tracks. The presence of wetland vegetation tells us that collection of rainwater has occurred in this area for quite some time. This area would benefit from a constructed wetland/retention pond because this type of facility would filter the runoff water that collects after a rainfall. A constructed wetland could become an even greater amenity because it could also be used as an outdoor classroom for nearby students.

At this time Focus: HOPE lacks a defined main entry. The corner of Linwood Avenue and Oakman Boulevard has the potential to become the main entry. There is a parking lot located on each of the two east corners of the intersection. The northeast corner is where the parking lot for the Center for Children is located, and a vacant lot occupies the southeast corner. The purchase of this vacant lot should be one of the priorities of Focus: HOPE. This corner lot could help to give the Focus: HOPE campus a clearly defined entry.

There are several possible options to enhance and create a sense of entry at the intersection of Oakman Boulevard and Linwood Avenue. Pedestrian circulation is one issue that needs to be addressed at Focus: HOPE. Vehicular circulation currently dominates the Focus: HOPE campus. Oakman Boulevard has four lanes of traffic and parking lane on each side of the street. Vehicular circulation also penetrates the Focus: HOPE campus as it leads to various buildings and parking lots within the interior of the campus.

Pedestrian circulation is primarily confined to the sidewalks and street intersections where crosswalks are located. There are no clearly defined pedestrian circulation paths from Oakman Boulevard to the interior buildings at Focus: HOPE.

In addition to the much needed pedestrian routes within the campus there is a need for midblock pedestrian crosswalks at key points along Oakman Boulevard and other areas of Focus: HOPE, such as along Linwood and Fenkel Avenue.

Park A Program Development, Inventory, Analysis

The site of Pocket Park A was once the location of the Saran Company, a paint supplier that went out of business in 1990. Because of the building's condition, it was determined to be unsuitable for use in 1995 and demolished shortly thereafter. The now-vacant lot is enclosed by the Center for Advanced Technologies Annex on the west side, the Food Center on the east side and the F & H Manufacturing building on the north side. The lot is located on the north side of Oakman Boulevard between La Salle Boulevard and Fourteenth Street.

Focus: HOPE has decided that, as soon as funding is made available, this vacant lot will be the location of a pocket park. The lot is across the street from the Resource Center, where the administrative offices of the organization are located. The vacant lot can be seen from the second floor of the Resource Center and is the primary view from the windows on the north side of the building (also the location of the director and co-founder's Eleanor Josaitis' office). A row of evergreen trees was planted along the south side of the lot to help screen the view from the Resource Center and Ms. Josaitis' office. The second view from the park is of the alley behind the Food Center.

The vacant lot is closed off by a chain link fence on the south and east sides of the lot and by rows of barbed wire along the F & H Manufacturing building on the north side of the lot. The lot itself is completely vacant; no debris has been allowed to collect on it. There are three entrances to the park: one from Oakman Boulevard, a second from the alley between the CAT and the Food Center and a third from the Food Center. The lot is flat and contains some remnants of the building that once occupied it.

Pocket Park A is located in one of the three nodes of activity at Focus: HOPE. The overall campus would benefit greatly if this pocket park and the Resource Center were to be linked together so that they are visually one unit. There are three entrances to Park A: along Oakman Boulevard, from the Food Center, and from the alley behind the Food Center. The alley would need to be enhanced if it were to remain open. The alley could be a potentially unsafe area because it is hidden from any views from the street and from any offices or buildings in the area. Closing this alley is one possible solution.

The walls of the buildings that enclose the park have fallen into disrepair. These walls have been painted in the past. The walls can either be painted again or, depending on the condition of the bricks, the paint may be removed. Painting murals on these walls is another viable option.

The design of this park will have to ensure that access to the service corridor along the Center for Advanced Technologies Annex remains clear and open. Topsoil will have to be brought in; the current conditions of the site are not suitable for plant growth. The row of evergreen trees used as a temporary screen along Oakman Boulevard will have to be removed, as will the chain link fences.

Concept: CELEBRATION

The people who come to Focus: HOPE not only need to reflect upon their past, but they also need to celebrate their achievements, heritage and daily lives.

Park A Final Plan

There are three main components of the final design of Park A: a public space, a grove of trees, which create a transition between the public and semi-private space, and a semi-private space (see figure 3). The park begins at Oakman Boulevard, steps up to a grove of trees, ramps down through a more secluded space and terminates at a cafe. The dark, gloomy alley has been replaced by this cafe to ensure a constant flow of activity in the park, provide a safer alternative to the alley, and provide a back door to the park, which can be locked when it is not in use.

As one exits the cafe, a trellis provides some protection from the sun and allows the experience from indoor to outdoor to be a gradual procession. The next space is a more secluded place. Found in this space are several murals painted by local artists and seating areas to view the murals and ornamental displays in the planting beds under the murals. The change in elevation will encourage the pedestrian to slow down, maybe even stop and enjoy the beauty of the artwork on the walls and the vegetation coming from the earth within this park.

The walk from the cafe to the public space is a processional walk. The walkway itself is smaller at the cafe entrance but opens to merge with the public space. A grove of honey locust trees provides a transitional area between the two parts. Movable chairs can be found under the light, delicate canopy of the honey locust. As the trees end, the next space begins. A set of stairs, which is also a large seating area, gradually steps down into the public space at the main entry of the park.

At the edge of the park is an interactive fountain. This fountain may be turned off when Focus: HOPE has the need for a large public gathering space. The top of the set of stairs could then become a stage, and crowds could fill the area of the interactive fountain and spill out onto Oakman Boulevard.

In addition, the service corridor has been kept clear and three feet below the grade of the park, which keeps this area separate from the park. A service corridor has also been provided for the entry to the food center.

Park B Program Development, Inventory, and Analysis

Pocket Park B is located on the corner of Oakman Boulevard and Woodrow Wilson Avenue at the northwest corner. The building adjacent to the vacant lot (on Oakman Boulevard) is the former Communications building of Focus: HOPE. Newsletters and brochures were once published and stored there; this building is currently vacant. The other building, north of the vacant lot, is owned by Taylor Engineering Corp. (on Woodrow Wilson Avenue), not by Focus: HOPE. A chain link fence divides the two properties. Across the street from the pocket park site is the Yellow Pages Building. This building is owned by Focus: HOPE and is currently vacant. The future plans for this building are to renovate it into residential units for participants in Focus: HOPE's programs and hotel rooms for visitors. The building materials consist of red brick, off-white concrete blocks, and light brown brick. A large portion of the Taylor Engineering building is covered with corrugated green fiberglass.

The site itself is mostly gravel with some concrete remnants of the building that once stood here. The site is flat and large puddles of water tend to accumulate on this lot near the intersection. There is one light pole in the center of the vacant lot. This lot is currently being used as a parking lot. There are three vehicular entrances (paved driveways) to the vacant lot. Street trees have recently been planted along Oakman Blvd. in front of the vacant lot. Another feature of this site is the steam tunnel vents that are located along Woodrow Wilson Avenue. There are two vents that are approximately six feet tall and colored blue. Also, there is a utility corridor that traverses east-west along the chain link fence that separates Taylor Engineering's property from Focus: HOPE's property.

Park B, similar to Park A, is located in one of the three main nodes of the Focus: HOPE campus. The overall design of the campus would benefit if the two vacant buildings and the vacant lot visually read as one unit. The Yellow Pages building can be seen from the freeway and from any position on the Focus: HOPE campus. This building is a landmark building, and Focus: HOPE should take advantage of its presence.

The vacant lot can be divided into two main zones: a service/parking zone and a park zone. The park zone should be kept clear of automobiles. Vehicular circulation can and should be kept behind the vacant building. A use for the vacant building next to the park should be determined so the functions of the park and building go together.

The steam tunnel vents located along Woodrow Wilson Ave. cannot be moved. The utility lines, however, can and should be placed underground. Parts of the Taylor Engineering building

will need to be screened (particularly the corrugated green fiberglass). A planting buffer is also needed along the John Lodge Freeway. One view in particular is worth keeping, the view from the street edge towards the Taylor Engineering building. The facade of this section of the building is red brick, which is a pleasant background to the red brick building located in front of it.

Concept: REFLECTION LOOKING BACK LOOKING FORWARD

People who come to Focus: HOPE do so because they want to make their lives better. This park is for those people, to reflect upon their past and look forward toward the future.

Park B Final Plan

The design of Park B consists of a variety of seating areas, intricate paving patterns, trees, planting beds and a water element (see figure 5). Park B is a place of reflection, a "backyard" for the residents of the Tech Villa and other neighboring residents and visitors. The steam tunnel vents remain where they are, and this object has been repeated along both sides of Woodrow Wilson Avenue to visually link both sides of the street and to integrate the steam tunnel vent into the design of the park. The steam that comes from the two working vents is real, but the smoke that comes from the faux steam vents represents the smoke that lingered over the city of Detroit during the summer of 1967. This element will serve as a reminder of the Detroit Riots so this event can be reflected upon.

The fountain contains the symbol of Focus: HOPE. The hands are made of metal coated with a colored sealant. Along the centerline are a series of fountain jets. The water level of the fountain is just below the height of the hands. The outer edge of the fountain is 30" deep; this edge is also a seat wall.

There are thus a variety of seating areas in this park: around the fountain, along the planters and in moveable chairs that can be placed in the sun around the fountain area or under the shade of the honey locust trees. There are also moveable tables. There are two types of planters: one close to the street edge of Oakman Boulevard, with public seating areas, and another along the back edge of the park, a more private seating area. These planters are to be filled with colorful displays of annuals and perennials.

The paving patterns of this park are a manipulation of the diamond shape found on many buildings on the Focus: HOPE campus. The patterns are larger at the more public areas, and the pattern is smaller at the more private areas of the park. This paving pattern has been laid out to fit the dimension of a modular brick with sand swept joints. The diamond shape around the trees allows for the removal or addition of bricks depending on the growth of the trees.

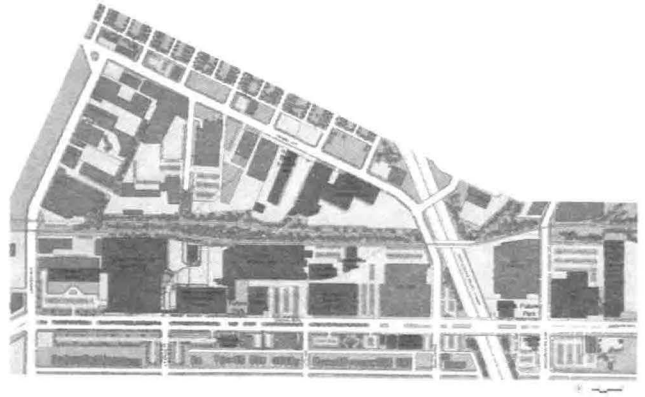


Figure 1: Map of the Focus: HOPE campus

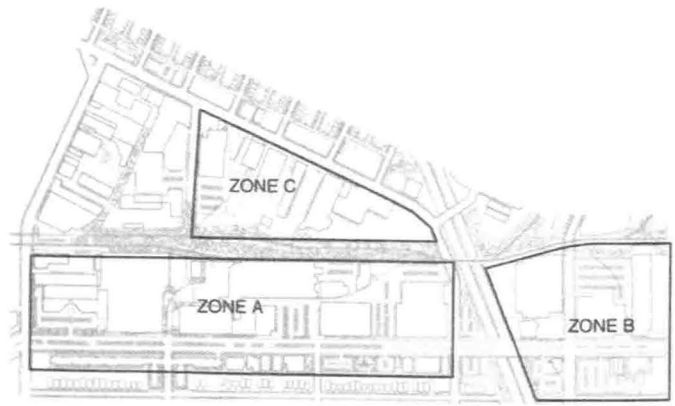


Figure 2: The three zones of the Focus: HOPE campus

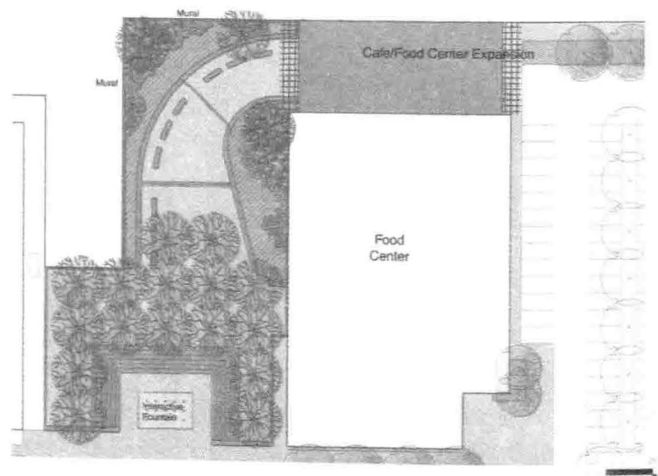


Figure 3: Pocket Park A final plan

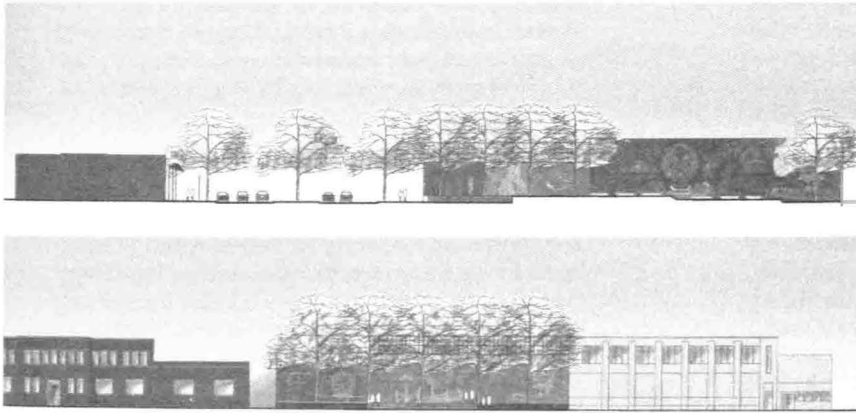


Figure 4: Pocket Park A sections

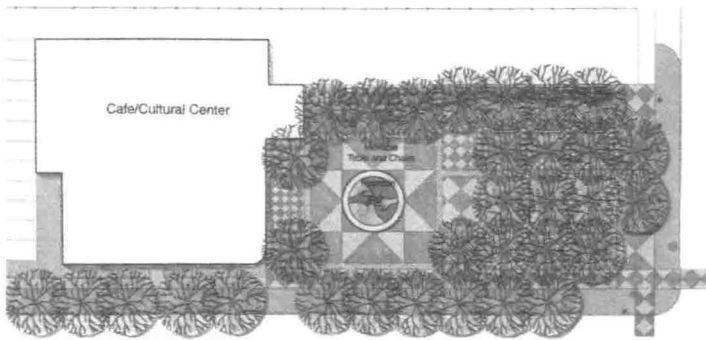


Figure 5: Pocket Park B final plan

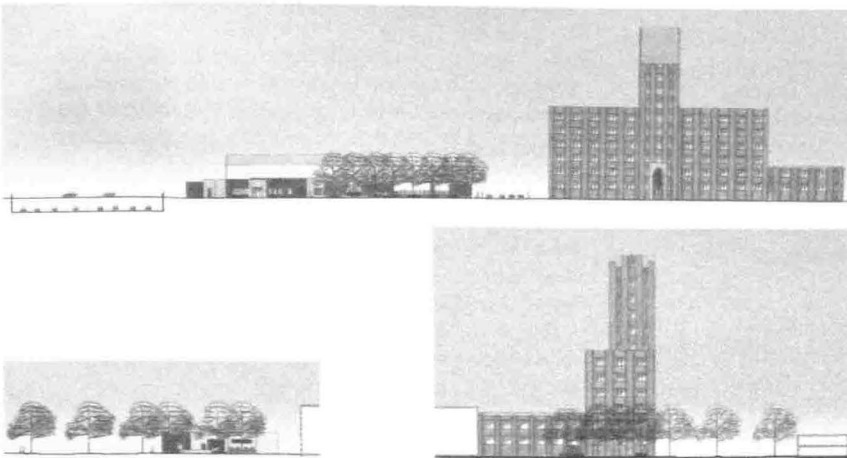


Figure 6: Pocket Park B sections

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Faculty comments

Judy Brittenum, Ms. Luks' primary mentor and critic on her thesis project, described her work as follows:

Jennifer's writing and research ability is among the most outstanding of the students I have mentored for the past three years. She courageously selected a senior demonstration project in Detroit, within a site directly related to the Detroit Race Riots of the sixties. Project Hope, the non-profit institution that brings the prospect of a better life to the millions who suffered during this time, was ready to expand their facilities in the heart of a very poor neighborhood, wanting to design the infill fabric for a contiguous set of unrelated buildings and services. Project Hope approved Jennifer's involvement, and she set forth to design a fairly straightforward project. Little did she know that the site was much larger than she first believed and that the program involved would take most of her design time to develop. Plans would require a far greater expertise and research ability than most landscape architecture thesis projects.

Jennifer had spent several semesters working at the University of Arkansas Community Design Center, learning their approach to process design. She had also held several professional internships, which allowed her entrée to landscape

architecture firms of note. The project she chose would command that she assemble all her knowledge and skills in determining a project solution that was adequate for Project Hope. Jennifer's first undergraduate degree was successfully completed in history, and contrary to common belief, a second degree in landscape architecture provided uncommon challenges to this traditional student.

The level of skill development and problem solving required are special to the architecture discipline, giving a wide berth for new educational roles to even the most seasoned student. Jennifer has completed a demonstration project that encompasses an understanding of ethnic, economic, community and ecclesiastical concerns. The work that she has done is not only a research work of merit but also a public service project worthy of publication and publicity. Her efforts are meritorious and her model for other students far exceeds most. I believe that you will find Jennifer Luks project provocative and stimulating.

Mark Boyer, who shared responsibility for the development of Ms. Luks' project during the final semester of work, is very complimentary as well. He said:

As one of Jennifer Luks' advisors, I was excited and intrigued about her Project Hope project in Detroit, Michigan, and am well-pleased with the end result. Through her work, Jennifer was able to expand the vision of possibilities from simply a plaza in a leftover space between buildings to a series of plazas, which serve not only the client but also the surrounding community.

The thoroughness with which Jennifer researched her site gave rise to a strong and compelling conceptual theme for the project. She drew inspiration from the site and community's history, the client's mission statement, and the cultural fabric to create rich spaces. These spaces provide not only for the intended function, but also for a sense of community ownership, which ensures higher project success. They tell the story of the place and will help keep current and future generations in touch with the rich cultural significance of that place. Jennifer's work has exceeded the expectations of the client and can be held up as an example of design process and success for future students.

Karen Rollet-Crocker also worked extensively with Ms. Luks. She had this to say about her:

Jennifer Luks' senior landscape architecture planning and design study about Project Hope was the result of an extensive planning and design process, which responded to revitalization concerns, educational needs, economic issues, social concerns, and racial issues in the city of Detroit, Michigan. In beginning her work, Jennifer was faced with the kind of overwhelming situation that is typical of poor, isolated

inner city neighborhoods. In this case, the goal of a planner is to translate a broad range of community needs into design recommendations that can galvanize people to move forward step by step, in spite of the odds against them.

Jennifer found that her analysis and recommendations needed to be expanded to the context of the city to study an abandoned railroad line, nearby neighborhoods, and major boulevard access. She also looked at nearby underutilized buildings. It was only then that she could recommend design concepts to improve the streetscape and two outdoor plazas.

There was yet another issue to be resolved in her project, which turned out to be most difficult. This was discovering a visual design concept that related to the specific culture, identity and goals of a training and education center, which served the African American population. This was the topic of a rather heated faculty discussion at her preliminary presentation. She found a way out of the impasse by doing two things: looking at the details which emerged out of a derelict industrial site and discovering the art of the African American artist John Biggers. The result was that she became aware of the impact of African art, religious meaning, and southern farming culture on this inner city site. Her use of these ideas in designing the plazas was one of her proudest accomplishments.

She has taken full advantage of the opportunities that have been available to her at the University of Arkansas. She has spent several semesters at the UACDC, a branch of the School of Architecture, which works on community development projects. The work is very demanding, and students must have skills in graphics, computer use, conceptualization, and writing to succeed. Other learning opportunities included a scholarship to study English landscape style and urban studies with Karen Hanna, our departmental chair.

Her organizational skills have put her in several student leadership positions in our Department of Landscape Architecture, including President of the Student Chapter of the ASLA. In this position she has organized get-togethers for students and visitors to our school. She was the head of a design team working on a special student project for Ed Stone, Jr. who was here as our John Williams Fellow. Jennifer also obtained a position as an intern at the nationally known landscape architecture firm of Johnson, Johnson and Roy in Ann Arbor, Michigan. She was one of just a few students selected for this opportunity from schools across the country.