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**UMBC REVIEW**

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**UMBC REVIEW**

*JOURNAL OF UNDERGRADUATE RESEARCH*



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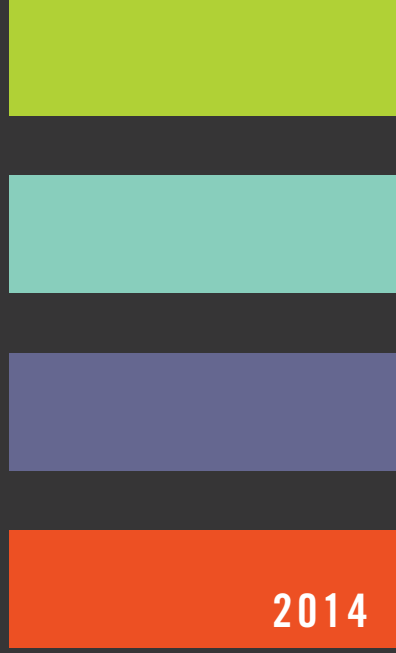
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# UMBC REVIEW

*JOURNAL OF UNDERGRADUATE RESEARCH*



2014



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## EDITORS' INTRODUCTION

You have in your hands the fifteenth edition of *The UMBC Review: Journal of Undergraduate Research*. For a decade and a half, this journal has highlighted the creativity, dedication, and talent UMBC undergraduates possess across disciplines. The university has a commitment to its highly renowned undergraduate research, and to that end the *UMBC Review* serves to present student papers in an academic and prestigious manner. The selections in this journal result from the rigorous scrutiny from professional, anonymous reviewers off-campus, some as close as College Park and others as far as China.

UMBC provides undergraduates with many opportunities to succeed, opportunities that often remain with them after graduation, and the *UMBC Review* is one such opportunity. Each year, undergraduate researchers submit papers with significant findings to their field, accomplished research that they would like to share with their fellows, faculty, and family. Through the combined effort of student editors and designers, with the continuous support of their faculty advisers, this journal selects and compiles several articles that best represent the diverse research performed on campus. We are pleased to present to you the ten articles in this issue:

**Robert Burton** notes the pollutants of the antibiotic tetracycline in the water supply via its excretion in human urine. Through chemical techniques, Burton investigates UV-H<sub>2</sub>O<sub>2</sub> treatment as an effective measure to mitigate this environmental hazard.

Through various computational methods, **Jane Pan** investigates the leading causes of oscillation death for the concentration of metabolites in a multicellular islet of the pancreas.

In their interdisciplinary study, **Justin Chang** and **Andrew Coates** introduce a mathematical model of intracellular calcium levels in the olfactory sensory neurons of mice to explain their experimental data.

**Isleen Wride** presents a correlational study between the ability to fight off disease and lifespan in fruit flies artificially selected for longevity and in a control. Her data ultimately support the life history theory, which indicates a tradeoff between immuno-competence and senescence.

**Lauren Bucca** details her trip to England, where she followed the pilgrimage of Saint Cuthbert, the patron saint of Northumbria. She uses interviews and folios to uncover the significance of the pilgrimage today and what people gain from pilgrimages.

In her study, **Grace Calvin** explores the behavior of Chinese-American mothers and their way of raising their children in the United States.

**Abigail Fanara** examines the tradition of giving diamond rings as engagement tokens by looking at the history of the diamond industry.

**Leslie McNamara** considers the racial and religious undertones of the Leo Frank case, a court case that riveted the state of Georgia in 1913.

**Kevin Triplett** explores the identity of fatherhood in gay men choosing to adopt or to conceive through surrogacy. He explores two novels to arrive at a conclusion about this identity and its permutations.

**Comfort Uдах** analyses three novels written by Nigerian women to find perspectives of class and gender issues as told from different points of view.



## ACKNOWLEDGMENTS

We would like to thank the faculty mentor of each student author for their support and their expertise toward the completion of each project. Each mentor guided their student in researching a topic, provided support throughout the process, and were gracious about adapting the writing into an interdisciplinary format:

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**DR. CAROLE MCCANN** - *Department of Gender and Women Studies*

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We are forever grateful to the reviewers who offered their time and expertise. These reviewers are peers from different institutions, and their comments guided the selection and editing process. For confidentiality purposes, these reviewers will remain anonymous.

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**AMANDA KNAPP** - *Undergraduate Education*

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We offer our gratitude to those committed to undergraduate research and provide funding for the *UMBC Review*.

Dr. Freeman Hrabowski  
The Office of Undergraduate Education  
The President's Office  
The Provost's Office

Finally, the *UMBC Review* student editors and designers owe their thanks to their respective faculty adviser for their continuous input and support by dedicating their time and expertise in creating the journal:

**DR. SUSAN MCDONOUGH** - *Editing*

**GUENET ABRAHAM** - *Designing*

It is our sincere hope that you enjoy this year's edition of the *UMBC Review*.

## EDITORS

**DOMINICK DIMERCURIO II** - *Junior, Biological Sciences & Mathematics*

**VANESSA RUEDA** - *Senior, English*

**GAGAN SINGH** - *Senior, English*



*ROBERT*  
***BURTON***

**ROBERT BURTON** .....

Robert Burton is a junior Chemical Engineering Major in the Environmental Engineering Track, with expected graduation in May 2015. He has a particular interest in wastewater treatment. Robert has been active in Engineers without Borders and is currently the vice president of the UMBC Chapter. He is also a member of the American Institute of Chemical Engineers. Robert would like to thank the Office of Undergraduate Education for their support via the Undergraduate Research Award. He also would like to especially thank Dr. Lee Blaney for giving him the opportunity to work in his lab. Dr. Blaney’s advice and guidance with experimental design and analysis has been invaluable. Robert would finally like to thank his family, lab mates, and friends for their support and guidance.

# TREATMENT OF TETRACYCLINE ANTIBIOTICS IN WATER USING THE UV-H<sub>2</sub>O<sub>2</sub> PROCESS

.....

Protecting natural resources has long been significant to me. On my path to Eagle Scout, I gained an appreciation for the importance of the environment to human civilization, and this awareness kindled my pursuit of a career that designs systems to protect natural waterways from damage. In Dr. Lee Blaney's environmental engineering lab, I was fortunate to be able to choose a research project at the intersection of my interests in agriculture, chemistry, and the environment. Pharmaceuticals, especially tetracycline, are an emerging contaminant in wastewater, contributed by both animal and human populations throughout the world. The purpose of my experiment was to decompose tetracycline into harmless compounds. A critical reason for this line of research is to mitigate the prevalence of antibiotic-resistant germs. This project studied the kinetics of tetracycline breakdown under ultraviolet light with varying amounts of hydrogen peroxide and with changes in the pH of the solution. We determined the rate constants of tetracycline degradation under ultraviolet light and the varying conditions. Rate constants that specify how fast a reaction occurs can be used to determine the time required to complete a reaction. This analysis will help wastewater treatment plants more effectively remove the tetracycline antibiotics by breaking them down before being released into our waterways.

## BACKGROUND

Tetracycline antibiotics are some of the most common antibiotics in use today for the treatment of bacterial infections in people. Tetracyclines are also widely utilized for treatment of pets and farm animals. According to the Food and Drug Administration, over 5.6 million kilograms of tetracycline antibiotics were consumed in livestock operations in 2010 (Food and Drug Administration, 2011). These antibiotics are not completely metabolized and have been detected in human urine (Kunin et al., 1956). Unsurprisingly, these pharmaceuticals have also been detected in water supplies around the world (Chang, 2008). From a macroscopic vantage, one source of this contamination is effluent from wastewater treatment plants (WWTPs), which contains low concentrations of tetracycline antibiotics as well as other pharmaceuticals (Kolpin, 2002). Ultimately, discharge from WWTPs becomes a drinking water supply for downstream locations. The presence of tetracycline pollutants in our water is a public health issue. One concern corresponds to the spread of antibiotic resistant bacteria (Kummerer, 2004). Tetracycline resistance genes have been discovered in various species of bacteria (Li et al., 1995). The tetracycline resistance genes have been discovered in various compartments of WWTPs, including the influent, activated sludge, and effluent streams (Auerbach et al., 2007). Microorganisms from groundwater near swine farms have demonstrated tetracycline resistance (Chee-Sanford et al.,

2001). For these reasons, and to preemptively secure the public health concerns resulting from antibiotics in water, research into removal of tetracycline antibiotics from water and wastewater is merited.

## PURPOSE

The focus of our research was to evaluate a treatment method for the removal of tetracycline antibiotics from water. We studied the abilities of ultraviolet (UV) irradiation and the ultraviolet/hydrogen-peroxide (UV-H<sub>2</sub>O<sub>2</sub>) advanced oxidation process to transform tetracycline antibiotics (tetracycline and chlortetracycline) into benign compounds, thereby, reducing the potential for development of antibiotic resistant microorganisms. In particular, we investigated the reaction kinetics, i.e., the rate at which the reaction proceeds, and the transformation efficacy.

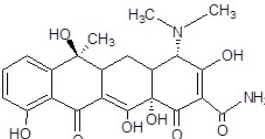
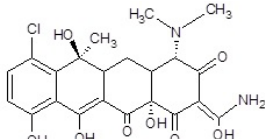
## METHODOLOGY

A set of solutions, containing tetracycline antibiotics at different pH levels and H<sub>2</sub>O<sub>2</sub> concentrations, were exposed to UV light in a batch-recycle reactor. Samples from the experiments were analyzed using advanced analytical instruments. The experimental materials and methods are further described in the following sections.

## CHEMICALS - TETRACYCLINE ANTIBIOTICS

Tetracycline and chlortetracycline (as chlortetracycline hydrochloride) were purchased from Sigma Aldrich (St. Louis, MO). More information on these two tetracycline antibiotics is provided below in Table 1.

**Table 1.** Tetracycline and chlortetracycline salient information.

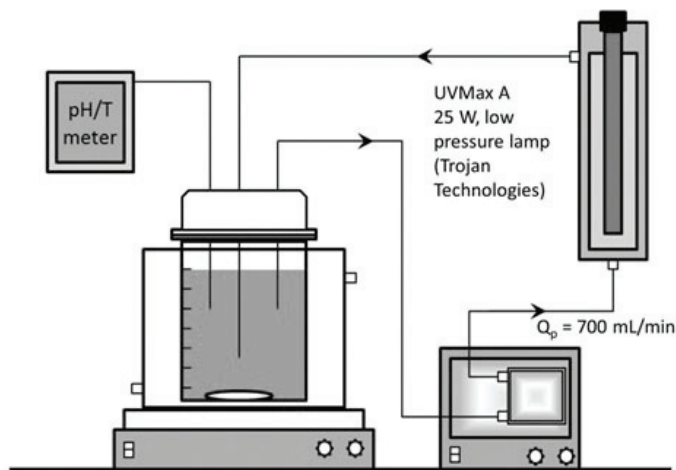
Antibiotic	Tetracycline	Chlortetracycline
Chemical Formula	C <sub>22</sub> H <sub>24</sub> N <sub>2</sub> O <sub>8</sub>	C <sub>22</sub> H <sub>23</sub> ClN <sub>2</sub> O <sub>8</sub>
Molecular Weight	444.44	478.88
Structure		



## REACTOR SETUP FOR TRANSFORMATION EXPERIMENTS

During experimentation, a solution containing tetracycline antibiotics, phosphate buffer (to control pH), and  $\text{H}_2\text{O}_2$  (when applicable) was pumped through a batch-recycle UV reactor. A schematic of the experimental set-up is shown below in Figure 1.

The initial concentration was diluted to 5 mg/L of tetracycline antibiotics for all UV and UV- $\text{H}_2\text{O}_2$  experiments. 5 mg/L tetracycline solutions were picked to ensure that the antibiotic was detectable throughout the experiment. One liter of solution was used for each run. A 10 mM phosphate-based buffer was added to the solution to establish a constant pH for the reaction. Stock solutions of 100 mg/L antibiotic and 100 mM phosphate buffer were employed throughout experimentation. The time of exposure to UV light (wavelength of 254 nm) was kept consistent between the runs by using a constant flow rate of 700 mL/min for each experiment. All experiments were performed at room temperature,  $22.5 \pm 1.0^\circ\text{C}$ .



**Figure 1.** Schematic of the batch-recycle UV reactor.

The time that each solution was run through the UV reactor was determined by how rapidly the antibiotics were transformed, which was generally a function of the solution pH. For direct photolysis (UV only), the experimental time ranged from 10 to 90 minutes with the solutions at higher pH run for shorter times. During the UV- $\text{H}_2\text{O}_2$  process, the transformation of tetracycline antibiotics occurred more rapidly; therefore, the

experimental time ranged from three to five minutes. Samples were taken at regular time intervals for each run; all samples were stored in the dark at 4 °C before analysis of tetracycline concentrations.

When organic compounds absorb UV light, the molecules become excited and chemical transformations can occur. As more UV light (i.e., energy) is absorbed, the extent of transformation is increased. If there is hydrogen peroxide in the solution, hydroxyl radicals can be generated.



Hydroxyl radicals are highly reactive and offer an alternative mechanism for water/wastewater treatment of tetracycline antibiotics. Our experiments focused on the abilities of two distinct treatment mechanisms: (a) direct photolysis (UV only), which transforms compounds through absorption of UV light and (b) advanced oxidation (UV-H<sub>2</sub>O<sub>2</sub>), which oxidizes tetracycline antibiotics by absorption of UV light and through reaction with hydroxyl radicals. These two mechanisms were investigated to determine the potential for tetracycline transformation in UV disinfection processes and to quantify the advantages of adding H<sub>2</sub>O<sub>2</sub> to such processes.

## EXPERIMENTAL PLAN

The experimental plan for this research project is shown below in Table 2. Chlortetracycline and tetracycline transformation during UV irradiation was investigated at eight different pH values. The UV-H<sub>2</sub>O<sub>2</sub> experiments focused on elucidating the effective reaction kinetics of tetracycline at pH 8.17 for different molar ratios of hydrogen peroxide to tetracycline. We posit that the benefits associated with the UV-H<sub>2</sub>O<sub>2</sub> process for tetracycline will be similar to those provided by chlortetracycline.

**Table 2.** Experimental plan for tetracycline and chlortetracycline.

Antibiotic	Type	pH	H <sub>2</sub> O <sub>2</sub> : TC (mole/mole)	Sampling Interval (min)
Chlortetracycline	UV	2.13	0	10
		2.85	0	10
		6.26	0	10
		7.00	0	10
		7.27	0	6
		8.00	0	3
		8.61	0	2
		9.00	0	1
Tetracycline	UV	2.10	0	1
		3.00	0	1
		4.40	0	10
		5.20	0	10
		6.26	0	10
		6.92	0	10
		7.27	0	6
		7.92	0	3
		8.61	0	2
		9.00	0	1
	UV-H <sub>2</sub> O <sub>2</sub>	8.17	0.1	0.5
		8.17	0.2	0.5
		8.17	1	0.5
		8.17	5	0.5
		8.17	10	0.5
		8.17	50	0.5

## ANALYTICAL METHODS

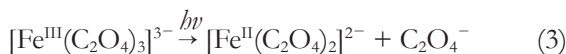
A Thermo Evolution 600 UV-Vis spectrophotometer was used to determine the molar absorptivity of tetracycline and chlor-tetracycline. Solutions containing 1-5 mg/L of the representative tetracycline at pH 2-12 (controlled using 10 mM phosphate buffer) were generated. The low-pressure UV lamp only emits photons at 254 nm, so the molar absorptivity at 254 nm was recorded.

Hydrogen peroxide concentrations were measured through potassium permanganate titrations using standard methods (Kasture et al., 2008). In brief, 1 N potassium permanganate was titrated, using a burette, into a solution containing hydrogen peroxide. The reaction between potassium permanganate and hydrogen peroxide frees the  $\text{Mn}^{2+}$  ion as shown in Reaction 2.



The potassium permanganate titrant has a deep purple color. Upon reaction with hydrogen peroxide, this color is lost. The colorless solution exists when  $\text{H}_2\text{O}_2$  has quantitatively reacted with  $\text{MnO}_4^-$ . The concentration of  $\text{H}_2\text{O}_2$  can be derived through the stoichiometric quantities from Reaction 2 when the color starts to appear in the solution. A hydrogen peroxide stock solution was made at 0.42 M and stored at 4°C in an amber bottle.

Potassium ferrioxalate actinometry was used to determine the photon flux of the UV lamp. Potassium ferrioxalate is highly sensitive to light with wavelengths shorter than 500 nm (Murov et al., 1973). This sensitivity manifests through the reduction of Fe(III) to Fe(II), as displayed in Reactions 3 to 5; Reaction 6 is the overall reaction.



By quantifying the reduction of Fe(III) to Fe(II), we were able to determine the photon flux of the low-pressure UV lamp. A 6 mM solution of ferrioxalate was made by combining 0.2 M ferric sulfate solution in 2 N sulfuric acid with 1.2 M potassium oxalate solution and diluting with deionized water. This solution was irradiated using the conditions described above, and samples were taken over the course of 10 minutes. These samples were reacted with 1,10-phenanthroline to create a phenanthroline-Fe(II) complex, which was detected at 510 nm using the UV-Vis spectrophotometer. The photon flux was determined to be  $2.55 \times 10^{-4}$  Einstein/minute.

During UV and UV-H<sub>2</sub>O<sub>2</sub> experimentation with tetracycline and chlortetracycline, test samples were collected from the beaker at periodic intervals and put into amber bottles to protect them from light. These samples were analyzed using liquid chromatography (LC) with diode array detector (DAD) or tandem mass spectrometry (MS/MS) to determine the concentrations of the individual antibiotics; the instrument consisted of the Dionex 3000 Ultimate LC system with a Thermo Scientific TSQ Quantum Access Max tandem mass spectrometer. A previously reported method was employed (Environmental Protection Agency, 2007) for analysis of tetracyclines, and so only brief details are provided here. The eluents included (a) LC-MS water with 5 mM oxalic acid and (b) 1:1 acetonitrile and methanol with 5 mM oxalic acid. Both eluents were filtered and degassed before use. The method has a variable flow gradient as shown in Table 3. The flow rate of the eluents was 0.3 mL/min. A C<sub>18</sub> column was used to separate the analytes in the column compartment. Two UV channels were employed at 280 nm and 360 nm. The parent ion for tetracycline was  $m/z$  444, and the product ion was  $m/z$  410. For chlortetracycline, the parent and product ions were  $m/z$  479 and  $m/z$  444, respectively. These analytical methods were employed to measure experimental concentrations of tetracycline antibiotics during transformation experiments.

**Table 3.** Eluent gradient for LC-DAD-MS/MS methods.

Time (min)	Eluent A (%)	Eluent B (%)
0	90	10
5	60	40
6	10	90
10	10	90
15	90	10

During analysis, three samples of deionized water were first analyzed to establish a baseline and ensure that the column was properly equilibrated. Experimental samples were analyzed from the lowest concentration (i.e., longest irradiation time) to the highest concentration (i.e., the initial sample) to minimize carry-over effects. Before another set of samples was run, a set of three blanks was run to ensure no carry-over from one data set to another.

## RESULTS AND DISCUSSION

### CHEMICAL SPECIATION

In solution, tetracycline antibiotics exhibit four protonation states: cationic, zwitterionic, singly anionic, and doubly anionic. Using known  $pK_a$  values (Qiang and Adams, 2004), the speciation behavior of each tetracycline antibiotic can be determined for a given solution pH. The  $pK_a$  values represent the pH values at which the concentration of one species is equal to another (e.g.,  $pK_{a1}$  is the pH at which the concentrations of the cationic and zwitterionic species are equal). The speciation behavior of tetracycline is shown in Figure 2 and described for discrete values of solution pH in Table 4. Each species is expected to have distinct properties and reactivity in UV-based oxidation processes. In the pH range of interest to water and wastewater chemistry (i.e., between pH 5 and 9), tetracycline antibiotics mainly exist in the zwitterionic and anionic forms.

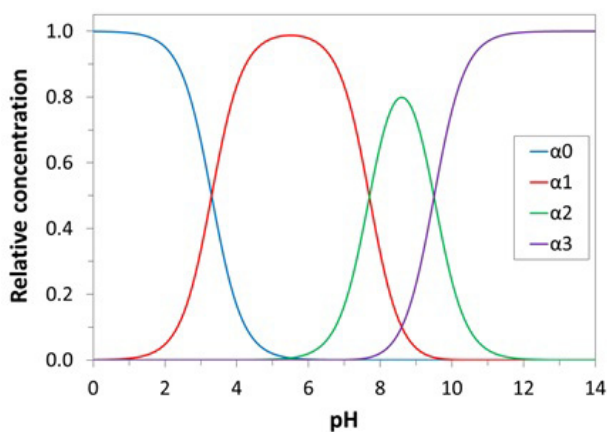


Figure 2. Speciation of tetracycline antibiotics.

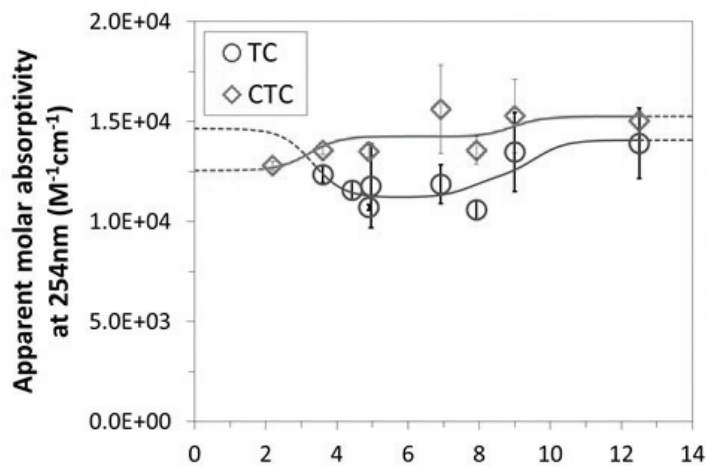
**Table 4.** Description of tetracycline and chlortetracycline speciation at select pH.

Compound	pK <sub>a</sub>	$\alpha_0$ (+,0,0)	$\alpha_1$ (+,-,0)	$\alpha_2$ (0,-,0)	$\alpha_3$ (+,-,-)
Tetracycline	3.3	0.50	0.50	0.00	0.00
	7.7	0.00	0.50	0.50	0.01
	9.5	0.00	0.01	0.50	0.50
Chlortetracycline	3.3	0.50	0.50	0.00	0.00
	7.4	0.00	0.50	0.50	0.01
	9.3	0.00	0.01	0.50	0.50

MOLAR ABSORPTIVITY

The molar absorptivity for tetracyclines is the amount of light absorbed by a solution containing a specific antibiotic concentration. As the UV lamp used in these experiments emits light at a wavelength of 254 nm, the molar absorptivity at 254 nm is of interest. Figure 3 shows that the molar absorptivity is a function of pH. To determine the molar absorptivity at any pH, we set specific values of molar absorptivity to the individual species (see Table 5) of tetracycline and chlortetracycline, as shown in the equation,

$$\epsilon_{app} = \alpha_0\epsilon_0 + \alpha_1\epsilon_1 + \alpha_2\epsilon_2 + \alpha_3\epsilon_3,$$



**Figure 3.** The molar absorptivity at 254 nm of tetracycline and chlortetracycline as a function of pH.

**Table 5.** Specific molar absorptivity at 254 nm of tetracycline and chlortetracycline species.

Compound	$\epsilon_0$ (M <sup>-1</sup> cm <sup>-1</sup> )	$\epsilon_1$ (M <sup>-1</sup> cm <sup>-1</sup> )	$\epsilon_2$ (M <sup>-1</sup> cm <sup>-1</sup> )	$\epsilon_3$ (M <sup>-1</sup> cm <sup>-1</sup> )
Tetracycline	13,700	10,600	12,400	12,700
Chlortetracycline	21,000	11,900	14,000	14,700

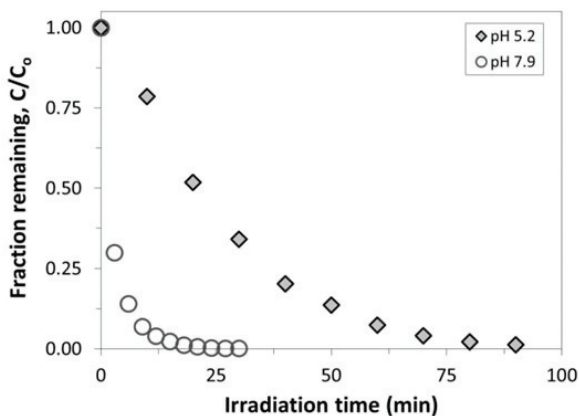
where the variable  $\alpha$  is the fraction of each species at a particular solution pH and  $\epsilon$  is the corresponding molar absorptivity; the subscript *app* refers to the apparent molar absorptivity at a particular pH. The 0, 1, 2, and 3 subscripts in this equation indicate the cationic, zwitterionic, anionic, and doubly anionic species, respectively (Jeong et al., 2010). This approach provides a good fit to experimental data (Figure 3). The molar absorptivity will be used to determine the reaction kinetics for transformation of tetracycline antibiotics with UV and UV-H<sub>2</sub>O<sub>2</sub> processes.

## TRANSFORMATION KINETICS

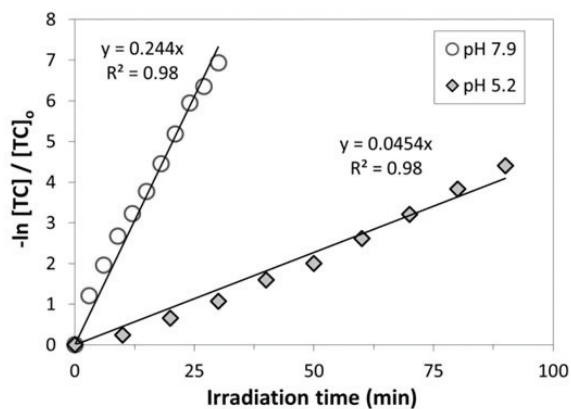
As expected, the transformation of tetracycline is a function of pH and time (Figure 4). By using this data, time-based first-order rate constants can be calculated (Figure 5); these rate constants allow for description of tetracycline transformation as a function of UV irradiation time. The observed, or apparent, rate constant for the different experimental solutions was calculated using the slope of the curve of the natural log of the normalized tetracycline concentration versus time. The equation for tetracycline at pH 5.2 is  $y = e^{-0.0454x}$  and the rate constant was 0.0454 min<sup>-1</sup> (Figure 5). At pH 7.9, that rate constant is 0.244 min<sup>-1</sup>, which corresponds to faster transformation in the UV reactor (see Figure 4). The apparent time-based first order rate constant ( $k'_{d,app}$ ) can be calculated as the sum of contributions from individual tetracycline species as shown in the equation,

$$k_{app} = \alpha_0 k_0 + \alpha_1 k_1 + \alpha_2 k_2 + \alpha_3 k_3 .$$





**Figure 4.** Transformation of tetracycline as a function of time and pH.



**Figure 5.** Determination of the time-based first-order rate constant for tetracycline transformation by UV.

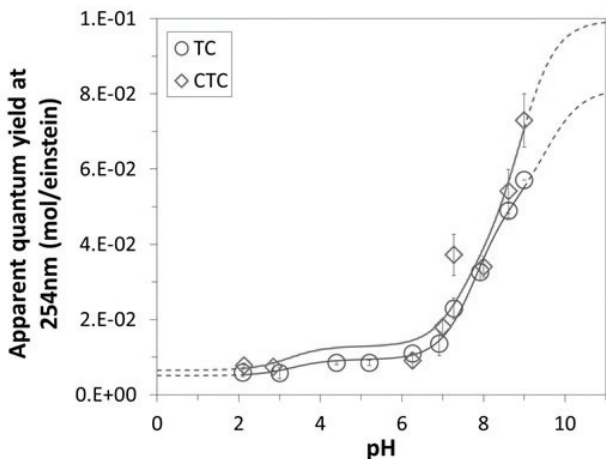
While the time-based rate constants fit our experimental data well, these results are not applicable to other systems. For example, a more powerful lamp would yield a different time-based rate constant. Therefore, time-based rate constants were converted to the quantum yield at 254 nm as shown in the equation,

$$\phi_{app} = -2.3 k_{app} I / \epsilon_{app}$$

The variable  $\phi$  is the quantum yield which has units of mole per Einstein;  $I$  is the photon flux in Einstein/min and  $\epsilon$  is the path

length. The quantum yield describes transformation of tetracycline antibiotics as a function of photons absorbed and is, therefore, applicable to any other system (Pereira et al., 2007). The apparent quantum yield is a function of the contributions of individual tetracycline species. By fitting experimental data values of the specific quantum yield associated with tetracycline species were determined (Table 6), as follows:

$$\phi_{app} = \alpha_0\phi_0 + \alpha_1\phi_1 + \alpha_2\phi_2 + \alpha_3\phi_3.$$



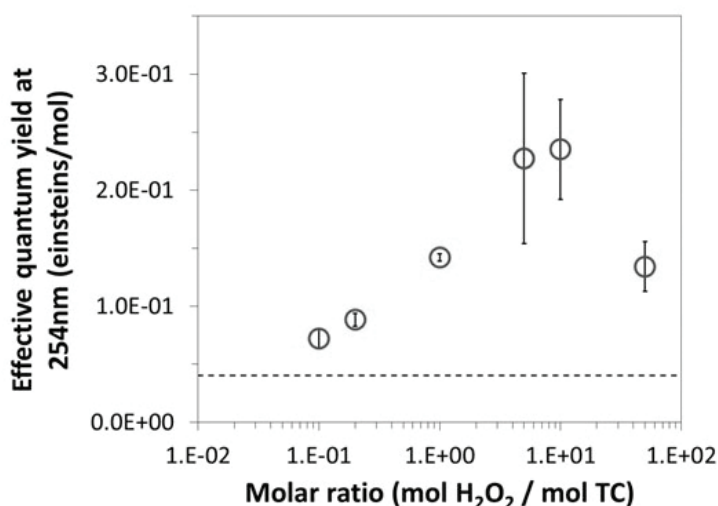
**Figure 6.** Quantum yield at 254 nm of tetracycline and chlortetracycline as a function of pH.

Pharmaceutical	$\phi_0$ (mol/Einstein)	$\phi_1$ (mol/Einstein)	$\phi_2$ (mol/Einstein)	$\phi_3$ (mol/Einstein)
Tetracycline	$5.09\times10^{-3}$	$9.38\times10^{-3}$	$5.11\times10^{-2}$	$8.13\times10^{-2}$
Chlortetracycline	$6.56\times10^{-3}$	$1.29\times10^{-2}$	$3.96\times10^{-2}$	$9.96\times10^{-2}$

## ADVANCED OXIDATION KINETICS

As previously discussed, addition of hydrogen peroxide allows for generation of hydroxyl radicals in UV processes. Figure 7 shows how the effective quantum yield at 254 nm increases as a function of hydrogen peroxide concentration. The effective quantum yield accounts for UV transformation as well as oxida-

tion through hydroxyl radicals. For specific  $\text{H}_2\text{O}_2$  doses (5:1 to 10:1 mol  $\text{H}_2\text{O}_2$  / mol tetracycline), the effective quantum yield can be increased to approximately five times that of the UV process. Between the molar ratios of 0.1:1 and 1:1 of hydrogen peroxide to tetracycline the transformation kinetics improve linearly with the ratio. When the molar ratio is less than 1:1, there are more tetracycline molecules than hydrogen peroxide molecules in solution, so hydroxyl radical reaction with tetracycline molecules is uninhibited. Between the 10:1 and 50:1 molar ratios of hydrogen peroxide to tetracycline, the rate constant decreases linearly; however, our data indicates that the resulting kinetics are still better than direct photolysis. This decrease stems from the scavenging of hydroxyl radicals by hydrogen peroxide. For these reasons, optimization of the UV- $\text{H}_2\text{O}_2$  process is important to ensure that maximum transformation of tetracycline antibiotics is accomplished during wastewater treatment.



**Figure 7.** Effective quantum yield at 254 nm of tetracycline as a function of hydrogen peroxide concentration.

Approximately 25 percent of US wastewater treatment plants now use UV disinfection. For disinfection purposes, the UV dose is typically 30–40  $\text{mJ}/\text{cm}^2$  (Shin *et al.*, 2001). The quantum yield can be converted into a fluence-based rate constant ( $k'_{p,254}$ ), which allows for relatively straightforward calculation of transformation efficiency as a function of UV dose, as shown

in the following equation. Note that  $U_{254}$  is the molar photon energy at 254 nm (i.e.,  $4.72\times10^5$  J/Einstein). The fluence-based rate constant is

$$k'_{p,254} = \frac{\varepsilon_{254} \phi_{254} \ln(10)}{U_{254}} \quad .$$

Table 7 summarizes the UV dosage requirement for 50%, 90%, and 99% transformation of tetracycline and chlortetracycline. In the presence of hydrogen peroxide, treatment of tetracycline antibiotics is feasible at realistic UV doses; however, minimal transformation can be expected at typical UV disinfection doses.

**Table 7.** Required UV dose for specific treatment objectives. An H<sub>2</sub>O<sub>2</sub> to tetracycline ratio of 10 mol/mol was used for this analysis.

Transformation efficiency	Tetracycline (pH 8)		Chlortetracycline (pH 8)	
	UV dose (mJ/cm <sup>2</sup> ) UV	UV dose (mJ/cm <sup>2</sup> ) UV-H <sub>2</sub> O <sub>2</sub>	UV dose (mJ/cm <sup>2</sup> ) UV	UV dose (mJ/cm <sup>2</sup> ) UV-H <sub>2</sub> O <sub>2</sub>
50%	329	56	254	38
90%	1090	187	842	127
99%	2190	374	1690	254

## CONCLUSION

The apparent molar absorptivity was successfully modeled by setting specific molar absorptivity values for individual tetracycline species. Transformation of tetracycline antibiotics is a function of time, UV irradiation, and pH, with better transformation efficiencies at higher irradiation times and pH. The values of the apparent quantum yield for tetracycline and chlortetracycline are similar across the pH 2 to 9 range. Given the structural similarity of other tetracycline antibiotics, we posit that the apparent quantum yield of all tetracycline antibiotics will be similar. For pH relevant to water/wastewater treatment, the apparent quantum yield ranges from 0.01-0.07 moles per Einstein. These values indicate that for every 100 photons absorbed, approximately one to seven molecules of tetracycline will be transformed.

In the UV-H<sub>2</sub>O<sub>2</sub> advanced oxidation process, an effective quantum yield can be calculated to demonstrate the impact of UV photolysis and oxidation by hydroxyl radicals. The ideal molar ratio of hydrogen peroxide to antibiotic is 5-20 mol H<sub>2</sub>O<sub>2</sub>/mol antibiotic. At this level, the effective quantum yield can be increased to 0.25 mol/Einstein at pH 8.2 indicating that 25 molecules of tetracycline are transformed for every 100 photons absorbed by solution. The optimal range of the molar ratio of hydrogen peroxide to antibiotic allows some operational flexibility with the UV-H<sub>2</sub>O<sub>2</sub> process in wastewater treatment plants.

While minimal transformation of tetracycline antibiotics is expected in UV disinfection processes, significant removal can be attained using the UV-H<sub>2</sub>O<sub>2</sub> process at realistic UV doses. Ultimately, this technology has promise to help wastewater treatment plants more effectively reduce the concentrations of antibiotics entering our waterways.

## **FUTURE WORK**

This research has described the reaction kinetics of two tetracycline antibiotics in the UV and UV-H<sub>2</sub>O<sub>2</sub> processes. Future research will focus on the benefits of UV-H<sub>2</sub>O<sub>2</sub> treatment over UV irradiation in different water matrices, such as wastewater effluent and stream water. Furthermore, I plan to investigate the behavior of other tetracycline antibiotics in the UV and UV-H<sub>2</sub>O<sub>2</sub> processes. In particular, I intend to study oxytetracycline and doxycycline, which are extensively used in human and veterinary health applications.

## **ACKNOWLEDGEMENTS**

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*JANE*  
**PAN**



**JANE PAN** .....

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# LOSS OF METABOLIC OSCILLATIONS IN A MULTICELLULAR COMPUTATIONAL ISLET OF THE PANCREAS

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As my freshman year was coming to a close, my anxiety was gradually increasing because my plans for the summer were still unknown. Little did I know, I was only one e-mail away from spending eight weeks of my summer working in the Research Experience for Undergraduates (REU) site: Interdisciplinary Program in High Performance Computing hosted in the Department of Mathematics and Statistics at UMBC. Ever since I received an e-mail confirming my eligibility to participate in the program from my program directors Dr. Matthias Gobbert and Dr. Nagaraj Neerchal, I was not only exposed to a new learning environment, but I was also introduced to respected faculty members on campus as well as participants from across the country. My team's research during the eight weeks of the summer program involved examining the patterns that are exhibited by pancreatic beta-cells, which are the biological units responsible for secreting insulin into the bloodstream. Through modifying and implementing existing code in the mathematical software package MATLAB, we were able to simulate the cells' behaviors by manipulating various parameters. Understanding the factors that affect insulin secretion and finding conditions that cause beta-cells to behave in certain ways will allow researchers to gain a clearer insight into potential treatments for diabetes.

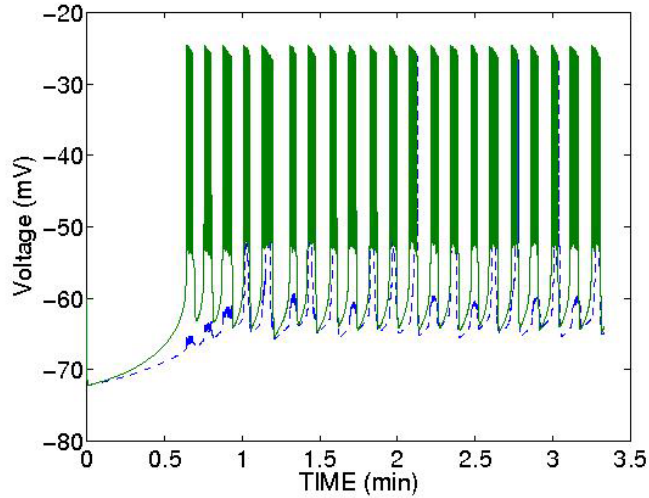
## 1 INTRODUCTION

Diabetes mellitus, commonly known as diabetes, is a group of diseases in which the body either does not have the capability to produce insulin or is not capable of producing sufficient amounts of insulin to compensate for the glucose that enters the body. According to the American Diabetes Association (ADA), diabetes affects the lives of approximately 8.3 percent of the U.S. population of all ages and racial backgrounds [4]. People experience diabetes across all regions of the world.

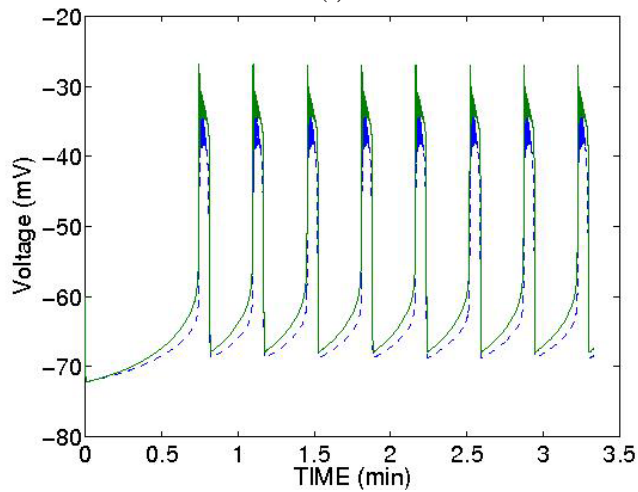
Normally, when blood sugar levels are increased by the consumption of glucose, a healthy human body naturally produces adequate amounts of insulin to remove excess glucose that could be harmful. The biological units that are responsible for the secretion of insulin are identified as beta-cells [10], which are one of four hormone-producing cell types located in the pancreas. Clusters of beta-cells are known as islets of Langerhans, which depend on other islets within the pancreas to successfully carry out the production of insulin. While type I diabetes involves the immune system directly attacking the beta-cells, type II diabetes is caused by the increasing resistance that the body develops towards the effects of insulin rather than the lack of beta-cells directly.

In order to have a better understanding of diabetes in the hopes of finding effective methods to treat it, it is necessary to analyze the behavioral patterns exhibited by pancreatic beta-

cells. Previous studies have observed that beta-cells undergo series of voltage oscillations during the course of insulin secretion. Once glucose enters the beta-cell, the cell itself experiences an increase in ATP, which leads to the depolarization of the beta-cell, allowing calcium to enter and insulin to be released into the bloodstream [7]. The frequency at which insulin is secreted correlates to the oscillating behavior of the cells. Oscillations are grouped in bursts of electrical activity.



(a)



(b)

**Figure 1.1** (a) Oscillation behavior of two coupled beta-cells with an electrical coupling value of 0.01 pS. (b) Oscillation behavior of the beta-cells with an electrical coupling value of 0.1 pS.

Coupling is a natural process that occurs between cells within the islets of Langerhans. Gap junctions serve as pathways for the coupling that occurs between these cells, allowing for effective communication from cell to cell, including the transfer of ionic currents and calcium ions [1]. Previous findings have supported the notion that certain variations of coupling play a vital role in facilitating the production of insulin [10]. This can be seen primarily in the bursting patterns that the cells exhibit.

Figure 1.1 displays the oscillation behaviors of two heterogeneous beta-cells when they are electrically coupled with one another. One cell has parameters that support a short period between bursts, fast burster, while the other cell supports longer periods between bursts, slow burster (details are in Section 2). Both plots display continuous voltage alterations between rapid spiking behavior and stages of gradual increase. The rapid voltage oscillations denote the bursting action of the beta-cells, signifying the release of insulin. The smooth lines following these rapid spiking phases represent the periods of rest before insulin is secreted again.

Cases in which the cells contain stronger electrical coupling strengths eventually become synchronized. Figure 1.1 (a) looks fairly synchronized. Figure 1.1 (b) contains the results that are obtained when the electrical coupling strength is increased by a factor of 10. It can be seen that the oscillations between the two cells are more harmonized, which suggests that the bursting behaviors between the two heterogeneous cells are becoming similar.

Our team was particularly interested in studying the factors that contributed to oscillation death. The term “death” is used to signify the loss in slow metabolic oscillations that the beta-cells exhibit. In order to analyze this specific case, our team needed to take into account beta-cells that are metabolically coupled to one another, in which certain metabolites are transferred through the gap junctions of the cells. We ran simulations that implemented various combinations of electrical and metabolic coupling by the metabolites fructose 1-6-biphosphate (FBP) and glucose 6-phosphate (G6P). Previous studies performed by Sherman [10] obtained results that suggested a correlation between oscillation deaths and the addition of G6P coupling. We aimed to extend Sherman’s research by running simulations with larger islets of cells rather than just two cells. Since an islet of cells in the human body is generally comprised of approximately 1000 cells, it would be beneficial to run simu-

lations using more realistic values in order to corroborate Sherman's proposed theory in the death of oscillations.

## 2 MATHEMATICAL MODEL

To approach this problem, we represent a computational islet using an  $N \times N \times N$  cube, where  $N$  represents the dimensions of the cube measured in number of cells. In each cell, this beta-cell model uses a model with glycolytic dynamics initially developed by Smolen [9] and combined with electrical dynamics by Sherman [10]. The model's dependent variables are voltage  $V$ , fraction of open potassium ( $K^+$ ) channels  $n$ , and five other chemical concentrations. The equations form a stiff system of seven coupled ordinary differential equations (ODEs)

$$(2.1) \quad \frac{dV}{dt} = - \frac{I_K + I_{Ca} + I_{K(Ca)} + I_{K(ATP)}}{C_m}$$

$$(2.2) \quad \frac{dn}{dt} = \frac{n_\infty - n}{\tau_n}$$

$$(2.3) \quad \frac{d[Ca]}{dt} = f_{\text{cyt}}(J_{\text{mem}} + J_{\text{er}})$$

$$(2.4) \quad \frac{d[Ca_{\text{er}}]}{dt} = -\sigma_v f_{\text{er}} J_{\text{er}}$$

$$(2.5) \quad \frac{d[ADP]}{dt} = \frac{[ATP] - [ADP] \exp\{(r+\gamma)(1 - \frac{[Ca]}{n})\}}{\tau_a}$$

$$(2.6) \quad \frac{d[G6P]}{dt} = k(R_{\text{GK}} - R_{\text{PFK}})$$

$$(2.7) \quad \frac{d[FBP]}{dt} = k(R_{\text{PFK}} - 0.5R_{\text{GPDH}})$$

where  $[XX]$  denotes the concentration of  $XX$  in the cytosol for calcium ( $Ca$ ), adenosine diphosphate ( $ADP$ ), glucose-6-phosphate ( $G6P$ ), fructose-1,6-bisphosphate ( $FBP$ ), and in the endoplasmic reticulum ( $ER$ ) for calcium ( $Ca_{\text{er}}$ ). The forms for consumption of  $G6P$  due to phosphofructose kinase  $R_{\text{PFK}}$  and dehydrogenase consumption of  $FBP$   $R_{\text{GPDH}}$  can be found in [2].

Additional definitions are

$$\begin{aligned}
 I_K &= g_K \bar{n} (V - V_K), \\
 I_{Ca} &= g_{Ca} \bar{m}_\infty(V) (V - V_{Ca}), \\
 I_{K(Ca)} &= g_{K(Ca)} (V - V_K), \\
 g_{K(Ca)}([Ca]) &= \frac{\bar{g}_{K(Ca)}([Ca])}{1 + \left(\frac{K_d}{[Ca]}\right)^2}, \\
 I_{K(ATP)} &= g_{KATP} (V - V_K), \\
 g_{KATP} &= \bar{g}_{KATP} o_\infty([ADP]), \\
 m_\infty(V) &= \frac{1}{1 + \exp\left[-\frac{20 + V}{12}\right]}, \\
 J_{er} &= 0.0002([Ca_{er}] - [Ca]) - 0.4[Ca], \\
 J_{mem} &= (4.5 \times 10^{-6}) I_{Ca} - 0.2[Ca], \\
 o_\infty([ADP]) &= \frac{0.08 + \left(1 + 2 \frac{0.165[ADP]}{17}\right) + 0.89 \left(\frac{0.165[ADP]}{17}\right)^2}{\left(1 + \frac{0.165[ADP]}{17}\right)^2 \left(1 + \frac{0.135[ADP]}{17} + 0.05 [ATP]\right)}.
 \end{aligned}$$

The potassium channel has current,  $I_K$ , with maximal conductance,  $\bar{g}_K$  and gating variable  $n$  driven by the potential's difference from the channel's Nernst potential,  $V_K$ . Similarly, the calcium, calcium-sensitive potassium, and ATP-sensitive potassium channel with currents,  $I_{Ca}$ ,  $I_{K(Ca)}$ , and  $I_{K(ATP)}$ , each have a maximal conductance  $\bar{g}_{K(Ca)}$ ,  $\bar{g}_{Ca}$ , and  $\bar{g}_{K(ATP)}$ . Each also has conductance dynamics defined by  $m_\infty(V)$ ,

$$\frac{([Ca])}{1 + \left(\frac{K_d}{[Ca]}\right)^2}$$

with sensitivity parameter  $K_d$ ,  $[Ca]$  and  $o_\infty([ADP])$ , respectively. Calcium enters the cytosol via the membrane,  $J_{mem}$ , or from the ER,  $J_{er}$ . A corresponding amount is lost from the ER,  $-J_{er}$ . Each calcium dynamic is scaled by  $f_{cyt}$  or  $f_{er}$  representing buffering in the respective compartment, and  $\sigma_v$  is the ratio of volume fraction of cytosol to ER. The parameter  $k$  scales the rates of metabolism reactions. The factor  $\exp\left\{\left(r + \gamma\right)\left(1 - \frac{([Ca])}{r_1}\right)\right\}$  captures calcium feedback onto the production of ADP produced with a time constant,  $T_a$ . We use constants:  $C_m = 5300$  fF,  $V_K = -75$  mV,  $g_K = 2700$  pS,  $T_n = 20$  ms,  $\bar{g}_{Ca} = 1000$  pS,  $V_{Ca} = 25$  mV. Note that  $R_{GK}$ ,  $\bar{g}_{K(Ca)}$ , and  $\bar{g}_{KATP}$  are parameters that impact bursting rates of electrical potential (voltage). For example, in Figure 1.1 the fast bursting cell has  $R_{GK} = 0.4$ ,  $\bar{g}_{K(Ca)} = 25000$  pS, and  $\bar{g}_{KATP} = 600$  pS, while the slow bursting cell has  $R_{GK} = 0.2$ ,  $\bar{g}_{KCA} = 27000$  pS, and  $\bar{g}_{KATP} = 100$  pS. In the rest of the work, the

cell heterogeneity is due only to changes in  $R_{\text{GK}}$ .

In order to couple the cells together, we define a matrix  $G$  that contains the coupling strengths between each pair of cells. The matrix  $G$  will be defined such that the coupling is diffusive ( $\alpha(V_i - V_j)$  where  $\alpha$  is the coupling strength,  $V_i$  is the neighboring cell and  $V_j$  is the current cell). Thus the system of ordinary differential equation can be written as

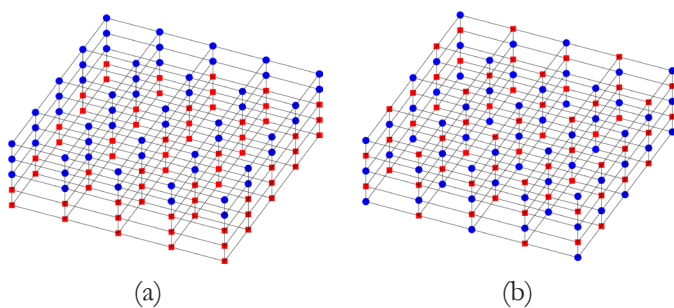
$$(2.8) \quad \frac{dy}{dt} = \mathbf{f}(t, \mathbf{y}) + G\mathbf{y},$$

where  $\mathbf{y} = (V, n, [\text{Ca}], [\text{Ca}_{\text{er}}], [\text{ADP}], [\text{G6P}], [\text{FBP}])^T$  is a vector of length  $7N^3$  (i.e.,  $V = [V_1, \dots, V_N]^T$ , etc.),  $\mathbf{f}(t, \mathbf{y})$  is the right hand side of equations (2.1)–(2.7), and  $G$  is a  $7N^3 \times 7N^3$  matrix.

Our research focuses on two arrangements of cells in the  $N \times N \times N$  islet, termed the grouped and the equal distribution structures. Figure 2.1 provides a visual representation of the arrangement of the two cell types in each distribution in a  $5 \times 5 \times 5$  islet. In the grouped structure, cells of the two heterogeneous types are arranged together and cell type is coupled to the other type only along the middle layer of the islet. In the equally distributed structure, cells are arranged in an alternating pattern such that no cell is coupled to another cell of its own type. Using these particular distributions allows us to interpret two extremes of the possible arrangements of two cell types in the islet.

### 3 METHODOLOGY

We now move to modifying the existing seven-variable model for our study.



**Figure 2.1** The arrangement of cells in a  $5 \times 5 \times 5$  islet. The red squares and blue circles represent the two different cell types in the (a) grouped structure and (b) equally distributed structure.



Using a similar model, the authors of [10] were able to demonstrate that oscillations in FBP and G6P concentrations will stop if certain parameters of two heterogeneous cell types are appropriate. We aim to be able to demonstrate that such “oscillation death” also occurs in multicellular computational islets.

### 3.1 SIMULATING METABOLIC COUPLING

We start by extending an existing model [10] of the beta-cell, which can handle electrical coupling already, to be able to handle G6P and FBP coupling. To implement these additions, our simulations use three matrices  $C_V$ ,  $C_{G6P}$ , and  $C_{FBP}$ , where the  $(a, b)$  entry of each matrix contains the coupling strength between the  $a$ th cell and the  $b$ th cell. As in [7],  $a$  and  $b$  are indexed with  $i + N(j - 1) + N^2(k - 1)$  being the one-dimensional index of the  $(i, j, k)$ -th cell for  $1 \leq i, j, k \leq N$  in a  $N \times N \times N$  islet. We now use these three matrices to define the matrix  $G$  in (2.8) by

$$G = \begin{bmatrix} C_V & 0 \dots 0 & 0 & 0 & 0 \\ 0 & 0 \dots 0 & 0 & 0 & 0 \\ \vdots & \vdots \dots \vdots & \vdots & \vdots & \vdots \\ 0 & 0 \dots 0 & 0 & 0 & 0 \\ 0 & 0 \dots 0 & C_{G6P} & 0 & 0 \\ 0 & 0 \dots 0 & 0 & 0 & C_{FBP} \end{bmatrix}.$$

The matrix is a  $7 \times 7$  block matrix with blocks of size  $N^3 \times N^3$ . This formulation of  $G$  allows (2.8) to simulate coupling in voltage, G6P, and FBP, while having no other couplings.

Since the distribution of heterogeneous cell types within the islet is unknown, we simulate the metabolically coupled islet with several different arrangements. Following the work of [7] on arrangements of two cell types, we use the arrangements of

1. *Grouped Structure* : The islet is split into two equally sized blocks of  $\frac{N^3}{2}$  slow cells and  $\frac{N^3}{2}$  fast cells.
2. *Equally Distributed Structure* : The islet is split so every neighbor of a slow cell is fast and every neighbor of a fast cell is slow.

Since the feedback from the electrical subsystem onto the glycolytic subsystem is weak, we can effectively isolate the glycolytic subsystem to locate a critical transition in parameters. In order to investigate the parameter space of where oscillation death, we vary the following parameter space in a  $5 \times 5 \times 5$  islet:

**1. Coupling strength:** Vary the metabolic coupling strength of G6P and FBP across a range while holding initial conditions and other parameters the same.

**2. Initial Values of Metabolites:** Look through the four-dimensional parameter space of initial values in G6P and FBP for two heterogeneous cell types while holding other parameters the same.

**3.  $R_{GK}$  values:** Change the  $R_{GK}$  values for two types of cells with different initial values.

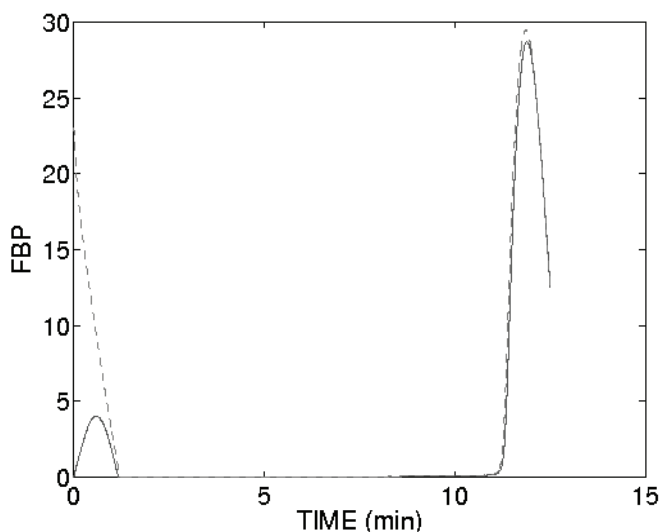


Figure 3.1 FBP in cell with  $RGK = 0.05 \text{ s}^{-1}$  (dashed) and  $RGK = 0.06 \text{ s}^{-1}$  (solid).

### 3.2 DETECTING OSCILLATIONS

We also implement a function which automatically determines if oscillation occurs in FBP concentrations in a cell, due to the large number of studies run to obtain our results. This function gives time for the dynamics in the cell to stabilize and then uses

a discrete derivative to examine whether the absolute value of the estimated rate of change is above a certain threshold. If it is not, we classify the study to be non-oscillating and determine whether or not the difference is within a threshold limit of synchronous oscillation death (see Section 4.1.1).

While this algorithm catches most cases of oscillation death, there are cases, especially near the transition around oscillation dynamics, where this algorithm fails from large rest periods and lack of computational time. For example, Figure 3.1 demonstrates an example where a potential error could occur. If the simulation had only captured 10 minutes, the late oscillation would not have been detected. The subject of a future study can be to formulate a method of detecting, with greater accuracy, whether no oscillation will occur.

The different studies we run for the  $5 \times 5 \times 5$  islet are as follows:

- 1. Electrical Coupling Study:** This study varies electrical coupling strength from 25 pS to 600 pS incrementing by 25 pS while holding G6P and FBP coupling constant at  $0.0 \text{ ms}^{-1}$  and  $R_{\text{GK}}$  at  $0.2 \text{ s}^{-1}$  for both types of distributions.
- 2. FBP Coupling Study:** This study varies FBP coupling strength from  $0 \text{ ms}^{-1}$  to  $0.1 \text{ ms}^{-1}$  incrementing by  $0.005 \text{ ms}^{-1}$  while holding G6P coupling constant at  $0.0 \text{ ms}^{-1}$ , voltage coupling at 100 pS, and  $R_{\text{GK}}$  at  $0.2 \text{ s}^{-1}$  for both types of distributions.
- 3. G6P Coupling Study:** This study varies G6P coupling strength from  $0 \text{ ms}^{-1}$  to  $0.1 \text{ ms}^{-1}$  in increments of  $0.005 \text{ ms}^{-1}$  while holding FBP coupling at  $0.01 \text{ ms}^{-1}$ , voltage coupling at 100 pS, and  $R_{\text{GK}}$  at  $0.2 \text{ s}^{-1}$  for both distributions.
- 4.  $R_{\text{GK}}$  Study:** This study varies  $R_{\text{GK}}$  from  $0 \text{ s}^{-1}$  to  $0.6 \text{ s}^{-1}$  incrementing by  $0.025 \text{ s}^{-1}$  while holding voltage coupling at 100 pS, FBP coupling at  $0 \text{ ms}^{-1}$ , and G6P coupling at  $0 \text{ ms}^{-1}$  for both types of distributions.

We also run a sampling of these studies for the  $3 \times 3 \times 3$  islet to see if and how varying islet size affects the threshold.

### 3.3 NUMERICAL METHOD

Given the different reaction rates of the system of differential equations (2.1)–(2.7), we have to treat this system as a stiff system of differential equations. We use a memory-modified version of MATLAB's `ode15s` with automatic differentiation developed in [5] to run our simulations. MATLAB's standard implementation of `ode15s` uses a version of Numerical Differentiation Formulas (NDF $k$ ), which is a standard method for stiff systems of differential equations [8]. In order to solve the system, NDF $k$  requires the Jacobian matrix of the right-hand side of the ODE system, which MATLAB allows to be handled in multiple ways. We supply a sparse Jacobian derived analytically using automatic differentiation, computed via the ADiMat software [3]. This is the optimal choice for our studies, because it has a significant speedup compared to most other methods, as observed in [7] as well as allows us to make modifications to the model in our simulations without having to recompute the Jacobian by hand.

MATLAB's standard `ode15s` has significant speed and memory issues in solving the seven variable model, even when supplied with a Jacobian found using automatic differentiation. The memory-modified version developed in [5] reduces the amount of memory allocated for each iteration of the process and removes the feature of `ode15s` that stores the gradient vector for each iteration, since it is not used in any of the post-processing, for our model. Efficiency tests in [7] show that there is a significant speedup when the combination of ADiMat and the memory-modified `ode15s` is used, which allows for more simulations.

In addition, usage of MATLAB's Parallel Computing Toolbox provided significantly higher simulation throughput. The command `parfor` is a parallel for-loop for studies with multiple runs of code, one for each of the for-loop values. Each for-loop parameter typically represents one parameter value, for which a run of the code is needed. On the cluster *tara* with eight computational cores on each node, MATLAB distributes the job associated with each parameter value in the parallel for-loop to one of the eight cores. Since these jobs are independent of each other and run simultaneously, the overall study can be completed eight times as fast as a serial run.

### 3.4 THE COMPUTING ENVIRONMENT

The computations for this study were performed using the MATLAB programming language ([www.mathworks.com](http://www.mathworks.com)) under the Linux operating system on the cluster tara, located in the UMBC High Performance Computing Facility ([www.umbc.edu/hpcf](http://www.umbc.edu/hpcf)). The distributed-memory cluster tara consists of 86 nodes, with each node containing two quad-core Intel Nehalem X5550 processors (2.66 GHz, 8 MB cache) and 24 GB memory; thus, up to eight parallel processes can be run simultaneously per node. All nodes and the 160 TB central storage are connected by a quad-data rate InfiniBand interconnect.

## 4 RESULTS

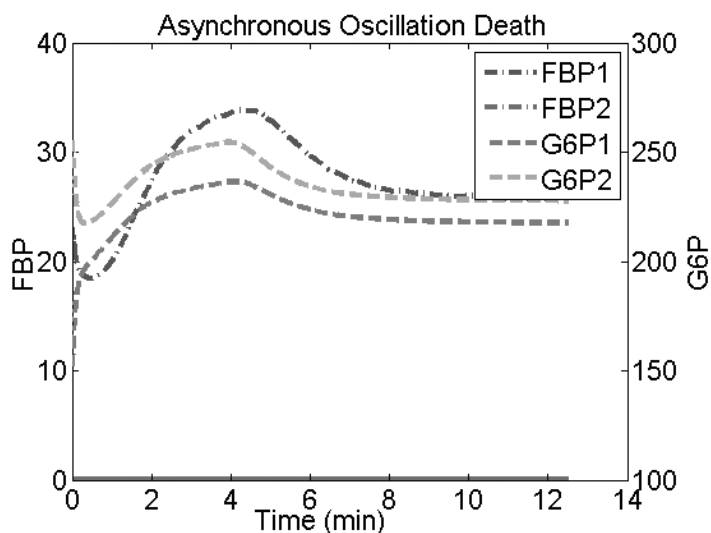
Our modifications to previous studies allow for metabolic coupling by the two metabolites glucose 6-phosphate (G6P) and fructose 1-6-bisphosphate (FBP) and enable us to study the effects of metabolic and electrical coupling on the oscillation behaviors exhibited by pancreatic beta-cells.

### 4.1 OSCILLATION DEATH

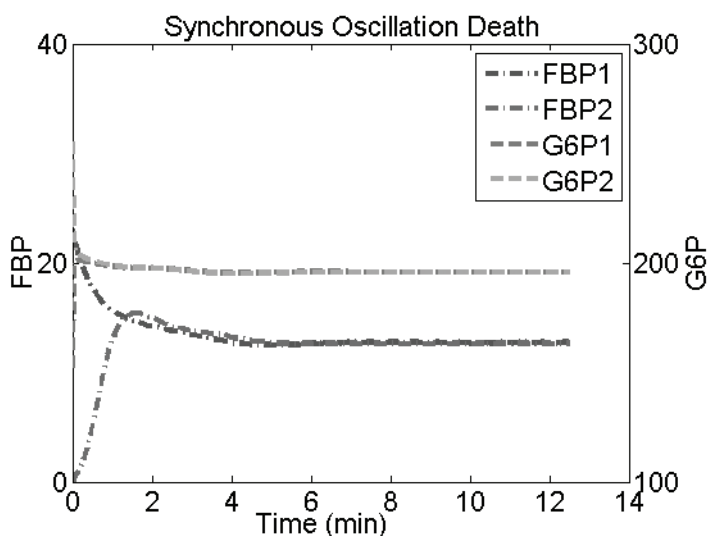
At certain combinations of electrical and metabolic coupling strengths, slow metabolic oscillations have been found to reduce and disappear in simulations run with a two-cell model [10]. We extend the findings of previous studies and consider a multicellular islet to observe for which initial conditions and coupling strengths we lose metabolic oscillations. To remain consistent with the model supplied by the study, we extend some portions of our implementation to include MATLAB translations of XPP files that produced figures in [10]. For additional consistency, we include heterogeneity of cells by allowing for the coupling of two types of cells with different initial conditions and  $R_{GK}$  values. Our simulations accept values for electrical, G6P, and FBP coupling strengths as parameters.

Figure 4.1 displays three classes of metabolic behavior that we observe in our two types of heterogeneous cells when we vary coupling strengths and initial conditions of FBP and G6P; these classes are asynchronous oscillation death, synchronous oscillation death, and oscillation. Numerics can be used to show that these three types of dynamics can be observed within the metabolic components even in a two-cell case. By adjusting  $R_{GK}$

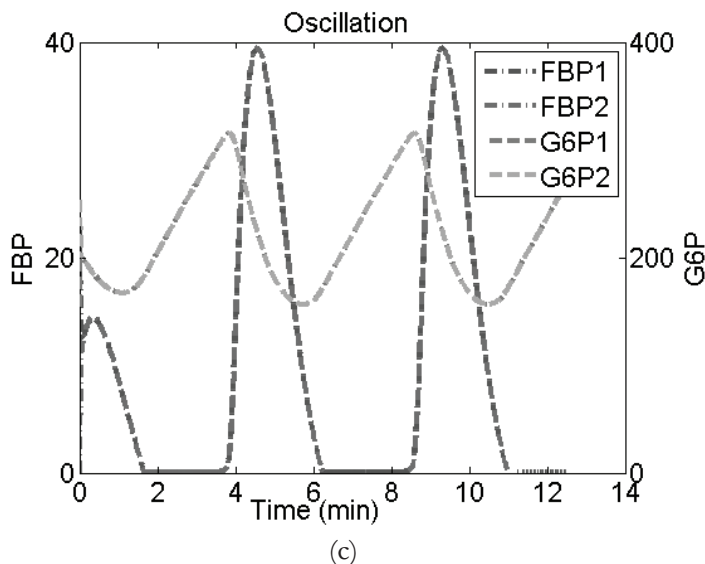
values, we change from a three-equilibria system to a one-equilibrium system, effectively displaying a pitchfork bifurcation. This suggests that altering RGK values might have a significant impact on a model with a larger cell count, which we examine in Section 4.1.3. For a more detailed analysis of this bifurcation in a two-cell case, see [10].



(a)



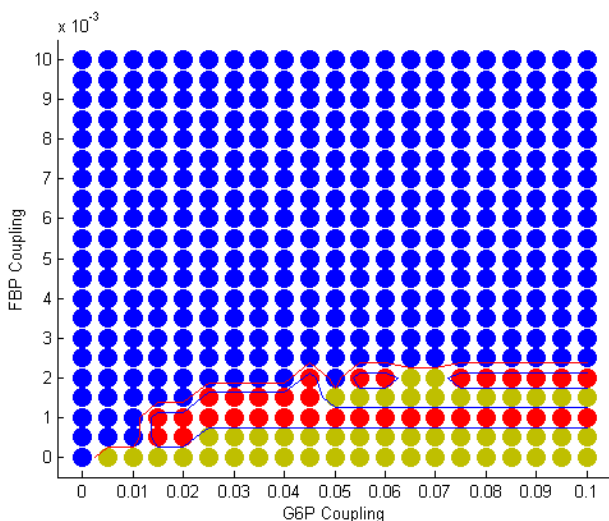
(b)



**Figure 4.1** Classes of metabolic behavior: (a) asynchronous oscillation death with  $g_V=75$  pS,  $g_{G6P}=0.01$  ms<sup>-1</sup>, and  $g_{FBP}=0.001$  ms<sup>-1</sup>, (b) synchronous oscillation death with  $g_V=75$  pS,  $g_{G6P}=0.1$  ms<sup>-1</sup>, and  $g_{FBP}=0.001$  ms<sup>-1</sup>, (c) continued oscillation with  $g_V=75$  pS,  $g_{G6P}=1$  ms<sup>-1</sup>, and  $g_{FBP}=0.1$  ms<sup>-1</sup>.

#### 4.1.1 OBSERVING THE EFFECTS OF METABOLIC COUPLING ON OSCILLATIONS

Oscillation death in the two-cell case was observed with electrical coupling of 75 pS and metabolic coupling of 0.001 ms<sup>-1</sup> for FBP and 0.01 ms<sup>-1</sup> for G6P. Manipulating our model such that only two cells are coupled to one another, we were able to reproduce this behavior with the same parameters. However, applying the same parameters to a multicellular islet of  $5 \times 5 \times 5$  beta-cells with the grouped and equal distributions, as detailed in Section 3.1, we find that oscillation death does not occur. In contrast, we observe metabolic oscillation death when all parameters are kept the same except for FBP coupling strength, which we decrease by a factor of 10. In following studies where we investigate the effect of altering initial conditions to test for oscillation loss, we use this updated combination of coupling strengths, since we have confirmed that it can produce oscillation death in a multicellular islet.



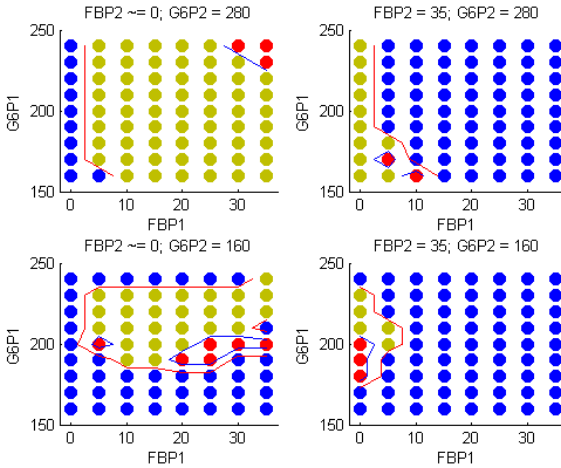
**Figure 4.2** Scatter plot with contour lines separating regions of different oscillation behavior. Blue signifies continued oscillation, red signifies synchronous oscillation death, and green signifies asynchronous oscillation death.

While finding a single set of coupling strengths for which oscillation death occurs is desirable, as it confirms that these observations in the two-cell model also occur in the multicellular islet, the boundary in parameter space between continued oscillation and oscillation death is also of interest in our studies. By running a study in which we varied the G6P coupling strength from  $0 \text{ ms}^{-1}$  to  $0.1 \text{ ms}^{-1}$  in steps of  $0.005 \text{ ms}^{-1}$  and the FBP coupling strength from  $0 \text{ ms}^{-1}$  to  $0.01 \text{ ms}^{-1}$  in steps of  $0.0005 \text{ ms}^{-1}$ , we produce Figure 4.2. We see that all three types of metabolic behavior occur as we vary the coupling strengths of the two metabolites for the given initial conditions and electrical coupling strengths, which are held constant.



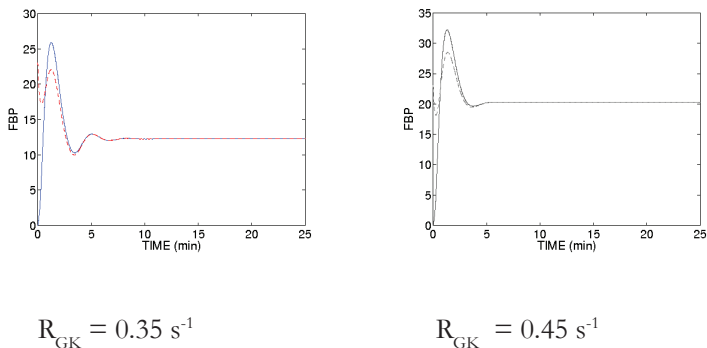
#### 4.1.2 INITIAL CONDITIONS

We are interested in combinations of initial conditions and coupling strengths that result in bistable solutions, particularly in asynchronous oscillation death, shown in Figure 4.1(a). Due to the dynamics of the two metabolites, the initial values heavily influence which basin of attraction the behavior will demonstrate.



**Figure 4.3** Coupling strengths kept constant at ( $L$ ) 75 pS, (G6P) 0.01 ms<sup>-1</sup>, and (FBP) 0.001 ms<sup>-1</sup>. Blue regions signify continued oscillation, green regions signify asynchronous oscillation death, and red regions signify synchronous oscillation death.

Figure 4.3 plots slices of the four dimensional space composed of varying the initial concentrations of FBP and G6P in two heterogeneous cell types. Plots with regions showing basins of attraction, such as Figure 4.3, can be constructed for a chosen set of coupling strengths on a mesh of initial concentrations of G6P and FBP in the two types of cells, allowing us to predict the class of solution of our multicellular islet. Providing a perturbation sufficient to alter the concentrations of the two metabolites so that they lie in a different basin of attraction, we can switch between bistable solutions; this extends the previous result in coupled cells in [10] to the multicellular islet.



**Figure 4.4** Parameter values and initial conditions are as described in Figure 7(c) of [10], except  $R_{GK}$  which is set to the values given, in both types of cells.

#### 4.1.3 VARYING $R_{GK}$ VALUES

Many of our simulations use values of  $R_{GK}$  fixed at  $0.2 \text{ s}^{-1}$  and  $0.25 \text{ s}^{-1}$  for the two heterogeneous cell types. Preliminary runs use coupling strengths and initial conditions as described in previous studies but set a single  $R_{GK}$  value shared by both cell types. These preliminary results suggest that oscillation death can also occur as a result of altering this parameter. Plots from these preliminary runs with  $R_{GK}$  values of  $0.35 \text{ s}^{-1}$  and  $0.45 \text{ s}^{-1}$  in both cell types can be seen in Figure 4.4. Runs with both values display synchronous oscillation death in the islet.

Varying  $R_{GK}$  and reintroducing heterogeneity of this parameter reveals that certain combinations of  $R_{GK}$  values in the two cell types result in asynchronous or synchronous oscillation death. As the rest periods between oscillations get increasingly longer, we encounter a problem with the oscillation detection that we use (see Section 3.2) such that we were not able to conclusively determine which long-term behavior the metabolites were exhibiting. This problem is magnified greatly for small  $R_{GK}$  values — for an example, see Figure 3.1. Thus, accurate contour plots summarizing our tests could not be created until a better oscillation detection method is developed, though we can observe oscillation death in particular cases while varying values of  $R_{GK}$ .

**Table 4.1** Runtimes in HH:MM:SS for 200,000 ms with the range of islet dimensions  $N \times N \times N$  considered in our studies comparing the original ode15s and the memory-modified ode15s code. The ADiMat software is used in both tests.

$N \times N \times N$	Original ode15s	Memory-Modified ode15s
$3 \times 3 \times 3$	00:00:28	00:00:21
$4 \times 4 \times 4$	00:01:38	00:00:33
$5 \times 5 \times 5$	00:04:07	00:00:46
$6 \times 6 \times 6$	00:10:02	00:01:14
$7 \times 7 \times 7$	00:24:26	00:01:45
$8 \times 8 \times 8$	00:32:52	00:02:47
$9 \times 9 \times 9$	00:48:47	00:04:51
$10 \times 10 \times 10$	00:11:58	00:07:48

#### 4.2 NUMERICAL PERFORMANCE STUDY

Efficiency studies were performed in [7] to show that the numerical implementation that we use is optimized. We compare the original ode15s method with the memory-modified version to justify its continued use when we introduce metabolic coupling capabilities and associated computations into the model. Table 4.1 gives the wall clock time in HH:MM:SS for a simulation with coupling strengths of ( $I$ ) 75 pS, (G6P)  $0.01 \text{ ms}^{-1}$ , and (FBP)  $0.001 \text{ ms}^{-1}$  for 200,000 ms in the grouped distribution.

The results in Table 4.1 show dramatic improvement in simulation runtime, particularly as islet dimension  $N$  increases. Islets in the human body have approximately 1000 beta-cells, which makes the performance of simulations run at  $N = 10$  significant for biological applications.

### 5 CONCLUSIONS

Through our studies, we gained a better understanding of the effects of coupling on the oscillation and bursting behaviors of pancreatic beta-cells. Oscillation behaviors exhibited by beta-cells in our multicellular islet are similar but not identical to those obtained from simulations run with two beta-cells. Manipulating coupling strengths, initial conditions, and  $R_{\text{GK}}$

parameters that corresponded to two heterogeneous cell types all led to metabolic oscillation death within the islet for particular values. Methods that we developed can predict the class of solution of our multicellular islet – whether it displays continuous oscillation, asynchronous oscillation death, or synchronous oscillation death – when given a specific set of initial conditions and coupling strengths.

Based on the tests that we ran, we believe that there is a correlation between metabolic oscillation death and the metabolite parameter G6P. When coupled only through voltage and FBP, the beta-cells in our islets did not experience metabolic oscillation death; however, when G6P coupling was introduced into our model, the islet exhibited oscillation loss for certain coupling strengths. Furthermore, increasing FBP coupling appeared to restore oscillations. These observations may have biological implications.

Further tests could also be conducted to try to identify the specific range of coupling strengths that result in each one of the metabolic behaviors that we describe in Figure 4.1. Looking ahead, we hope that our studies will be beneficial to researchers in the biological fields who can run experimental versions of our simulations to confirm the accuracy of the results that we obtained through our studies.

## ACKNOWLEDGMENTS

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*JUSTIN & ANDREW*  
***CHANG COATES***



**JUSTIN CHANG & ANDREW COATES ······**

*Co-authors: Mr. Steven A. Szebenyi, Dr. Jon Bell, Dr. Weihong Lin*

**Justin Chang** graduated with a B.S. in biological sciences in May 2013; and **Andrew Coates** a B.S. in mathematics in December 2012 and an M.S. in applied mathematics in December 2013. As undergraduate students, Chang and Coates participated in the Interdisciplinary Training for Undergraduates in Biological and Mathematical Sciences (UBM), funded by the National Science Foundation. Chang is currently working with Dr. Weihong Lin and Dr. Tatsuya Ogura at UMBC as a neuroscience research assistant; meanwhile, Coates is applying to mathematical finance programs. They would like to thank their faculty advisors for their guidance, patience, and insight throughout the project and the members of the Lin lab, without whom this project could not have been completed.

They would like to recognize specifically Mr. Steven A. Szebenyi for training and calcium imaging data and Drs. Jon Bell and Weihong Lin for providing training, advice, and guidance throughout the project.

# MODELING THE EFFECTS OF CANONICAL AND ALTERNATIVE PATHWAYS ON INTRACELLULAR CALCIUM LEVELS IN MOUSE OLFACTORY SENSORY NEURONS

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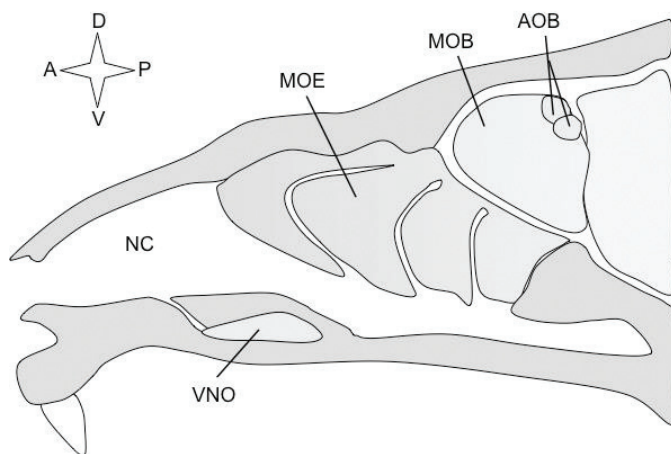
We became involved in this project through our participation in the Interdisciplinary Training for Undergraduates in Biological and Mathematical Sciences (UBM) program, where we solved problems in biomathematics under the guidance of Dr. Weihong Lin and Dr. Jon Bell. For more than two years, we dedicated our efforts to studying the signal transduction kinetics in the mammalian olfactory sensory neuron and constructed numerous mathematical models that might help us explain and understand our observations derived from the experimental results. Based on literature and experimental data, we expanded and amended our models many times throughout the years. Even though the current models look promising, many questions still remain. It has been a challenging yet rewarding experience for both of us, and we have gained invaluable research experience and knowledge in biomathematics. As we part our ways after graduation, we hope that the students after us can continue our project and efforts.

## 1 INTRODUCTION

Mammals, including humans, have a sophisticated olfactory system that can detect a wide range of odors and transform the chemical cues to electrical signals that are later transmitted to and processed in the brain. The ability to correctly detect and differentiate among various kinds of odors is essential to the survival of individuals and species. Found in the nasal cavity, the olfactory sensory neuron (OSN) plays an important role in detecting odor chemicals and initiating the sense of smell. By understanding olfactory transduction pathways with insight in the response kinetics, we can apply the findings not only to mammalian olfactory system but also to other physiological systems that employ similar pathways or mechanisms.

The sensation for smell in mammals begins in the OSNs in the olfactory system. In mammals, a majority of OSNs are found in the main olfactory epithelium (MOE) of the nasal cavity (Figure 1). When the organism breathes, the airborne odorants are carried into the nasal cavity along with the airflow. These odorants diffuse into the mucus layer on the surface of the MOE, where they interact with odorant receptors of OSNs (Figure 2). The main structures of an OSN are the soma, dendrite, dendritic knob, and cilia (Figure 3). The cilia protruding from the dendritic knob are the first site to contact with odorants. The odorants, acting as ligands, bind to odorant recep-

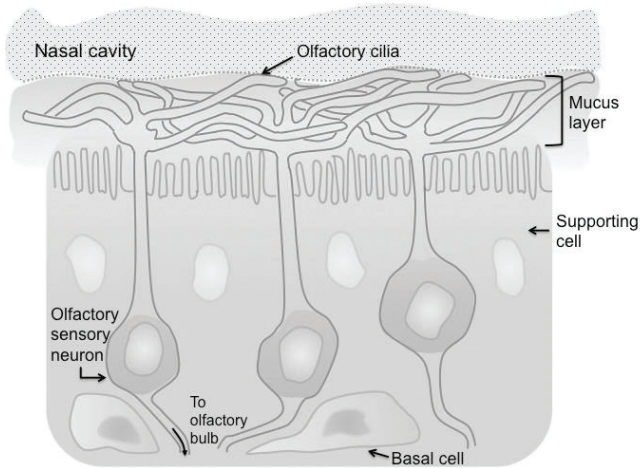
tors in the cilia. Odorant receptors in the OSNs are G-protein coupled receptors (GPCR); when activated, they trigger odor signal transduction, i.e., converting the interaction with odorant molecule into electrical signals that excite OSNs. When an OSN becomes more excited (depolarized) and reaches its threshold, the OSN produces action potentials that are organized and transmitted as electric signals to the brain for sensory processing, initiating the sense of smell (Firestein, 2001; Frings, 2001).



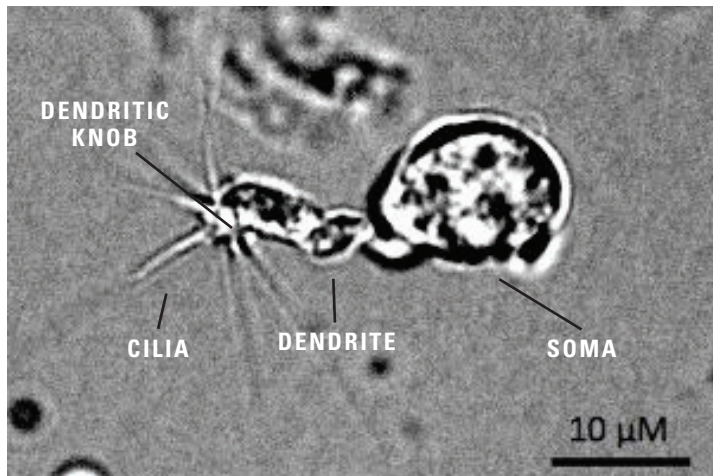
**Figure 1. Schematic of a mouse's olfactory system.** NC = Nasal cavity; MOE = Main olfactory epithelium; MOB = Main olfactory bulb; VNO = Vomeronasal organ; AOB = Accessory olfactory bulb. As the mouse breathes, air flows into the NC, carrying various airborne odorants. The MOE is responsible for detecting such odorants. The other labeled structures are not involved in our model. Adapted from Brennan and Zufall (2006).

Odorant receptors, upon binding to odorant molecules, undergo conformational changes, which activate the heterotrimeric G-protein complex, resulting in GTP binding and dissociation of the alpha subunit ( $G_\alpha$ ) and the beta-gamma subunits ( $G_{\beta\gamma}$ ). The  $G_\alpha$  and  $G_{\beta\gamma}$  can subsequently activate one or more signal transduction pathways. In the canonical pathway,  $G_\alpha$  subunit  $G_{\alpha_{olf}}$  activates adenylyl cyclase type 3 (ACIII), which converts adenosine triphosphate (ATP) to cyclic adenosine monophosphate (cAMP). The increased concentration of cAMP leads to the opening of cyclic nucleotide-gated (CNG) channels and subsequently an influx of  $Ca^{2+}$  into the OSN (Schild and Restrepo, 1998; Gold, 1999) (Figure 4A). The increases in intracellular  $Ca^{2+}$  level further leads to OSN depolarization and firing

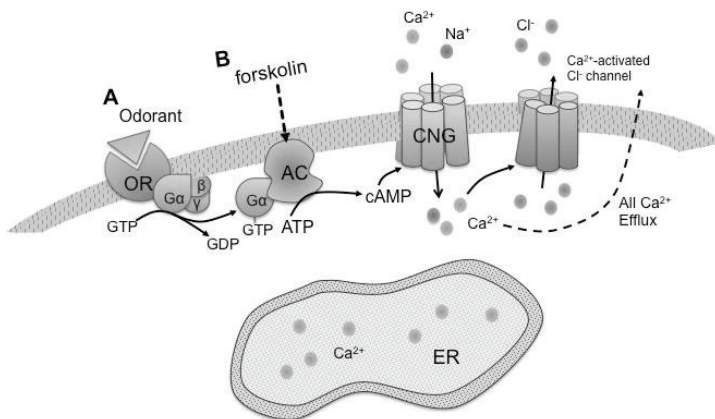
of action potentials, which propagate down its axon to higher-level olfactory sensation processing.



**Figure 2. Cell organization in the MOE.** The cilia of OSNs reside in the mucus layer, where odorants diffuse and activate the odorant receptors in the sensory neurons. Surrounding the OSNs are supporting cells that provide structural support and maintain the health of OSNs. The basal cells are precursor cells for the OSNs and supporting cells. The olfactory axons of the OSNs are organized by many olfactory bulbs in the central nervous system. Adapted from Firestein (2001).

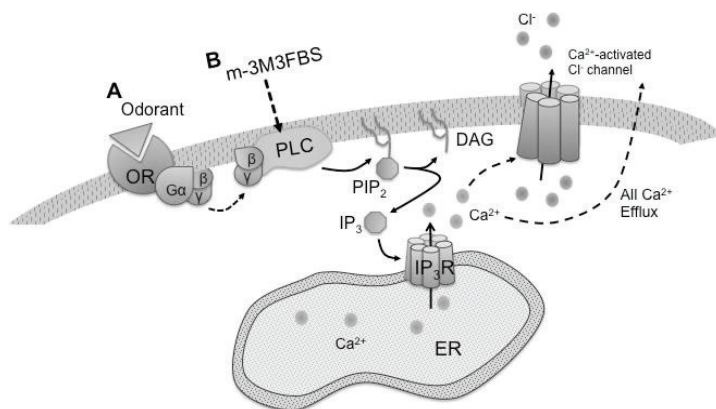


**Figure 3. Anatomy of a mature OSN.** The soma is the cell body where the nucleus resides. The dendrite is an extension of the cell body. At the end of the dendrite is the dendritic knob which hosts ten to fifteen cilia that detect a wide range of odorants. Image taken with an Olympus X71 inverted light microscope.



**Figure 4. The canonical (cAMP) pathway for odor signal transduction. (A)** As the OR is activated by a specific odorant, it undergoes a conformational change that allows the dissociation of the G-protein. GTP-bound G<sub>α</sub> then activates AC which converts ATP to cAMP. The CNG channel, in response to elevated level of cAMP, opens to allow an influx of Ca<sup>2+</sup> and Na<sup>+</sup>, depolarizing the cell. The Ca<sup>2+</sup> can then activate other channels, such as the Ca<sup>2+</sup>-activated Cl<sup>-</sup> channel which introduces Cl<sup>-</sup> to the system. Ca<sup>2+</sup> also leaves the cell through a leak current. Note that the internal Ca<sup>2+</sup> store, the ER, is not involved in this pathway. **(B)** Forskolin directly activates AC, leading to the increase of intracellular cAMP and activation of cAMP-mediated signaling cascade. The OR is not activated, so there is no G-protein dissociation.

On the other side, the G<sub>βγ</sub> can also trigger a signal transduction pathway; in this case, it activates phospholipase C (PLC), which breaks down phosphatidylinositol 4,5-bisphosphate (PIP<sub>2</sub>) into diacylglycerol (DAG) and inositol trisphosphate (IP<sub>3</sub>), and the latter binds to IP<sub>3</sub> receptors (IP<sub>3</sub>R) on the endoplasmic reticulum (ER) to release Ca<sup>2+</sup> from the internal store to intracellular space (Schild and Restrepo; Spehr et al., 2002) (Figure 5A). While the canonical pathway has been widely accepted as the main signaling pathway (Schild and Restrepo; Gold; Zufall and Munger, 2001), the involvement of the alternative pathway in olfactory signal transduction is not well-understood, although some studies have suggested that the alternative pathway also plays an important role in mammalian olfaction (Lischka et al., 1999; Kaur et al., 2001).



**Figure 5. The alternative (PLC) pathway.** (A) Like the cAMP pathway, as the OR is activated, the G-protein dissociates from the receptor. The  $G_\beta$  and  $G_\gamma$  subunits together may activate PLC, which later converts  $PIP_2$  into DAG and  $IP_3$ . Subsequently,  $IP_3$  binds to and activates  $IP_3$  receptor, which opens the internal  $Ca^{2+}$  store, elevating intracellular  $Ca^{2+}$  level. The  $Ca^{2+}$  in this pathway might activate the  $Ca^{2+}$ -activated  $Cl^-$  channel, depending on the distance between the ER and the channel.  $Ca^{2+}$  also leaves the cell through a leak current. (B) The PLC activator m-3M3FBS directly activates PLC, leading to the increase of intracellular  $IP_3$  and activation of  $IP_3$ -mediated signaling cascade. The OR is not activated, so there is no G-protein dissociation.

In this project, we sought to investigate the level of intracellular  $Ca^{2+}$  in the OSNs changing over time in response to stimuli that activate the two pathways of interest. For our purposes, we regarded the cAMP pathway as the canonical pathway and the PLC pathway as the alternative pathway. In our experiments, we utilized the olfactory system of the house mouse, *Mus musculus*, as our model for olfactory signal transduction in mammals. First, we isolated and perfused individual OSNs with  $Ca^{2+}$  dye in the calcium imaging preparation, and we observed changes in the intracellular  $Ca^{2+}$  level in each OSN *in vitro* as we applied chemicals that stimulate these pathways. Then, we created a mathematical model which implemented the quantitative data we obtained from calcium imaging in our simulation using the programming language MATLAB. In doing so, we could make inferences about the importance of the alternative pathway relative to the canonical pathway. Finally, we managed to produce a simplified model that, with some resolvable flaws, serves as a fair representation of the observed changes in the intracellular  $Ca^{2+}$  level in both the canonical and alternative pathways.

## 2 MATERIALS AND METHODS

**Animals.** C57BL/6 background adult mice were used in this study. All animal care and procedures were approved by the Animal Care and Use Committees of University of Maryland, Baltimore County.

**Solutions and chemicals.** Tyrode's saline, which resembles the extracellular ionic environment, was used as the bath solution to incubate OSNs. The Tyrode's saline contains (in mM): 140 NaCl, 5 KCl, 3 CaCl<sub>2</sub>, 1 MgCl<sub>2</sub>, 10 N-2-hydroxyethylpiperazine-N'-2-ethanesulfonic acid buffer (HEPES), 10 sodium pyruvate, and 10 D-glucose (pH to 7.4 with 1N NaOH) (Ogura et al., 2011). The stock solutions of AC activator forskolin (Calbiochem, San Diego, CA) and the PLC activator m-3M3FBS (Tocris Bioscience, Minneapolis, MN) were made in DMSO and diluted with Tyrode's into final concentrations of 1  $\mu$ M and 25  $\mu$ M, respectively.

**Intracellular Calcium Imaging on Isolated OSNs.** The following method for the isolation of OSNs from the MOE was adapted from previous studies (Lin et al., 2008b; Ogura et al., 2011).

**Calcium Imaging Preparation Setup.** Ratiometric fura-2 AM fluorescent dye (Invitrogen) was used as the intracellular calcium level indicator. Pluronic F127 (F127) was used to facilitate loading fura-2 dye into OSNs. F127 (1  $\mu$ L) and 2  $\mu$ M fura-2 (2.5  $\mu$ L) were mixed and kept from light. 5 U/ml of enzyme papain (Worthington, Lakewood, NJ) was used to dissociate OSNs from the MOE, and 2 mM cysteine was used to activate the enzymatic activity of papain. For each experiment, papain (4  $\mu$ L) was mixed in Ca<sup>2+</sup> Mg<sup>2+</sup>-free solution (2 mL) with 142  $\mu$ M 1,2-bis(o-aminophenoxy)ethane-N,N,N',N'-tetraacetic acid (BAPTA), followed by an addition of cysteine (40  $\mu$ L). The enzyme solution was made and set aside for 30 minutes at room temperature for full activation before being used. On each experimental slide, concanavalin A (Con-A; Sigma) was used as cell-adhesive to immobilize OSNs, and an O-ring was glued onto the slide using high-vacuum silicon grease to form a recording chamber.



**Dissection of Mouse.** Mice were euthanized with carbon dioxide exposure, followed by cervical dislocation and exsanguination. Then the head was skinned and separated from the body at the jawline, and placed in a petri dish partially filled with icy Tyrode's solution. After the soft palate was removed and shallow cuts on the anterior and posterior ends of the head were performed, the head was split in halves along the anterior-posterior axis. The two half-heads were rinsed lightly with Tyrode's solution and then placed separately in two new petri dishes covered by Tyrode's solution-soaked Kimwipe. Then, the half-heads were incubated on ice for 25 to 30 minutes.

**Isolation of the OSNs.** After the incubation, the MOE tissues were collected from the two half-heads. Each MOE tissue was then placed in a centrifuge tube filled with 0.5 mL of previously made enzyme solution for two to three minutes at room temperature. The enzyme was then inactivated by addition of normal Tyrode's solution containing 3 mM  $\text{Ca}^{2+}$  to the tubes. Gentle mechanical trituration was then performed. Before transferring the triturated samples, the slides were washed with Tyrode's solution. To each slide, two drops of each sample were transferred and incubated for five minutes at room temperature. Later, Tyrode's solution (700  $\mu\text{L}$ ) was added to the previously made fura-2 mixture. Then, the fura-2 mixture was added to each slide dropwise with a ratio of one drop of fura-2 to two drops of extract. The OSNs were incubated for another 25 minutes away from light at room temperature allowing loading of the  $\text{Ca}^{2+}$  dye.

**Calcium Imaging Hard- and Software Setup.** The excitation light of wavelengths between 340 and 380 nm was guided through a liquid optical fiber to the Olympus IX71 inverted light microscope, which was incorporated with a xenon lamp system (Lambda LS; Sutter Instruments, Novato, CA) and a Hamamatsu CCD camera. The fluorescent images were captured with a 40X oil UV objective with a  $510 \pm 42$  nm emission filter (Semrock, Rochester, NY). The intracellular  $\text{Ca}^{2+}$  level was indicated by the ratio of fluorescence intensity at excitation wavelengths of 340 and 380 nm. The emission of the two wavelengths and the ratio (F340/F380) were recorded every three seconds. Imaging Workbench (IW; INDEC BioSystems, Santa Clara, CA) software was used for imaging recording and

filter positioning. Experiments were performed in a room with limited illumination to reduce background signals.

**Calcium Imaging Experiments.** Forskolin (1  $\mu\text{M}$ ) and PLC activator (25  $\mu\text{M}$ ) were used to activate AC and PLC, respectively. Application durations varied, about 55 seconds for forskolin and 35 seconds for PLC. Tyrode's solution was applied to maintain an isotonic and ionic environment suitable for the cell, and it was also used as a washing solution after each application of activator. All solutions were added to the wells dropwise using regular pipettes. In the bright field, three criteria were used to identify a healthy OSN: i) presence of a round, undamaged soma, ii) intact axons and dendritic knob, and iii) preferentially numerous intact cilia. In addition, the  $\text{Ca}^{2+}$  resting level should remain stable. To measure the fura-2 emission, two recording regions were placed above the OSN: one on the soma and one on the dendritic knob. One additional recording region was placed in the background for background subtraction. The changes in intracellular  $\text{Ca}^{2+}$  level were recorded in IW after each application.

**Imaging Data Analysis.** The quantitative measures of the changes in intracellular  $\text{Ca}^{2+}$  level were made into smooth marked scatter plots in Microsoft Excel using a pre-existing Excel Macros program (not shown) kindly provided by Steven A. Szebenyi that automated this task. The values of interest (such as the amplitude, base level, and peak level) were calculated and analyzed manually on MS Excel.

**Quantification of Amplitude.** Base intracellular  $\text{Ca}^{2+}$  level is defined as the stable resting level of  $\text{Ca}^{2+}$  before the addition of the stimulus. A new base level is determined after the  $\text{Ca}^{2+}$  level recovers to stable resting values from the initial stimulus. The peak intracellular  $\text{Ca}^{2+}$  level is defined as the highest point of the trace after the stimulus is applied right at or before the washing of Tyrode's. The value of  $\text{Ca}^{2+}$  level amplitude, or response amplitude, is calculated as the difference of the peak and base values; we normalized each response amplitude as the quotient of that difference and the base value.

**Model Simulation.** All simulations were done using MATLAB ODE solver `ode23t()` with time steps restricted to a maximum

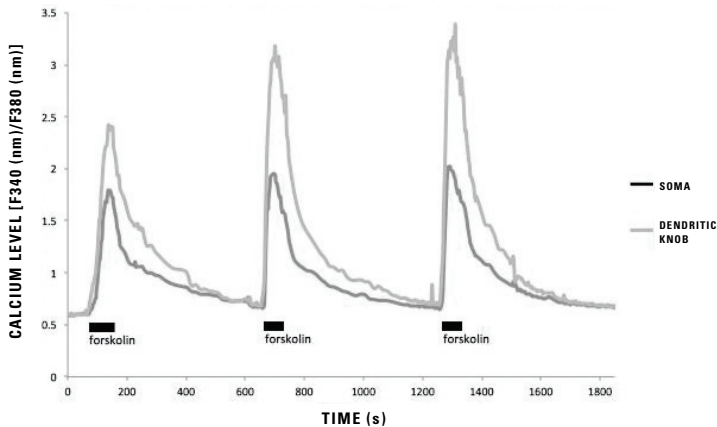
of 0.25 s. After trying the other ODE solvers, we found that `ode23t()` provided the smoothest results, indicating that our model was a stiff system.

### 3 EXPERIMENTAL RESULTS

To monitor intracellular  $\text{Ca}^{2+}$  changes, we used the  $\text{Ca}^{2+}$  dye fura-2 AM, which is a ratiometric chemical dye that exhibits differential spectral properties when bound to  $\text{Ca}^{2+}$  in the intracellular space. The dye's peak excitation wavelength shifts from 380 to 340 nm when bound to  $\text{Ca}^{2+}$ . Therefore, the ratio of [F340 nm/F380 nm] is directly related to the level of intracellular  $\text{Ca}^{2+}$  level (Ogura et al., 2011). To select OSNs for our experiments, we looked for OSNs that possessed healthy anatomical and physiological characteristics. Because the activators have different biochemical properties, specific concentration and application duration were designated to optimize signal transduction in each application. For our purposes, we were more concerned with the changes in intracellular  $\text{Ca}^{2+}$  level in the dendritic knob, rather than the level in the soma, because the cilia, protruding from the dendritic knob, are the first to be in contact with odorants and the advent of signal transduction in the MOE. Nonetheless, we still analyzed and presented such changes in the soma for perspective. Based on the quantitative data derived from the calcium imaging experiments, we analyzed each response for its amplitude value, latency, and such.

#### 3.1 FORSKOLIN-INDUCED RESPONSE

Forskolin (1  $\mu\text{M}$ ) was used to activate AC in the OSNs in single-cell intracellular calcium imaging (Figure 4B). A representative response is shown in Figure 6. The OSN was responsive to repeated forskolin applications, showing consistent response characteristics. In addition, the response amplitude in the dendritic knob was generally greater than that in the soma (Table 1), which is in agreement with previous studies and indicate that the canonical pathway was activated profoundly in the knob region (Leinders-Zufall et al., 1997; Menini, 1999). In general, the forskolin-induced responses were consistent in terms of response kinetics across different OSNs. For modeling purposes, we selected the best representative forskolin-induced response trace (Figure 6) to be the target of our simulation.



**Figure 6. Changes in intracellular  $\text{Ca}^{2+}$  level in response to forskolin applications in a single OSN.** The responses show consistent characteristics and recover close to initial base level. The dendritic knob region has a greater increase in  $\text{Ca}^{2+}$  compared to the soma region. The application durations are (in chronological order): 90 s, 55 s, and 55 s. Similar traces are presented in Ogura et al. (2011).

soma	base	peak	amplitude	normal- ized amplitude
1 <sup>st</sup> Application	0.5956	1.7929	1.1973	2.0102
2 <sup>nd</sup> Application	0.6703	1.9452	1.2749	1.9020
3 <sup>rd</sup> Application	0.6629	2.0183	1.3554	2.0447
Average	0.6429	1.9188	1.2759	1.9856

dendritic knob	base	peak	amplitude	normal- ized amplitude
1 <sup>st</sup> Application	0.6031	2.4114	1.8083	2.9983
2 <sup>nd</sup> Application	0.6836	3.0781	2.3945	3.5028
3 <sup>rd</sup> Application	0.7012	3.2673	2.5661	3.6596
Average	0.6626	2.9189	2.2563	3.3869

**Table 1. Quantitative analysis of the forskolin-induced intracellular  $\text{Ca}^{2+}$  level response amplitudes for three consecutive applications.** Each forskolin-induced response amplitude in the soma and dendritic knob was calculated and normalized with respect to each corresponding base level.

3.2 PLC ACTIVATOR-INDUCED RESPONSE

The PLC activator m-3M3FBS (25  $\mu\text{M}$ ) was applied to activate the PLC pathway in the OSNs in single-cell intracellular calcium imaging (Figure 5B). A representative response is presented in Figure 7, and the quantitative analysis is shown in Table 2. The OSN was responsive to two applications of PLC activator.

However, compared to forskolin-induced responses, the patterns and the changes in intracellular  $\text{Ca}^{2+}$  levels in the PLC activator-induced OSNs were less consistent, and occasionally we observed oscillations and variable latency times. Because PLC activator is speculated to be biochemically less stable than forskolin, the induced responses might not have completely standardized conditions, which can potentially explain why the PLC activator-induced responses showed more variability in terms of response kinetics in comparison with the forskolin-induced responses. For modeling purposes, we selected the best representative PLC activator-induced response trace (Figure 7) to be the target of our simulation because of its relatively consistent response characteristics and recovery close to the base values.

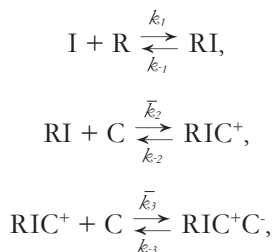
**Figure 7. Changes in intracellular  $\text{Ca}^{2+}$  level in repeated PLC activator applications.** Compared to forskolin-induced responses, repeated PLC activator-induced responses have less consistent characteristics. The response latency time is also more variable. The application durations are (in chronological order): 35 s and 35 s.

dendritic knob	base	peak	amplitude	normal- ized amplitude
1 <sup>st</sup> Application	0.5885	1.4372	0.8487	1.4421
2 <sup>nd</sup> Application	0.6133	1.4719	0.8586	1.4000
Average	0.6009	1.4546	0.8537	1.4211

**Table 2. Quantitative analysis of the PLC activator-induced intracellular  $\text{Ca}^{2+}$  level response amplitudes for two consecutive applications.** The first and second PLC activator-induced response amplitudes in the soma and dendritic knob were calculated and normalized with respect to the corresponding base levels.

## 4 MODELING THE CYTOPLASMIC CALCIUM CONCENTRATION OF AN OLFACTORY SENSORY NEURON

In an attempt to keep the model simple, we chose to follow the four-state framework for the  $\text{IP}_3\text{R}$  (Othmer and Tang, 1997). We had originally tried to use the single equation representation for  $\text{J}_{\text{IP}_3\text{R}}$  (Keener and Sneyd, 2008). The model performed well with the cAMP pathway, but was a very poor match for the PLC pathway, so we decided to try a more complex model for  $\text{J}_{\text{IP}_3\text{R}}$ . Rather than moving to the more complicated eight-state framework (Sneyd, 2003), we wanted first to try the four-state model (Othmer and Tang). Let  $I$  represent  $\text{IP}_3$ ,  $C$  represent the cytosolic  $\text{Ca}^{2+}$  concentration, and  $C_s$  represent the  $\text{Ca}^{2+}$  concentration inside the store. Then the four possibilities are the receptor being bare, denoted  $R$ , the receptor- $\text{IP}_3$  complex, denoted  $\text{RI}$ , the  $\text{RI}$  with  $\text{Ca}^{2+}$  bound at the activating site, denoted  $\text{RIC}^+$ , and the  $\text{RI}$  with  $\text{Ca}^{2+}$  bound at both the activating and inhibitory sites, denoted  $\text{RIC}^+\text{C}^-$  (Othmer and Tang). The resulting scheme for transitions between states is as follows:



Introducing the variables  $x_2, x_3, x_4, x_5$  for the fraction of receptors in states  $R, \text{RI}, \text{RIC}^+$ , and  $\text{RIC}^+\text{C}^-$ , respectively, we arrived at the following governing equations:

$$\begin{aligned}
\frac{dC}{dt} &= \gamma(r_2 + r_1 b(x_4))(C_s - C) - J_{serva} + J_{CNG} - J_{leak}, \\
\frac{dx_2}{dt} &= -k_1 IP_3 x_2 + k_{-1} x_3, \\
\frac{dx_3}{dt} &= k_1 IP_3 x_2 + k_{-2} x_4 - (k_{-1} + \bar{k}_{-2} C) x_3, \\
\frac{dx_4}{dt} &= \bar{k}_2 C x_3 + k_{-3} x_5 - (k_{-2} + \bar{k}_3 C) x_4, \\
\frac{dx_5}{dt} &= \bar{k}_3 C x_4 - k_{-3} x_5.
\end{aligned} \tag{1}$$

The  $Ca^{2+}$  pump between the ER and cytoplasm is a tetramer with four binding sites, so we will use a Hill's function

$$J_{serva} = \frac{\bar{v}_p C^2}{\bar{K}_p^2 + C^2}$$

where  $\bar{v}_p$  is a scaling constant  $\bar{K}_p^2$  and is the Hill's constant. The  $Ca^{2+}$  influx from the CNG channel will be modeled as a proportion of the current through the CNG channel (Dougherty et al., 2005). That is,

$$J_{CNG} = \alpha g_{CNG} \frac{eAMP}{\bar{K}_e + eAMP} (E_{CNG} - \bar{v})$$

where  $\bar{\alpha}$  is a scaling constant and  $g_{CNG}$  is the conductance of the CNG channel. We used a linearization to model the leak flux,  $J_1 = c_1 x_1$ , where  $c_1$  is a scaling constant. We use bar and hat notation so that there is no ambiguity in the final formulation of the model after it is put through some scaling and nondimensionalization.

Observe that  $0 \leq x_k \leq 1$ ,  $k = 2, 3, 4, 5$  and  $\sum_{k=2}^5 x_k = 1$  by definition, and so  $\sum_{k=2}^5 \frac{dx_k}{dt} = 0$  holds true. Here,  $\gamma$  is the ratio of the volume of the ER and the cytoplasm,  $r_2$  is the basal permeability of the calcium store membrane in the absence of  $IP_3$  per unit volume of the ER, and  $r_1$  is the density of  $IP_3$  sensitive channels on the membrane of the ER per unit volume of the ER. The function  $b(x_4)$  represents the fraction of  $IP_3R$  in the open  $RIC^+$  state. We will use the linearization  $b(x_4) = x_4$  since the correct functional representation is not known (Othmer and Tang).

$$\text{Let } C_0 = \frac{C + \gamma C_s}{1 + \gamma} \text{ and } x_1 = C / C_0.$$

$$\text{This implies that } \gamma(C_s - C) = C_0(1 + \gamma)(1 - x_1) \text{ and } \frac{dC}{dt} = C_0 \frac{dx_1}{dt}.$$

We also consider the equations for voltage and the concentrations of cAMP and IP3. The change in voltage will be the sum of the contributors of current to the cell, namely the channels which allow ions to pass in or out. Note that the ER does not contribute to the cell's potential, because it is within the cell. When it releases or uptakes calcium from the cytoplasm, there is no change in the charge contained within the cell as a whole. We used simple reaction kinetics to model the change in  $IP_3$  and cAMP concentrations. This gives us

$$\begin{aligned} C_m \frac{dy}{dt} &= I_{CNG}(v, cAMP) + I_{Cl(Ca)}(v, C) + I_{leak}(v), \\ \frac{dcAMP}{dt} &= \bar{k}_4 f(t) - k_{-4} cAMP, \\ \frac{dIP_3}{dt} &= \bar{k}_5 r(t) - k_{-5} IP_3, \end{aligned} \quad (2)$$

$$\begin{aligned} \text{where } I_{Cl(Ca)}(v, C) &= \bar{g}_{Cl} \frac{C_m}{\bar{K}_a + C_m} (E_{Cl} - v), \\ I_{leak}(v) &= g_{leak} (E_{leak} - v), \\ \text{and } I_{CNG}(v, cAMP) &= g_{CNG} \frac{cAMP}{\bar{K}_a + cAMP} (E_{CNG} - v). \end{aligned}$$

$C_m$  is the cell's conductance. We used piecewise exponentials to represent the concentrations of the stimuli. Before the time of application the concentration is 0. During the time of application we assumed the concentration to be constant at 1  $\mu M$  for forskolin and 25  $\mu M$  for PLC activator. When the stimulus is washed, we assume exponential decay. Thus, our functions are:

$$\begin{aligned} f(t) &= 0 : t < t_{app}, \quad 1 : t_{app} < t < t_{wash}, \quad e^{-k_{cAMP} t} : t_{wash} < t \\ r(t) &= 0 : t < t_{app}, \quad 25 : t_{app} < t < t_{wash}, \quad 25e^{-k_{PLC} t} : t_{wash} < t \end{aligned}$$

We went through a few steps to nondimensionalize our system.

$$\text{Firstly, let } C_0 = \frac{C + \gamma C_s}{1 + \gamma} \text{ and } x_1 = C/C_0.$$

This implies that  $\gamma(C_s - C) = C_0(1 + \gamma)(1 - x_1)$  and  $\frac{dC}{dt} = C_0 \frac{dx_1}{dt}$ .

This removes the dependence upon  $C$  and replaces it with non-dimensionalized  $x_1$ . Similarly, we let  $u = cAMP/cAMP_0$  and



$p = IP_3/IP_3$ . Finally, we let  $\tau = R_m C_m$  and  $v = \bar{v}/v_{char}$ , where  $R_m$  is the resistivity of the cell and  $v_{char}$  is the characteristic potential of the cell. This way  $\tau$  has units of time. A summary of the variables in the model can be found in Table 3. Our final system is as follows:

$$\begin{aligned} \frac{dx_1}{dt} &= \lambda(r_2 + r_1x_4)(1 - x_1) - \frac{v_p x_1^2}{K_p^2 + x_1^2} + \alpha \bar{g}_{CNG} \frac{u}{K_u + u} (E_{CNG} - v) - c_1 x_1 \\ \frac{dx_2}{dt} &= -k_1 p x_2 + k_{-1} x_3, \\ \frac{dx_3}{dt} &= k_1 p x_2 + k_{-2} x_4 - (k_{-1} + k_2 x_1) x_3, \\ \frac{dx_4}{dt} &= k_2 x_1 x_3 + k_{-3} x_5 - (k_{-2} + k_3 x_1) x_4, \\ \frac{dx_5}{dt} &= k_3 x_1 x_4 - k_{-3} x_5, \\ \tau \frac{dv}{dt} &= g_{CNG} \frac{u}{K_u + u} (E_{CNG} - v) + g_{Cl(Ca^{2+})} \frac{x_1}{K_v + x_v} (E_{Cl(Ca^{2+})} - v) + g_1 (E_1 - v), \\ \frac{du}{dt} &= k_4 f(I) - k_{-4} u, \\ \frac{dp}{dt} &= k_5 r(I) - k_{-5} p, \end{aligned} \tag{3}$$

where  $\alpha = \bar{\alpha} v_{char}$ ,  $\hat{g}_{CNG} = g_{CNG} R_m / C_0$ ,  $\bar{g}_{Cl} = g_{Cl} R_m$ ,  $\bar{g}_1 = g_1 R_m$ ,  $E_{CNG} = E_{CNG} / v_{char}$ ,  $\bar{E}_{Cl} = E_{Cl} / v_{char}$ ,  $E_1 = \bar{E}_1 / v_{char}$ ,  $v_p = \bar{v}_p / C_0$ ,  $K_u = \bar{K}_u / cAMP_0$ ,  $K_v = \bar{K}_v / C_0$ ,  $\bar{k}_4 = k_4 / cAMP_0$ ,  $c_1 = \bar{c}_1 / C_0$  and  $k_5 = \bar{k}_5 / IP_3$ .

$x_1$	nondimensionalized cytosolic $Ca^{2+}$ concentration
$x_2$	proportion of $IP_3$ receptors in state R
$x_3$	proportion of $IP_3$ receptors in state RI
$x_4$	proportion of $IP_3$ receptors in state $RIC^+$
$x_5$	proportion of $IP_3$ receptors in state $RIC^+C$
$v$	nondimensionalized electrical charge contained by the cell
$u$	nondimensionalized cytosolic cAMP concentration
$p$	nondimensionalized cytosolic $IP_3$ concentration

**Table 3.** Summary of model variables.

#### 4.1 STEADY STATES AND THE DETERMINATION OF INITIAL CONDITIONS

By making the simplifying assumption that  $u(0) = 0 = p(0)$ , we immediately get  $X_2 = 1$ ,  $X_3 = X_4 = X_5 = U = P = 0$ . Finding the solutions is more complicated and involves using the cubic formula with coefficients:

$$a_2 = \frac{v_p - \lambda r_2}{\lambda r_2 + c_1}, a_1 = K_p^2, \text{ and } a_0 = -\frac{K_p^2 \lambda r_2}{\lambda r_2 + c_1}, \tag{4}$$

where the cubic polynomial is of form

$$p(\tilde{x}) = \tilde{x}^3 + a_2\tilde{x}^2 + a_1\tilde{x} + a_0.$$

The explicit solution is too long to display here. We are interested in the positive, non-complex root. A real root clearly exists, because the function is cubic. It is unrealistic for the intracellular calcium level to be negative, so if the root happens to be negative, then there must be an issue with the parameters in use. Having found the steady state solution for  $x_1$ ,  $X_1$ , we can solve for the final steady state,

$$V = (g_{Cl} \frac{x_1'''}{K_c''' + x_1'''} E_{Cl} + g_1 E_1) / (g_{Cl} \frac{x_1'''}{K_c''' + x_1'''} + g_1). \quad (5)$$

We then use these steady states as the initial values to our system. That is, if we write  $X_1$  and  $V$  for the steady state values of  $x_1$  and  $v$ , respectively, then our initial values are:

$$\begin{aligned} x_1(0) = X_1, x_2(0) = 1, x_3(0) = x_4(0) = x_5(0) = 0, \\ v(0) = V, u(0) = 0, p(0) = 0. \end{aligned} \quad (6)$$

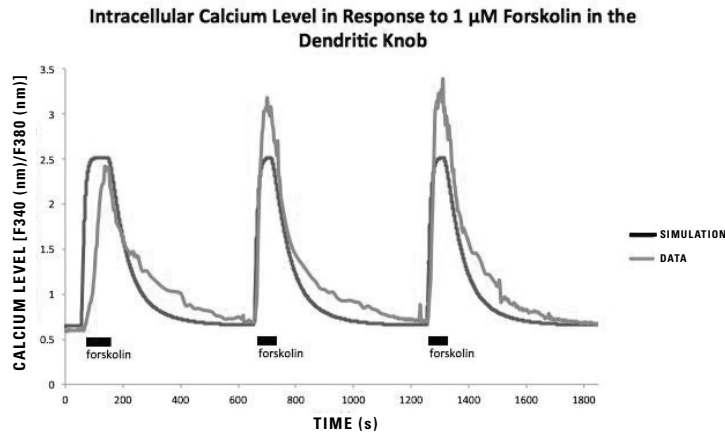
As long as no odorant has bound, or in our case no stimulus applied, the cell is unprovoked and should remain at its steady state. Saying there is no cAMP nor  $IP_3$  in the cytoplasm is certainly false. However, the minor amounts in the cell during rest cause little disruption to the equilibrium, allowing us to monitor the change in cytoplasmic  $Ca^{2+}$  as with the assumption that there is no cAMP nor  $IP_3$  in the cytoplasm during rest.

## 4.2 MODEL PERFORMANCE AND LIMITATIONS

Due to the low sample size that induced variability in the response amplitudes of the pathway activator-induced responses, statistical and error analysis tell us very little about what quantitative changes can be made to improve upon our model. This problem is especially challenging for the PLC pathway. However, we were still able to make qualitative critiques. We chose the unknown parameter values so that the model performed best in the sense that during each phase of the model (before application, during application, and after wash) the rate and amplitude of change in intracellular calcium level were visually good in most experiments. Indeed, looking at the inverse problem may allow for the solution of best parameters in some least-squares

sense. This would be a good avenue to investigate if this research were taken further, but at this time it is not clear to us that the inverse problem would have a unique solution for each set of experimental data and we are not equipped for such analysis.

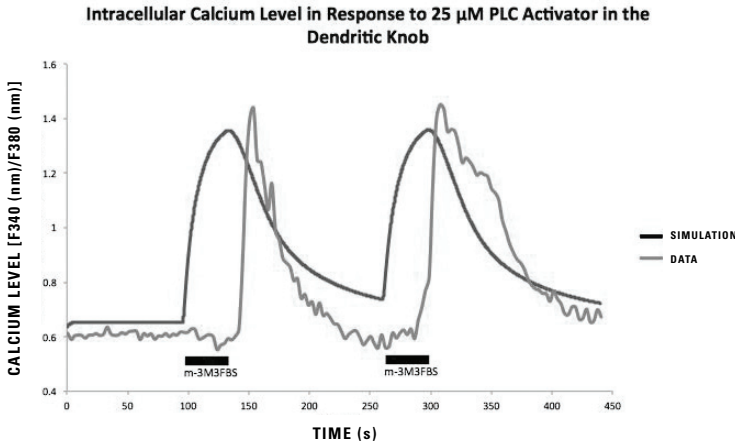
When comparing our model to the cAMP pathway (Figure 8), we notice that our model spikes slightly before the lab data on only the first application. This is likely the result of omitting the intermediate reaction kinetics between the application of forskolin and the introduction of cAMP to the system. This problem does not exist in later applications. It also spikes at a higher rate than the lab data on only the first application. We believe this to be the result of experimental noise due to the difference between the response to the first application and the second and third responses. A noticeable flaw in our model is that the maximum value of the first response is equal to that of the second and third responses, despite the application time being significantly longer. This indicates that the level of  $\text{Ca}^{2+}$  at which our model reaches a steady state during forskolin application is too low. After the forskolin has been washed, the model well matches the  $\text{Ca}^{2+}$  level decay rate briefly, but then continues to decay at a higher rate longer than the cell.



**Figure 8. cAMP model.** Plot of data from a forskolin experiment (gray) with the corresponding model simulation (black). The application durations are (in chronological order): 90 s, 55 s, and 55 s.

When comparing our model to the PLC pathway (Figure 9), we noticed that our model spikes much earlier than the lab data. This is likely in part the result of our simplifying assumption which overlooks many slow reaction kinetics in the production

of  $IP_3$ . We believe that addition of the aforementioned reaction kinetics would resolve this issue, as well as the slow  $Ca^{2+}$  level decay of our model after washing. In the biological context, the inherent delay in  $IP_3$  production would decrease the amount of time  $IP_3$  receptors are open, and thus the amount of  $Ca^{2+}$  flowing from the ER into the cytoplasm. Because the reactions in our four state model of the  $IP_3R$  would remain the same, the rate at which would change should remain the same, but the duration, and hence total  $Ca^{2+}$  flow, would be decreased. Observe, also, how the lab data continues to increase and peaks after the m-3M3FBS has been washed, whereas our model stops increasing the moment washing occurs. This is another indicator of the importance of the slow acting reaction kinetics leading to the production of  $IP_3$ .



**Figure 9. PLC model.** Plot of data from a PLC pathway experiment (gray) with the corresponding model simulation (black). The application durations are (in chronological order): 35 s and 35 s.

$k_{cAMP}$	0.01	$k_{PLC}$	0.01
$C_0$	1.56	$cAMP_0$	0.2
$IP3_0$	0.1	$I_{bar}$	0.2
$v_{char}$	-65	$\gamma$	0.185
$r_2$	0.1	$r_1$	20.5
$v_p$	0.2	$K_p$	0.1
$\alpha$	15.147	$g_{CNG}$	0.76
$K_n$	75	$E_{CNG}$	0.01017
$k_1$	0.12	$k_{-1}$	8
$k_2$	3.5	$k_{-2}$	1.65
$k_3$	1.8	$k_{-3}$	15
$k_4$	0.002	$k_{-4}$	0.3
$k_5$	0.0012	$k_{-5}$	2
$g_{CJ}$	0.8028	$K_c$	3.45
$m$	2.2759	$E_{CJ}$	-14.3
$g_l$	7.252	$E_l$	-65
$R_m$	0.1	$C_m$	0.002

**Table 4. Parameter values used in Figures 8 & 9.** The unscaled parameter values used in the solution of our model as seen in Figures 8 & 9. That is, these parameters are the barred or hatted values in the development of the model, not the parameters in the final model (3).

## 5 DISCUSSION

The mammalian olfactory system is a delicate system that has evolved to detect a wide range of odors and differentiate them as signals related to food, danger, courtship, and other behaviors that are essential for the animal's survival and socialization in the species. Sensory signal transduction is the first step of olfaction. By understanding how each olfactory signaling pathway works in a systematic, mathematical manner, we can gain a better insight into how each variable or reaction, such as the  $Ca^{2+}$  influx,  $Ca^{2+}$  uptake, and cAMP binding to the CNG channel, impact the signal transduction; and we can make inferences about the importance of the alternative pathway relative to the canonical pathway. Because human and mouse have a similar olfactory system, by studying the latter we can learn more about the olfactory mechanisms of our own. Ultimately, our research can be applied to the human olfactory system.

In this study, we were successful in activating both the canonical and alternative pathways in the OSN by applying

specific chemical stimuli. Using calcium imaging, we were able to measure the quantitative changes of intracellular  $\text{Ca}^{2+}$  level. We constructed mathematical models based on past studies that might explain the observed response characteristics. Then we showed how the simulations match our observations from calcium imaging. In the end, we were able to simulate the canonical and alternative pathways with relative accuracy, with the sole major inaccuracy resulting from, we believe, the omission of intermediate reaction steps in the signaling cascades essential to their respective signal transductions.

### 5.1 CHEMICAL-INDUCED CANONICAL AND ALTERNATIVE PATHWAYS IN THE OSN

We applied the chemical stimuli, forskolin and m-3M3FBS, to the OSNs to induce the canonical and alternative pathways, respectively. In single-cell studies, we found that the forskolin-induced responses had consistent response characteristics and repeatability, providing us a good foundation for simulations. Even at a small dosage (1  $\mu\text{M}$ ), forskolin was able to induce a fast and relatively large response in both the soma and dendritic knob regions. In addition, we observed greater response amplitudes in the dendritic knob region, which can be attributed to the cilia of the OSN where most odorant receptors and AC reside (Bakalyar and Reed, 1990). For future experiments on the forskolin-induced response, we can see if different concentrations of forskolin and/or different application durations cause different response kinetics.

However, the PLC activator-induced responses did not show consistent response characteristics when compared to the forskolin-induced responses, and occasionally we observed oscillating intracellular  $\text{Ca}^{2+}$  levels and variable latency times as we applied the PLC activator. We were not sure why the OSNs responded differentially to the PLC activator. One reason could be that the OSNs have different degrees of sensitivity to the PLC activator, thus showing differential activation patterns. Another explanation could be that the ER, the internal source of  $\text{Ca}^{2+}$  release, has different  $\text{Ca}^{2+}$  capacity between the cells. Moreover, empirically the PLC activator is thought to be biochemically less stable than forskolin, thus hindering response rate. Nonetheless, we showed that the PLC activator, m-3M3FBS, was able to induce a significant change in intracellular  $\text{Ca}^{2+}$  level in the OSN at 25  $\mu\text{M}$ . In the future, we might also want to

change the concentrations of the PLC activator and/or application durations to see if there is any difference in the response kinetics, or if the response kinetics would be more consistent. Furthermore, to eliminate the possibility of  $\text{Ca}^{2+}$  coming from outside the cell during the PLC activator application, we can incubate the OSN in a  $\text{Ca}^{2+}$ -free Tyrode's solution. Therefore, we can make sure a PLC activator-induced response in a  $\text{Ca}^{2+}$ -free bath is mostly derived from the ER, not from an outside source.

## 5.2 MODELING ASSUMPTIONS AND REFLECTION

The goal of our simulations was to match the average intracellular  $\text{Ca}^{2+}$  level across several calcium imaging trials. While calcium imaging is great for detecting the change in calcium levels, its downside is that ratiometric measurement results are unitless and hard to relate back to the true  $\text{Ca}^{2+}$  concentrations without additional sets of calibration experiments. For this reason we have opted to scale the results of our model such that the important factors are the relative change and shape of the model, and not the precise values of the concentration.

In developing our model, we made a few simplifying assumptions. The most significant of these is well-mixedness. That is, the concentrations are uniformly distributed across the cell, and do not rely on a spatial variable. This reduces what would have been a system of partial differential equations in four variables, three spatial and one time, to a system of ordinary differential equations in one time variable. As a consequence of this, the location of the ER within the cell is irrelevant to our model. However, in an actual cell the location of the ER is important. An example effect of this is if the ER is located too far away from the  $\text{Ca}^{2+}$ -activated  $\text{Cl}^-$  channel, the  $\text{Ca}^{2+}$  released in from the ER in a PLC pathway experiment may not reach the channel to activate it. Another major assumption that we made was a simplification of the reaction kinetics involving the creation of  $\text{IP}_3$  and cAMP. We treat their concentrations as a reaction with just their respective activator, and omit the intermediate reactions.

In addition, we excluded mitochondrial  $\text{Ca}^{2+}$  store and the mitochondrial  $\text{Na}^+/\text{Ca}^{2+}$  exchanger from our model. Mitochondria plays an important role as a buffer for the intracellular  $\text{Ca}^{2+}$  level and another source of internal  $\text{Ca}^{2+}$  in the cell (Werth and Thayer, 1994; Kiedrowski and Costa, 1995). Finally, the involvement of transient receptor potential cation channel subfamily

M member 5 (TRPM5) in the OSN was also excluded. TRPM5 is a  $\text{Na}^+$ -permeable  $\text{Ca}^{2+}$ -activated cation channel that carries positive currents into the intracellular space, thus depolarizing the cell (Liu and Liman, 2003; Prawitt et al., 2003; Lin et al., 2007).

If more time were available to work on this project, the two priority objectives would be to obtain average response traces from a larger number of cells to improve the quantitative accuracy of the model, and to include the reaction kinetics that occur between the release of the  $G_{\beta/\gamma}$  protein and the creation of  $\text{IP}_3$  as well as between the release of the  $G_\alpha$  protein and the creation of cAMP. We believe with the inclusion of more reaction kinetics, both models will become qualitatively correct. Given enough samples of lab data, we believe this model can become sufficiently quantitatively accurate.

## AUTHOR CONTRIBUTIONS

Justin Chang and Andrew Coates analyzed the experimental results, built the models, and wrote the paper. Research Assistant Steven A. Szebenyi in Dr. Weihong Lin's lab conducted calcium imaging and provided the results used in this paper. Mr. Szebenyi also provided training for calcium imaging experiments. Dr. Weihong Lin from the Department of Biological Sciences and Dr. Jon Bell from the Department of Mathematics and Statistics provided training and advice over the course of this project. Dr. Weihong Lin and Dr. Jon Bell also reviewed and edited the paper.

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*ISLEEN*  
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**ISLEEN WRIDE** .....

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# **THE COSTLY TRADE-OFF BETWEEN IMMUNE RESPONSE AND ENHANCED LIFESPAN IN *DROSOPHILA MELANOGASTER***

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As the genetic influences on aging and immunology are largely unknown, this project sought to contribute to the small but growing body of knowledge involving the age-related decline of the immune system. I was pleased to receive this project on highly novel and intriguing approaches to immunosenescence and, through the Undergraduate Research Award (URA) program, was able to uncover these findings in several ways and gain valuable technical experience. I would like to thank my mentor, Dr. Jeff Leips and the URA program for making my research possible. I entered the Leips lab in spring 2009 as my first research experience and am so grateful for the opportunity that started my interest in research. Personally, this research afforded me a unique chance to participate in a novel research experiment and consider various practical considerations in experimental design. My interactions with like-minded peers and professors and my exposure to current literature were invaluable. My positive experiences with research have in turn motivated me to encourage other undergraduates to participate in research.

The ability to clear infection generally declines with age in all organisms.<sup>1</sup> Despite this pattern, there is extensive, genetically-based variation among individuals in natural populations in their ability to clear infection at different ages.<sup>2</sup> Mounting an immune response is an energetically costly process.<sup>3,4</sup> Thus, when individuals differ in age-specific immunity, this variation may reflect individual differences in the amount of energy allotted to mounting an immune response with age. This implies that individuals are allocating limited resources to other energetically demanding tasks (e.g., reproduction), and thus producing a trade-off with immune function. In this experiment, genetically based trade-offs between enhanced lifespan and age-specific immunocompetence were examined using the fruit fly, *Drosophila melanogaster* as a model system.

## THE IMMUNE SYSTEM

The innate immune system is the first line of defense of all organisms against pathogens once infection has occurred. This system is non-specific and reacts against foreign invaders with global reactions and cell-mediated defenses. In the fruit fly, *D. melanogaster*, there are two aspects of the innate immune system that respond to infection, secretion of antimicrobial proteins (a chemical defense) and engulfment of bacteria by blood cells (a cell-mediated defense resulting in phagocytosis).

Non-specific chemical defenses include Toll-like receptors in humans, the Toll pathway in *Drosophila*, production of chemical factors like antimicrobial peptides (AMPs) and the complement system.<sup>3</sup> These non-specific defense mechanisms determine the presence of and react against foreign material by detecting microbial-specific molecules. These microbial-specific molecules are called pathogen-associated molecular patterns (PAMPs) and are typically external components of bacteria, such as flagellin, lipopolysaccharide, lipid A or lipoteichoic acid, and may even include the molecular signatures of viruses like single-stranded viral RNA or DNA.<sup>4</sup>

Phagocytosis is performed by specialized cells called phagocytes, which engulf and destroy pathogens wholesale. The phagocyte physically surrounds pathogens and encloses them. This vesicle containing the foreign invader will be combined with a specialized organelle called a lysosome, which contains oxidizing chemicals or a low pH environment to inactivate and digest foreign material.<sup>1</sup> Many phagocytic cells exist in humans in the innate immune system, but all differentiate from multipotent stem cells in bone marrow (vertebrates only). In *Drosophila*, blood cells called hemocytes have this function.<sup>5</sup>

*D. melanogaster* is a well-characterized, genetically tractable model organism. Its relevance to aging and immune functions stems from the conserved genes that it shares with related organisms, including humans.<sup>6</sup> Among these conserved genes are those in the two pathways regulating AMP activation, the *Toll* and *imd* pathways<sup>7</sup> and genes involved in phagocytosis.<sup>8</sup> The modes of activation for the pathways differ: the *Toll* pathway is activated by Gram-positive bacteria and fungi, while the *imd* pathway is activated by Gram-negative bacteria. This experiment used *Escherichia coli*, a Gram-negative, non-pathogenic bacteria with regards to *D. melanogaster*.

Aging has been the subject of both science and speculation for two centuries, beginning with experimentation on calorie restriction, stress factors and mutations.<sup>9</sup> The use of model organisms and advanced genetics has opened new frontiers in this area of research and makes its application to humans within reach. The primary questions of aging research are targeted towards understanding the amazing diversity among species in rates of aging that have evolved (the evolution of aging itself) as well as its genetic basis. To this end, *D. melanogaster* is eminently useful. Two hypotheses were tested in this study. One is that all traits of the organism should exhibit similar rates of senescence



as predicted by evolutionary theory<sup>9</sup> and so artificial selection to extend life span should produce correlated improvements in general physiological function, including immune function, at older age. Alternatively if, as life history theory suggests, there is a trade-off between somatic maintenance and other traits (e.g., immunity), then individuals from populations selected to live longer might be expected to have a poorer immune response at later age.

In this study, we compared the age-specific ability of flies to clear infection, comparing two genetically different populations: one selected for longer life span and the other a control population. We also measured the expression of an important immune response gene, *diptericin*. *Diptericin* is one of many genes that code for an antimicrobial peptide (AMP). AMPs are highly conserved, effective mediators of the innate immune system. The age-related misregulation of gene expression has been suggested as a possible cause for the deterioration of the immune system as a function of age, and age-related misregulation of the *diptericin* gene has been used as an indicator of immune function reduction in older individuals.<sup>10</sup>

## MATERIALS AND METHODS

This experiment used a paired selection-control population system in which two populations underwent multiple generations of artificial selection to extend life span and the other two populations were used as controls. Originally, both selection and control populations descended from one population of wild-caught *D. melanogaster*.<sup>11</sup> The original wild population was halved to create the control (no treatment) population and the selection population. Selection populations' lifespans were enhanced by allowing only the offspring of the eldest flies to propagate a new generation. This procedure was repeated with the eldest flies of that generation, for twenty generations, resulting in a population with a 10 percent increase in lifespan.<sup>11</sup>

In this experiment, paired selection and control populations (C1: control population replicate 1, S1: selection population replicate 1, C3: control population replicate 3, S3: selection population replicate 3) were maintained in sealed, square, plexiglass boxes. Each population was initiated with 400 males and 400 females. Populations were maintained by providing standard fly food on plates every three days. Food plates were removed to prevent offspring from emerging and adding new

adults to the population (flies lay their eggs in food sources, and maturation takes 10 days from egg to adult on average). A standard amount of water was also provided in the form of solidified one-percent agar. Fly survival was monitored, and deceased flies were removed from the cage every two days.

## **FEMTOJET MICROINJECTION IMMUNE CHALLENGE ASSAY**

To perform the injection assay, female flies were removed 24 hours prior to injection time and placed on new food. The injection protocol used pulled capillary needles loaded with *E. coli* grown to 1.5 optical density (OD, measured at  $\lambda = 600$  nm on a spectrophotometer). Flies were anaesthetized using carbon dioxide and a Femtojet microinjector was used to inject a standard load of bacterial solution into the body cavity of the female fly (Eppendorf Femtojet Microinjector: injection pressure  $P_i = 0.46$  psi; compensation pressure  $P_c = 0.2$  psi; injection time  $t_i = 0.2$  sec). Flies were then allowed to mount an immune response for 24 hours following injection.

After mounting an immune response, flies were homogenized using motorized pestles in a standard amount of PBS solution. Individual flies were placed in 1.5 milliliter Eppendorf tubes with 200  $\mu$ L of PBS solution. The homogenate was then plated onto LB agar plates using a spiral plating technique (Microbiology International Whitley Automated Spiral Plater) to serially dilute the sample. Plates were incubated at 37°C for an additional 24 hours, after which the colonies that had grown were counted using automated colony counter software ProtoCOL by Microbiology International. Greater numbers of colonies represented a reduced ability to clear the bacteria while few or no colonies indicated complete clearance and thus an effective immune response by the fly. The effects of age, population of origin and the interaction between these variables on colony counts were analyzed in ANOVA with SAS V9.1 software.

## **QUANTITATIVE REAL-TIME PCR (qrtPCR)**

As stated previously, the innate immune response relies on a collection of defenses, most notably phagocytosis and the production of antimicrobial peptides (AMPs) which are activated

when microorganisms enter the body cavity of the fly. qrtPCR assays can track the upregulation of certain genes that create different AMPs by quantifying the level of mRNA for that protein at that time period; in this way, qrtPCR can measure the transcriptional response of the immune system at the genetic level. Levels of diptericin B transcript were quantitated upon reaching a certain threshold level of fluorescence and normalized to the values obtained for the ribosomal protein, rp49. A lower threshold level indicated a higher amount of transcript.

A previous study analyzed the immune function of flies at multiple times of exposure:<sup>10</sup> at ages one, two, three and four weeks of age and times 0, 6, 12, 24 and 48 hours following the injection assay. This experiment also approached monitoring *dptB* expression, which is effectively done using qrtPCR, at similar time points. As the strength of using qrtPCR lay in visualizing the production of gene products as the immune response was being mounted, this complemented the immune response reflected in clearance data. Female flies were selected after injection events at two time periods: 0 hours (uninjected flies for a baseline measurement) and 24 hours. Whole flies were anaesthetized and preserved for later use in Qiagen RNeasy lysis solution and frozen at -20°C until RNA was extracted.

RNA extraction techniques resulted in collection of all mRNA present in the fly at the time of death. The mRNA was then converted to cDNA so as to be more tractable and storable. The cDNA was mixed with sybrGREEN fluorescein and two primers: one for diptericin B, the gene whose expression levels were desirable to track (forward primer 5' – AGT GCG TCG CCA GTT CCA AT – 3' and reverse 5' – ACC AAG GTG CTG GGC ATA CG – 3); and rp49, a ribosomal protein generally known as a “housekeeping gene” that was used as a loading control. This internal control provided a better comparison point for experimental populations than did absolute quantities.

qrtPCR data appeared as levels of fluorescence exceeding a base or threshold level; levels of fluorescence were directly related to the amount of gene expression.

## RESULTS AND DISCUSSION

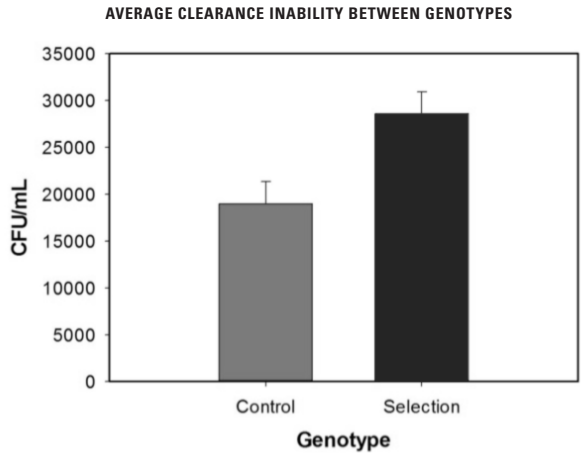
ANOVA analysis of the data showed significant differences in age ( $F_{2,537} = 7.91$ ,  $p = 0.0004$ ), population ( $F_{1,537} = 12.22$ ,  $p = 0.0005$ ) and the interaction between these two variables

( $F_{2,537} = 9.12$ ,  $p = 0.0001$ ), on the ability to clear infection (see Table 1). Overall, an age-dependent effect was seen with regard to the effectiveness of an immune response for both populations. Additionally, as seen in Figure 1, a significant difference was found between control and selection populations over all ages and all lines. Selection populations were found to be significantly less immunocompetent as evidenced by higher colony counts.

**Table 1:** ANOVA analysis of interactions between age, genotype, and replicate populations.

Source	df	Mean Square	F-Value	p
Age	2	46.453	7.91	0.0004
Genotype	1	71.777	12.22	0.0005
Age-genotype	2	53.597	9.12	0.0001
Replicates	2	44.962	7.65	0.0005

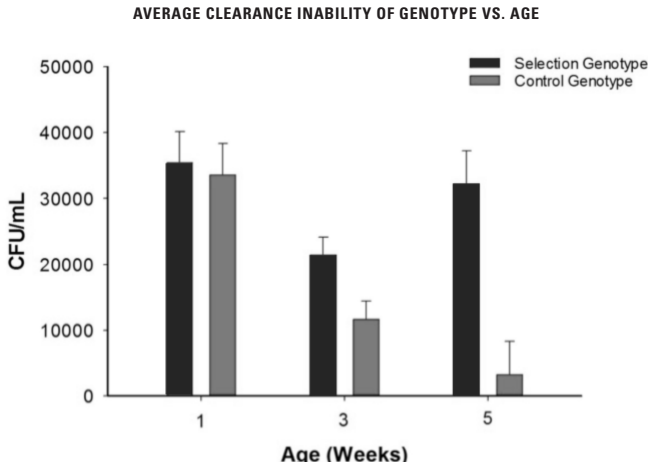
**Note:** Significant at the  $p < 0.05$  level.



**Figure 1:** The significant effect of enhanced lifespan on clearance ability between genotypes can be seen pooled over replicate populations and age. The control genotype demonstrated a higher level of clearance, evidenced by lower cfu/mL counts.

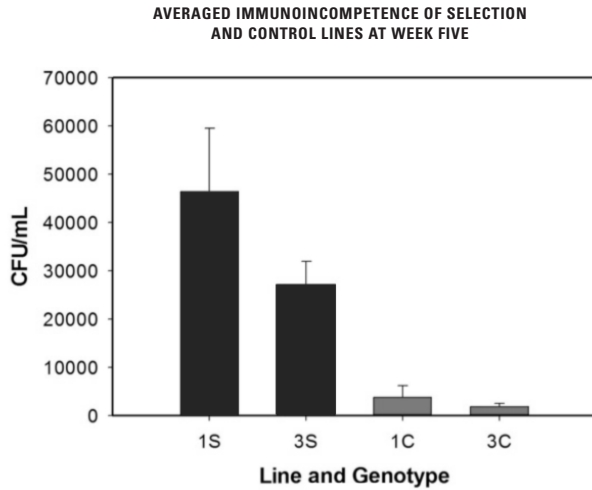
A significant effect of age was seen on immunocompetence across all populations (Figure 2) and indeed, compared to the oldest age, the clearance ability of control populations was actually seen to improve relative to the same control populations' performance and younger weeks of age. Five weeks,

which corresponds to middle or early late age, was the age at which the greatest difference in immunocompetence could be seen between control and selection populations (Fig. 3). The clearance ability of control populations increased across all lines in response to the assay, effects which became pronounced over age. Selection populations, however, appeared to remain at a certain level of poor immunocompetence across all populations and ages. Previous studies using similar jab assays have supported the conclusion that older flies are less immunocompetent, resulting in immunosenescence, perhaps due to deficiencies in antimicrobial peptide production pathways.

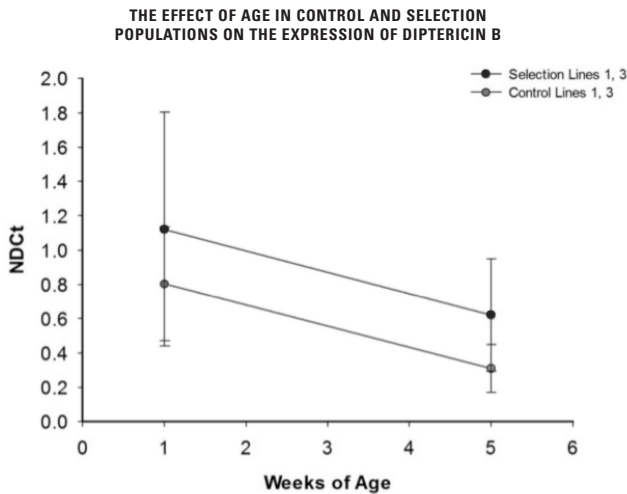


**Figure 2:** When separated by age time points, the relationship between selection and control genotypes and their clearance ability can be seen progressing with respect to age. While both genotypes are comparable at 1 week, the most dramatic difference can be seen at 5 weeks of age.

Quantitative real-time PCR (qrtPCR) provided a new level of resolution on the picture of immune response. The normalized results of qrtPCR corroborated an age-specific response in the immune system (Figure 4) as seen in clearance data. Less transcription of *diptB* occurs in younger flies in both control and selection populations. Higher levels of *diptB* expression, just as found in Zerofsky et al., in older flies implies immunosenescence and results in the poor immune response seen in the clearance assay by older flies which can be considered a net result of immune function.



**Figure 3:** Replicate populations within genotype performed comparably when assayed for clearance ability.



**Figure 4:** When expression levels of diptericin B were quantified by qrtPCR, both genotypes displayed an upregulation of diptericin B at old age (5 weeks).

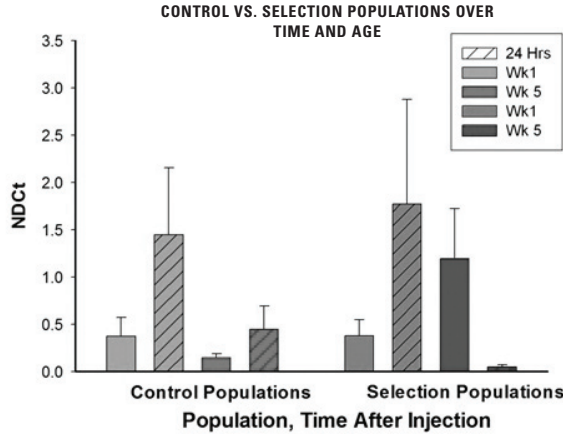
In addition to the overall immune response 24 hours after injection, Figure 5 presents the baseline (0 hours) for each age and genotype and reveals a significant difference between control and selection populations. Control populations showed lower levels of diptericin B expression than selection populations, as well as a less significant change in amount of transcript 24 hours following an injection event. Selection populations, however, possessed a high baseline amount of diptB transcript (0 hours), but this level dropped after 24 hours post-injection.

# EXPRESSION OF DIPTERICIN B IN CONTROL AND SELECTION POPULATIONS AFTER INJECTION EVENT



**Figure 5:** A baseline for diptericin B expression was established by assaying flies before injection (0 hours). These results were then compared to flies given 24 hours to clear the injected bacteria. Selection flies appeared to display decreased levels of diptericin B expression after 24 hours.

The most marked difference between genotypes can be seen in Figure 6. Selection populations behaved similarly to the control populations at week one during the injection event, but a massive upregulation of diptericin B can be seen at week five, 24 hours after injection, results which were also found by Zerofsky et al. As hypothesized in this experiment and previous studies, the innate immune response of older flies is activated post-exposure to pathogens and certain mechanisms of regulation seen in younger flies no longer appear to be in place. Further experiments done by Zerofsky et al. regarding fecundity of female flies implied that regulation of the immune response at young ages contributed to reproductive success. Thus, the cost of enhanced lifespan results in trade-offs with regard to the immune system.<sup>12</sup>



**Figure 6:** While control and selection genotypes largely reflect each other at young age (week 1) at both 0 and 24 hours after the injection event, the genotypes are remarkably different at old age (week 5). While control genotypes appeared to have a higher level of transcript at old age, evidenced by lower threshold values, selection flies appeared to be less prepared for the injection event at 0 hours.

As the experiment performed is novel and contributes to a growing body of knowledge, a review of the existing literature is necessary. A couple papers of note exist that examine the fundamental concern that this experiment also addresses: Zerofsky et al. (2005) and Ye et al. (2009). The experiment conducted by Zerofsky provides a relevant comparison to that summarized in this paper; female flies over a range of ages were challenged with a non-pathogenic bacterium and surveyed for immune function by measuring expression levels of dipterecin for a time period after injection. The Zerofsky experiment, however, used a different species of bacteria, *Micrococcus luteus*, in addition to *E. coli*, surveyed more time points and used a single strain of lab-bred flies.

Zerofsky et al. reached several conclusions involving dipterecin levels and trade-offs during old age that informed the observations in this experiment. Zerofsky found heightened levels of dipterecin expression in older flies upon infection and proposed three reasons for the finding: microbes may survive inside the fly, resulting in poor clearance ability and persistent activation of the *imd* pathway; older flies generally have deficient physical defenses to environmental pathogens and thus are primed for an immune response; which contributes in turn to chronic inflammation, a state in which AMP production is constant. These reasons prompted Zerofsky to conclude that



the older female flies were undergoing immunosenescence, an age-related change (specifically, a decrease in functionality) rather than merely a cumulative exposure to pathogens. However, in his experiment, Zerofsky did not have measurements of infection level as we had in our experiment and so could only hypothesize about why mRNA levels of diptericin were higher in older flies following infection.

Ye et al. performed a related experiment except in their case, observed a trade-off with the ability of flies to survive infection by *Pseudomonas aeruginosa*, a natural pathogen of *D. melanogaster*, and the effect of life span on immune response. In their case, flies were bred to have increased antibacterial resistance to the pathogen, which resulted in a trade-off between lifespan and fecundity (notably, amongst females). Ye et al. concluded that an evolved capacity for defense corresponded with reduced longevity in the selection populations as compared to the control populations.

Age has been thought to have been fundamentally linked to immunity.<sup>9</sup> In our experiment, age affected immune response, but the effect varied depending on genotype. In this experiment, only the population selected for increased life span demonstrated immunosenescence, defined as the gradual deterioration of the immune system brought on by natural age advancement. This effect was not surprising, as life history theory predicts this trade-off between traits that demand energy; however, our results are at odds with one of the evolutionary theories of aging that predicts age related declines in physiological performance should be reflected in all traits.<sup>9</sup> In our study, this was not the case. Of note, the immunocompetence of the control line appeared to improve with age; this may be possibly related to the over-expression of antimicrobial peptides with progressive age<sup>13</sup> or a decrease in the amount of energy devoted to reproduction with age in the control populations. These hypotheses remain to be tested.

## LIMITATIONS AND FURTHER RESEARCH

This research provided complete clearance assay data for four populations of genetically distinct female flies at three ages in replicate. Significant differences were shown between control and selection lines between the youngest (week 1) and the oldest age (week 5). This experiment also provided a molecular viewpoint of the transcription levels of the antimicrobial pep-

tide dipterin B in response to infection at different ages in female flies. The results of these experiments can be synthesized or considered with experiments done with a different bacteria (such as *Enterococcus faecalis*, a natural pathogen of *D. melanogaster*) or immunosenescence experiments that used both male and female flies. Other possibilities include examining the cellular immune responses instead of the humoral or examining a different AMP gene for further rtPCR assays.

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**LAUREN BUCCA .....**

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# **ST. CUTHBERT AND PILGRIMAGE 664-2012AD: THE HERITAGE OF THE PATRON SAINT OF NORTHUMBRIA**

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"St. Cuthbert and Pilgrimage 664-2012AD: The Heritage of the Patron Saint of Northumbria" initially began as an independent study with Dr. Gail Orgelfinger during spring 2011. My independent study focused on traveling and pilgrimage during the Middle Ages, and later developed into a project tracing the pilgrimage route of St. Cuthbert, a seventh-century Northern English saint. I received funding from an Undergraduate Research Award to personally trace St. Cuthbert's pilgrimage route called "St. Cuthbert's Way," a 62-mile journey beginning in Melrose, Scotland and ending in Lindisfarne, England. In order to understand the contemporary appeal of pilgrimage in this isolated area, I traveled part of the pilgrimage route myself and interviewed people connected with the route. This study combined an analysis of medieval literature, manuscript illuminations, and history with contemporary travel in order to see how pilgrimage has evolved over the course of 1,300 years. It is my hope to reveal that pilgrimage is by no means only a medieval tradition, but one that remains alive and relevant in contemporary society.

When it is high tide, the Pilgrims' path is flooded by the North Sea. The waves glisten under a cloudless sky, and the seagulls call to one another as the water rushes in. Lindisfarne on Holy Island is isolated from the English mainland twice each day, a tidal island termed "holy" because of its association with Cuthbert (634/635-687), a Northumbrian saint. The beauty and isolation of Lindisfarne have made it an ideal location for pilgrimage, from the time of Cuthbert to the present day. Lindisfarne is the end point of a pilgrimage journeyed for the past 1,300 years as countless people, from travelers to kings, have come to pay homage to the heritage of Cuthbert. This route, called St. Cuthbert's Way, spans 62.5 miles from Melrose, Scotland to Lindisfarne, England (Figure 1). The history of this route reveals the significance of pilgrimage as a concept that has flourished for over a millennium.

Pilgrimage, a journey to a saint's shrine, was one of the most common forms of travel during the Middle Ages. As John Crook describes in *English Medieval Shrines*, "what impelled the devout to visit these holy graves was a belief that in some mysterious way the saint . . . continued to maintain contact with the earthly sphere through the physical remains that he left behind" (Crook 5). Some of the most well known medieval pilgrimages were to Canterbury to the shrine of St. Thomas Becket (fictionally depicted in Chaucer's *Canterbury Tales*), to Jerusalem, which is filled with sites relating to Christ's ministry, death, and resur-

rection, and to the Camino de Santiago de Compostela, where St. James is said to have been buried. Pilgrims traveled to the aforementioned sites to do penance for their sins, as mortality and the afterlife were prominent themes during this time, as even Chaucer writes in *The Canterbury Tales*: “This world nys but a thurghfare ful of wo,/And we been pilgrymes, passynge to and fro; /Deeth is an ende of every worldly soore” (Chaucer, *A Knight’s Tale*, 1.1989-81).

The difficulty of the journey played a meaningful role in the pilgrim’s spiritual quest, for “by inflicting physical hardship on the pilgrim, it satisfied a desire for the remission of his sins” (Sumption 114). Such “physical hardship” included not only the terrain, but the lack of proper traveling clothes, for “pilgrimages on foot were very common, and among sincere penitents almost obligatory” (Sumption 127). Although there were penitential purposes for a pilgrim to go barefoot and wear humble attire, even more often a pilgrim dressed modestly to avoid robbers. A common image of a pilgrim is one wearing a broad-brimmed hat bent backwards at the front (in order to hold badges of the places they visited), wearing a shoulder sash, carrying a staff, and walking barefoot (Friedman 480).

The pilgrimage in honor of Cuthbert is prominent today, as Cuthbert remains one of the most famous saints in Northumberland, England (Bernicia in Northumbria during the seventh century). Although pilgrims traveled many paths in England and Scotland in order to see Cuthbert, there is one walking path officially designated as a pilgrimage: St. Cuthbert’s Way. This route commemorates and roughly follows the path Cuthbert traveled in the mid-seventh century when he relocated monasteries from Melrose to Lindisfarne. The area is preserved by both Historic Scotland and English Heritage, and still resembles a seventh century landscape, as the majority of it is preserved as Northumberland National Park. Located between the Scottish Borders of the south of Scotland and Northumbria in the north of England, this route encompasses mountains, hills, rivers, and vast empty spaces. Save for a few towns along St. Cuthbert’s Way, it is predominantly a nature walk undisturbed by contemporary structures.

## ST. CUTHBERT, PATRON SAINT OF NORTHUMBRIA

There are four accounts from the Middle Ages that describe Cuthbert’s life and ministry. The first is by an anonymous monk



from Lindisfarne and was completed in 698. This manuscript was used as a source by Bede, who wrote both a metrical and a prose version of his *Life of Saint Cuthbert* in 705 and 721, respectively. Bede's *Ecclesiastical History* from 731 also includes six chapters on Cuthbert's life. These texts were written less than a hundred years after Cuthbert's death, which testifies to his popularity as a saint in the seventh and eighth centuries. The surviving forty-five medieval manuscripts, dating from the tenth century, proclaim the importance medieval people attributed to Cuthbert. Of the surviving medieval manuscripts, seven are by the anonymous author and thirty-eight by Bede (Colgrave 19, 38). Several of these are illuminated, most notably the twelfth-century manuscripts BL Yates Thompson 26 and Oxford, University College, MS 165. These two manuscripts illustrate Cuthbert's life, but BL Yates Thompson 26, Bede's *Life of Saint Cuthbert*, contains full-page miniatures, providing a more detailed representation of Cuthbert's ministry. This BL Yates Thompson 26's account is unique in that the majority of manuscripts do not provide illuminations of Cuthbert's ministry.

Cuthbert spent his life and ministry in Northumbria. During the Anglo-Saxon period, this region extended from the north east of England to the Firth of Forth in south east Scotland. According to Bede's prose *Life of St. Cuthbert*, Cuthbert received the call to ministry when he was seventeen years old. While Cuthbert was keeping watch over a flock of sheep, he had a vision that St. Aidan, the founder of the monastery at Lindisfarne, had died (Colgrave 167). As the vision was realized, Cuthbert decided to devote his life to God by joining a monastery (Colgrave 167). His ecclesiastical career began at Melrose, where he began as a monk and later became prior, in 662. Illuminations of the *Life of Saint Cuthbert* from BL Yates Thompson 26 depict Cuthbert's journey to Melrose, as fol. 14r shows Cuthbert's traveling by horse to Melrose Priory (Figure 2). As described by Bede, Cuthbert found he could not complete his journey in the time he had hoped, so he resolved to find refuge in "some shepherds' huts close by" (Colgrave 171). Cuthbert, tired and hungry, walked away from the thatched hut with his horse following behind. The huts had been abandoned, holding no food for the hungry traveler. Bede writes that Cuthbert, "in the midst of his psalm-singing . . . saw the horse lift up its head, seize the thatching of the house with its mouth and drag it down" (Colgrave 171). This miracle highlights Cuthbert as one favored by God, as well as someone who was not only saintly

but very human, needing food like any other pilgrim on a journey. Yet, it must be noted that miracles were a traditional part of medieval saint's lives, and Bede is merely placing Cuthbert as part of that tradition.

Cuthbert's arrival at Melrose is represented by his dismounting his horse and being greeted by Boisil, the prior of Melrose (fol. 16r). Cuthbert's clothes are simple and appropriate for a pilgrim: he wears a light brown, plain frock that would not have attracted attention on the road to Melrose. Cuthbert's popularity grew at Melrose, for it was from here that he preached to the surrounding villages and earned the reputation of a preacher and miracle worker, as the anonymous *Life* describes Cuthbert "going along the river Teviot and making his way southward, teaching the country people among the mountains and baptizing them" (Colgrave 85). The river Teviot is about a day's walking distance from Melrose. Cuthbert faithfully preached to these villages, as he "was diligently teaching the word of the Lord at a certain village in accordance with his custom" (Colgrave 87). That this was "his custom" is interesting to note; Cuthbert was in the habit of caring for the people in the places surrounding him, not only the people who came to see him. Bede adds in his account that "not only did he give the monastery itself counsel concerning the rule and an example of it, but he sought moreover to convert the neighbouring people far and wide from a life of foolish habits to a love of heavenly joys" (Colgrave 185). Cuthbert fulfilled the rule of a humble preacher on foot, which was part of the Irish missionary tradition embedded in Britain during this time (Bede 114).

Cuthbert was transferred to the monastery at Lindisfarne in 665. Traveling to Lindisfarne can be difficult, as access to the island is determined by high and low tides, which Bede describes: "as the tide ebbs and flows, this place is surrounded twice daily by the waves of the sea like an island and twice, then the shore is left dry, it becomes again attached to the mainland" (Bede 113). As a prior he enforced the Roman tradition that was decided upon at the Synod of Whitby the previous year, which contrasted with the Irish way that had been held at Lindisfarne since the days of St. Aidan (the Irish tradition included a different calculation of the dating of Easter). As prior at Lindisfarne, Cuthbert demonstrated his ability to reconcile the Irish and Roman traditions. Although these two traditions were fiercely debated by his brethren, Cuthbert, "by daily effort . . . converted them to a better state of mind" (Colgrave 211).

Besides being reputed as a teacher who “perceived the ideal combination of Irish asceticism and Roman learning” (Story 25), Cuthbert became known as a preacher and miracle worker. Bede writes, Cuthbert “equally by his life and by his doctrine taught the monastic rule to the brethren” and “by frequent visits aroused the common people . . . to seek and earn heavenly rewards” (Colgrave 209). As demonstrated in Bede’s narrative, Cuthbert was not only a preacher, but a healer. Bede writes that “by the importunity of his prayers he restored to their former health very many who had been seized with various kind of diseases and afflictions . . . not only when present by praying, touching, commanding and exorcizing, but also when absent either by prayer alone” (Colgrave 211). Word spread about Cuthbert’s healing miracles, for as Bede writes, “many came to the man of God, not only from the neighbourhood of Lindisfarne but also from the remoter parts of Britain, having been attracted by the report of his miracles” (Colgrave 229). Although the “remoter parts of Britain” are not spoken of in any more detail, one can assume Cuthbert had established a reputation throughout England and Scotland.

Although it is possible to imagine Cuthbert spending his time peacefully teaching his brethren at Lindisfarne, it is not a completely accurate image of the adventuresome life Cuthbert led. The *Lives* describe how he sailed the sea on missionary voyages, was stranded on a land during a missionary journey, performed miracles, bravely preached and baptized throughout Northumbria, and wisely taught his brethren at Lindisfarne. However, in 676, all Cuthbert desired was the solitude at Inner Farne Island. This island is a short boat ride away from Lindisfarne. Cuthbert found refuge on this island for, although it is separate from Lindisfarne, it still affords an excellent view of the surrounding area. From the island, one can see the blurry outline of Bamburgh Castle, home of Northumbrian kings. Surrounded by stones, shells, and glistening waters, the island is the ideal place for contemplation and for Cuthbert would have afforded him privacy from pilgrims.

Cuthbert’s holy life was noted by Northumbrian royalty, including the royal abbess Elfeda (who requested Cuthbert to visit her at Croquet Island, a journey of approximately sixty-three miles) and Ecgfrith, a Northumbrian king whose court was situated at nearby Bamburgh. Cuthbert’s “reputation, even in this remote place [Inner Farne Island], grew greater and many made what must have been a perilous journey to see him.

Because of his reputation as a holy man the community of monks at Linsidarne naturally wanted him as their bishop” (Marner 13). Ecgfrith and his retinue traveled to Cuthbert’s hermitage at Inner Farne Island in 684, in order to plead with Cuthbert to accept his unanimous election to the bishopric of Lindisfarne. Cuthbert’s election to the bishopric was a great honor, as even King Ecgfrith, king of Northumbria, had found Cuthbert worthy enough to personally offer him the position (Figure 3). King Ecgfrith and his council implored Cuthbert “on bended knees” (Colgrave 111) to become a bishop. Cuthbert accepted, but it was “unwillingly and under compulsion” (Colgrave 111). The illumination in the *Life*, fol. 51r, reveals Cuthbert’s reluctance as he is greeted by King Ecgfrith and his company. On the left is Cuthbert, wearing a humble prior’s black garb. As he stands in front of his monastery, his head is bent down in reverence to the king. King Ecgfrith extends his hand to Cuthbert and points his finger as he declares his important message. In the foreground are the wavy shores of Lindisfarne, and a boat in which only the prow is seen; this is a reminder of Lindisfarne’s uniquely isolated location, whose tides have to be noted by kings as well as contemporary pilgrims.

As a bishop, Cuthbert attracted even more attention from the Northumbrian community, for “his duties as bishop brought him back into the world of kings and nobles, and he acquired a considerable reputation as a pastor, seer, and healer” (Story 25). Cuthbert created a name for himself by his reforms, miracle work, and travels originating at Lindisfarne monastery. Unfortunately, Cuthbert would only be bishop of Lindisfarne for two years. On March 20, 687, Cuthbert died in his thatched hut on Inner Farne Island. Bede writes the last words of Cuthbert, which were most likely Bede’s invention, but nevertheless convey Cuthbert’s character: “I know that, although I seemed contemptible to some while I lived, yet, after my death, you will see what I was and how my teaching is not to be despised” (Colgrave 285). Nine years after his burial on Lindisfarne, Cuthbert’s tomb was opened and his body found incorrupt, meaning that his body appeared just as it had when he was buried (Colgrave 293). To the monks at Lindisfarne, this confirmed Cuthbert’s holiness and worthiness of sainthood. After a series of miracles occurred at Cuthbert’s tomb, pilgrims flocked to his shrine, and many of them were reportedly healed, according to Bede’s *Life* (Marner 14).

The exhumation of Cuthbert's relics initiated his cult, as "the discovery . . . of his relics marked the beginning of the cult of St. Cuthbert, which was to alter the course of the community's history" (Story 27). This exhumation "provided confirmation of his saintly status" (Marner 14). After the exhumation, Cuthbert became not only a notable holy man, but a distinctly Northumbrian saint whose mark would be seen in Northern England for hundreds of years to come. However, the peaceful time at Lindisfarne did not last, as the ninth-century Viking attacks forced the monks at Lindisfarne to transfer Cuthbert's body to a safer burial place. Cuthbert's body was transferred many times across Northumbria over a hundred-year span, until his remains were brought to Chester-le-Street in County Durham. The body was later moved to Durham Cathedral, the Shrine of St. Cuthbert, which was finished in 1104 as a burial place for both Cuthbert and the Venerable Bede.

Cuthbert's reputation as a healer and preacher throughout Northumbria, and burial in Durham Cathedral, distinguishes him specifically as a *Northumbrian* saint. The narrative accounts of Cuthbert "placed him firmly in a northern landscape and provided geographical and topographical connections between the people of the region and their saint, thereby strengthening his power as a unifying symbol of the region" (Marner 19). Cuthbert was undaunted by turbulent storms of the North Sea and the uncultivated northern terrain, indeed he went remarkable distances: he traveled from Melrose to Lindisfarne, from Lindisfarne to surrounding Northumbrian villages, and from Lindisfarne to places like Coquet Island, Hexham, and even Fife in Scotland. Cuthbert's appeal derived from his reputation as a Northumbrian missionary, for Cuthbert "was the most important saint of the Anglo-Saxon kingdom of Northumbria. He commanded the respect of Deirans, Bernicians, Scots, and Danes alike and lent prestige to the Lindisfarne community" (Young 28-29). The Deirans and Bernicians lived in northern and southern Northumbria, respectively. Cuthbert, remarkably, "commanded the respect" of these various people, despite their differences. There was nothing that could deter him from reaching people, as Bede describes, "he used especially to make for those places that were far away on steep and rugged mountains, which others dreaded to visit and whose poverty and ignorance kept other teachers away" (Bede 224). Cuthbert's name as a healer and traveler in

Northumbria is a testament to his genuinely kindhearted character, in that he endured difficult journeys in order to reach people.

## THE CULT OF ST. CUTHBERT

The fame of Cuthbert and Lindisfarne as a pilgrimage site was commemorated by the anonymous author and Bede's *Lives*, as well as the creation of the masterfully illuminated Lindisfarne Gospels (ca.700). The gospels' colophon reads: "Eadfrith, Bishop of the Lindisfarne church, originally wrote this book, for God and for Saint Cuthbert" (Marner 15). Cuthbert's memory was alive at Lindisfarne even after his death, manifesting not only in the creation of the Lindisfarne Gospels but in the growth of the cult of Cuthbert, for "after 698, when his body was enshrined before the high altar of the church, Lindisfarne became the most important pilgrimage centre in the north" (Story 3). Unfortunately the thriving cult at Lindisfarne was not to last, due to increased violence from Danish Viking invaders. Viking attacks from the eighth to ninth centuries were so destructive that the monks on Holy Island were forced to escape with Cuthbert's relics. Cuthbert's remains were removed to Chester-le-Street in Durham County in 995 and enshrined in Durham Cathedral in 1104 (Story 5).

Durham Cathedral was made for and dedicated to Cuthbert, and is called the "Shrine of Saint Cuthbert." Both Bede and Cuthbert are buried in the cathedral. With these two noteworthy figures buried at Durham Cathedral, it immediately became a popular pilgrimage site: "although the Norman conquest of the late eleventh century significantly altered the political and ecclesiastical landscape of England, the veneration of Cuthbert endured, growing in strength during the twelfth and thirteenth centuries" (Young 26-27). The continued veneration of Cuthbert's relics can be attributed to the influence of Bishop Hugh du Puiset (1125-95), who held the Episcopal seat at Durham Cathedral. Du Puiset helped make the cathedral and city a more accessible pilgrimage spot, for "his chief desire, it is clear, was to make the town of Durham as attractive and accessible as possible for pilgrims" (Young 33). Durham Cathedral continues to be a pilgrimage site, with visitors coming to see and venerate the relics of Cuthbert as well as marvel at the skillful artistry of the cathedral. The cathedral website reports that "each year

over 600,000 people come to Durham Cathedral from all over the world. The Cathedral appeals to a wide range of audiences . . . [including] those who come on pilgrimage inspired by the north's saints Cuthbert and Bede" ("Information for Visitors"). In the Feretory (an area in a church that holds relics) one finds Cuthbert's burial place. A stool has been placed at the foot of the tomb, where pilgrims can kneel in prayer before a grey slab on the floor inscribed with "Cvthbvrts." This is one of the most significant parts of pilgrimage; being in the same physical space as a saint's relics links the experience of a contemporary pilgrim with the experiences of pilgrims spanning hundreds of years.

While it is true that Cuthbert's memory lives in Melrose, Lindisfarne, and Durham, it is not confined to these places. As said before, Cuthbert is uniquely a Northumbrian saint. Cuthbert's name is not only linked to priories, cathedrals, and abbeys, but to the land itself, to the natural world. Cuthbert is often associated with Northumbrian nature, as he even became patron of the Eider ducks at Lindisfarne because he made laws to protect them. They are known as "Cuddy ducks" today in honor of their first protector ("Famous Eider Colony"). Besides his association with ducks, Cuthbert's life was intertwined with the geography of Northumbria. For example, in the twelfth century, King Aethelstan bequeathed the Liberty of Durham (a region between the Tyne and Tees River) to the ruling of the Bishop of Durham, and the inhabitants earned the name of *Haliverfolk*, or "people of the saint." These lands would be known as "'St. Cuthbert's land' and 'the Patrimony of St. Cuthbert'" (Marner 19). Politically, this created unity in this area: "the unifying factor of their lives was the shrine and land of St. Cuthbert. This provided them with a tremendous sense of cohesion and identity. In the imagination and daily life of 'the people of the saint', the land of Northumbria became integrated into the very idea of Cuthbert" (Marner 19). In the twelfth century, Cuthbert had become synonymous with Northumbria, and would continue to be so into the twenty-first century.

## ST. CUTHBERT'S WAY

Cuthbert was honored by the establishment of St. Cuthbert's Way in 1996, manifesting the perpetuity of St. Cuthbert's popularity and pilgrimage. The idea to establish an official walking route between Melrose and Lindisfarne began with Ron Shaw,



who worked for the Till Valley Tourist Initiative in Wooler, England, with the cooperation of Roger Smith, the Walking Development Officer for the Scottish Borders. According to their guidebook titled *St. Cuthbert's Way*, the route was meant to connect the “places associated with the life of St. Cuthbert and thus celebrating in a novel and very interesting manner the life of the seventh century saint” (Shaw and Smith ix). Although Durham has been visited by pilgrims since the twelfth century, it is not directly linked to Cuthbert’s ministry and therefore is not included in the pilgrimage.

St. Cuthbert’s Way is “a 100km (62.5 mile) . . . walking route across the Scottish Borders to the Northumberland Coast following in the footsteps of St Cuthbert (“St. Cuthbert’s Way”). This path commemorates the route St. Cuthbert took when he relocated monasteries from Melrose to Lindisfarne, as well as replicates the path pilgrims have followed to his shrines at said monasteries. The route also includes monastic sites and villages between these two towns, including Dryburgh, where there is a medieval abbey, and St. Boswell’s, Kelso, Morebattle, Town and Kirk Yetholm, and Wooler. The route contains everything from abbeys, to castles, to English and Scottish countryside. The diversity of the route is part of the reason why it has become such a popular walking holiday, having been walked by approximately 30,000 people at the time of St. Cuthbert’s Way ten-year anniversary in 2006 (Henderson).

In the twenty-first century, people walk St. Cuthbert’s Way for a multitude of reasons. Cuthbert’s preaching attracted people to Lindisfarne during his day, yet Cuthbert is not the sole reason people walk the route in more recent times. To discover the contemporary appeal of this route, I investigated the sites along the way, such as Melrose Abbey (Figure 4), Dryburgh Abbey, Cessford Castle, and Lindisfarne Priory (Figure 5). Interviews with fellow tourists, hikers, monument managers, and store proprietors in both England and Scotland helped me understand the contemporary perspective of pilgrimage. I began my own “pilgrimage” in Melrose, a small town tucked away in the shadow of the Eildon Hills. Historic Scotland, an organization which helps fund and preserve sites along St. Cuthbert’s Way, describes the history of Melrose Abbey: “founded in 1136 by David I, Melrose was the first monastery of the Cistercian order established in Scotland. The Cistercians were drawn to this fertile spot beside the River Tweed because of its intimate associations with the holy men St. Aidan and St. Cuthbert” (“Melrose



Abbey”). The fourteenth-century remains of Melrose Abbey stand proudly despite their imperfection and shadow of what they once were. The character of the abbey, however, remains strong; it is peppered with animal and angel sculptures on the exterior and filled with side aisles containing skeletal windows, as well as winding stairs leading to a balcony that overlooks the surrounding town and hills.

The location of Melrose appeals to anyone seeking a holiday, anyone in search of something that has endured the test of time. Melrose Abbey has been destroyed and rebuilt for nearly one thousand years. But still it remains, and testifies to the importance of preserving and remembering history. Melrose Abbey itself is a remarkable sight in the fading sunlight; the place is full of peace, a kind of stillness only disturbed by the fluttering wings of birds, or even a rabbit hopping amid the gravestones of the abbey. While Melrose may have a good tourist economy, it is untouched by commercialism.

There are still people in Melrose who assist pilgrims by providing them with a place to stay. Bryan and Alison Bell manage the Dunfermline House in Melrose, which is used by pilgrims, hikers, and tourists. This small Bed and Breakfast is down the street from Melrose Abbey, offering much more comfortable accommodations than what would have been available in the Middle Ages. The Bells are familiar with St. Cuthbert’s Way because of all the hikers who seek respite at the Dunfermline House. The Bells have not walked the entire route, as Bryan Bell remarked that “we’re not keen walkers so we just came back and went to the pub” (Bell). Walkers of the route are a common site for the proprietors, as they encounter ministers and hikers alike: “Everyday there is somebody here who will be doing St. Cuthbert’s Way” (Bell). With a grin, he added, “we’re very lucky, we get the walkers at the beginning of the walk and they are nice and clean . . . clean and keen as we say . . . some of the guys further along the walk are receiving walkers who are absolutely soaking and wet through and muddy and not so happy” (Bell). The people “further along” appear in towns like Wooler (44 miles distance) and Lindisfarne (62 miles distance), hosts towns that may entertain hikers after a long and weary journey.

Although St. Cuthbert’s Way may be a popular walking route, not everyone is aware of the saint himself. Bell explained to me that there are “two kinds” of walkers. He stated, with a voice as clear as the mountain air of Melrose, “40 percent are aware of the history behind it, and 60 percent have not a clue

and are just doing it because it's lovely" (Bell). Bell attributed the popularity of St. Cuthbert's Way to a revived interest in walking holidays, saying walking is "more popular every year" (Bell). And it will continue to be, as long as people are interested in seeing the diverse scenery of the route, as well as benefiting from the undisturbed area. Bell also discussed the future of St. Cuthbert's Way: "I don't see any need to change it. Everybody's always wanting to change things and improve things but I really don't think we can improve it. But as far as the viability of it, it's a huge success, a huge success" (Bell). Pilgrimage, Bell argued, will continue as it has evolved in modern times. When explaining to me how he has encountered both ministers and hikers alike on the route, he said, "nowadays I think [pilgrimage] is used for just about anything . . . people will do pilgrimage to America to see the house where, what's his name? Elvis Presley! To some people that's a pilgrimage" (Bell). The idea of a pilgrimage to Graceland may be humorous, but it still represents a truth about contemporary pilgrimage, though often religious, it has taken on new meanings.

The notion that walking in a silent, beautiful place can be "transformative" is not a new idea, but it is one that explains why St. Cuthbert's Way is still traveled today. Frank Burrell, Historic Scotland Monument Manager at Melrose Abbey, remarked "as long as people have religion, they'll continue to do that [pilgrimage]. I don't see it decreasing. I can only see it increase as long as people see walking as an exercise" (Burrell). There is a correlation between walking and thinking; sometimes it is needed as a means for reflection, something that people need regardless of the century. It is closely tied to "religion" because of its religious roots, in this case Northern English Christianity, but is not always defined by it.

While pilgrimage in the Middle Ages was primarily for religious purposes, in contemporary times people travel for countless reasons. Sometimes the distinction between tourist and pilgrim is blurred (Dyas), as both may approach sacred sites with the same outward signs of awe and curiosity. Today, people do not commonly seek shrines for healing, "as in the current age, we find a new global environment in which the status and meanings of sacred places are being redefined" (Plate 262). This redefinition implies that people do not always seek holy sites for the sake of the holy, such as walkers of the Camino de Santiago de Compostela or tourists traveling in Jerusalem. The reason for this definition is that pilgrimage has become more

about the journey, rather than the object of the journey: “there is something about the quest itself, whether for noble, pious, pure, impure, or just plain curious reasons, that makes the journey potentially transformative” (Plate 263). Pilgrimage is a kind of quest, whether it is spiritual or not.

While in Melrose, I became a hiker in order to understand what it means to be a pilgrim. One early morning I walked from the abbey to the foot of the Eildon Hills following the route markers with the image of St. Cuthbert’s cross emblem. Plate affirms that “pilgrimage is tightly bound to our sense of identity, and sometimes the best way to find ourselves is to get lost” (Plate 263). Being “lost” is certainly an aspect of pilgrimage one does not usually hear about; it is the idea that one can learn the most about oneself by wandering through isolated places. Seeing the ruins of Melrose Abbey in the distance and green hills circling the village reaffirmed to me the importance of contemplation in isolation, far away from the constant pace of twenty-first century life. This is something every hiker experiences when walking St. Cuthbert’s Way, for the area is so well preserved, that one cannot help but connect to the 1,300-year history.

After Melrose, I came to Morebattle, Scotland, a town along St. Cuthbert’s Way and a distance of approximately twenty-three miles from Melrose. The town is filled with tiny businesses and houses, and was completely quiet during my visit, with hardly anyone in sight. I encountered two walkers on the route, both from Antwerp, Belgium: Ivan Willems and a woman who chose to remain anonymous. Willems and the woman both offered their perspectives on pilgrimage: Willems remarked that it reminded him of “bare feet, which we didn’t do, because we’re not crazy” (Willems), while the woman thought that pilgrimage meant “to ask for forgiveness for something.” Willems explained why he wanted to go on St. Cuthbert’s Way before he begins work in Japan. “For me,” said Willems, “it’s more spiritual. It’s cleansing the mind” (Willems). Willems’ historical view of barefooted pilgrims aligns with the spiritual side of St. Cuthbert’s Way, in which pilgrims were often barefoot because they were performing penance for their sins. But their responses also demonstrate that contemporary pilgrimage can be used as something to clear the mind, an exercise of body and mind.

Although a pilgrimage may be a penitential or reflective exercise, it is also an aesthetic experience. The landscape along St. Cuthbert’s Way is stunning. This land has long been pre-

served, and is filled with small rivers crossed by stone bridges, and mountains dotted with sheep. Yet St. Cuthbert's Way is by no means the only walking route in this area. Walking is a popular activity in the United Kingdom, with the Border Abbey's Walk, St. Oswald's Way, Southern Upland Way, and the Pennine Way all intersecting St. Cuthbert's Way. According to *St. Cuthbert's Way: Official Guide*, "in the ten years it had been open the route had gained a reputation as one of Britain's most enjoyable long distance walks, with its rich historic and religious interest and the great variety of terrain" (Shaw vii). Pilgrims and hikers, when passing through small towns like St. Boswell's, Morebattle, and Wooler, are surrounded by varied landscape and wildlife.

Towns silently tucked away amid the Cheviot Hills, the mountains forming the border of Scotland and England, have benefitted economically from St. Cuthbert's Way, revealing that a walking route benefits not only those treading it. According to Shaw and Smith, "one of the reasons for creating the route was to provide economic benefit for the communities through which it passes and others close to the route. There is no doubt that this has happened, and as the route continues to become better known, this benefit should increase" (Shaw and Smith xi). In St. Boswell's, named after St. Boisil, the Abbot of Melrose and teacher of St. Cuthbert, a barista at St. Boswell's Main Street Trading Company remarked that "a lot of people come by on St. Cuthbert's Way, tour guides making reservations, and once came a group of five hundred Dutch people who didn't make reservations" (Barista). Considering the chuckle with which this statement was said, one may suspect its validity; regardless, the towns along St. Cuthbert's Way have benefitted financially from the route.

After journeying through the towns along St. Cuthbert's Way, visiting Dryburgh Abbey and Cessford Castle, I came to Holy Island. I visited Lindisfarne on a sunny, cloudless day. The town was filled with elderly couples, families, and hikers, as well as people stopping in places such as Oswald's Café and Pilgrim's Coffee. The twelfth and fourteenth-century remains of Lindisfarne priory mark the end of St. Cuthbert's Way, and indeed the beauty of the site makes it a very rewarding end. The rainbow arch (the name of a curved arch that has remarkably remained despite its precarious position) of Lindisfarne priory in the warm light stood out against a cloudless blue sky, an architectural marvel considering all of the destruction and weathering that the priory

has experienced. Lindisfarne is a place of quiet beauty, something that is simple and yet majestic; a perfect place to end a pilgrimage.

Pauline Collins, a friendly woman with curly grey hair, works almost next door to the priory as an assistant at the Lindisfarne Centre. Her husband, Paul Collins, is the vicar of St. Mary's Church, a church established in the twelfth century that still functions today. Collins discussed the process of pilgrimage to Lindisfarne and her contact with those on St. Cuthbert's Way. Said Collins, "some people come for the natural history, as well as the spiritual. Some people have faith, and it takes them on their journey" (Collins). Much like Bryan Bell, Collins commonly sees people along the walking route. Collins noted that she encountered many people on a pilgrimage: "church groups sometimes call my husband before they come. My husband does the Eucharist for church groups" (Collins). Collins proceeded to tell me that the route "brings people all year long, especially April through October. "I just had two ladies who completed St. Cuthbert's Way. Most days we have one to two people who walked St. Cuthbert's Way" (Collins). By Collins observation, pilgrimage is by no means a dying tradition.

Reverend Paul Collins, like his wife, encounters the more traditionally religious pilgrimage, as he commonly encounters people on St. Cuthbert's Way or those just coming to Lindisfarne. Rev. Collins sees pilgrimage as "people journeying by different means, with spiritual goals . . . people seeking holy and the 'other' " (Rev. Paul Collins). Collins personally helps those who are in search of the "holy," for he holds the position as the "cure of souls" for those living on the island and those on pilgrimage. Concerning pilgrimage, he serves more than seventy-five groups each year which includes "parish groups, ecumenical groups, schools, colleges, universities, theological colleges, tourist groups, individual/family group tourists" (Rev. Paul Collins). Mostly, Rev. Collins serves by speaking to these people or leading worship services.

It would seem, considering the Collins' remarks, that nearly everyone visiting Lindisfarne knows the history of St. Cuthbert and comes for the spiritual side of the journey. This, however, is not the case. Ryan Douglas, Historic Properties Steward at Lindisfarne sees pilgrimage as "a group of people in search of something" (Douglas). Douglas' interpretation of pilgrimage was certainly this situation at Lindisfarne during the time of Cuthbert, when many people would come to seek healing or to

be taught about God. Today this “something” could mean anything from the “Cuddy” ducks, to the priory with its hundreds of years of history. Douglas also said “we get 650,000 [visitors] yearly and only 150,000 visit the priory” (Douglas). This comment implies that not every person visiting the island has the religious history in mind, which constitutes the difference between the casual tourist and the visitor with a previous interest in the religious history of Lindisfarne.

I found through my interviews that although pilgrimage in the Middle Ages was primarily for religious purposes, it has evolved and taken on many forms in contemporary times. Regardless of their intentions, those who walk St. Cuthbert’s Way participate in a tradition that is both personally edifying and aesthetically rewarding. I met those who were hiking the route for its beauty, others for silence to clear their minds, others to draw near to God, and even those who came for a holiday, like a couple from Edinburgh whom I met in Lindisfarne. The isolation of St. Cuthbert’s Way, in addition to its beauty, teaches the meaning found in journeying through a space that feels at once holy and full of memory.

A journey can put the processes of walking, of movement, to use in order to reflect and ponder, whereas in a fast-paced twenty-first century society, reflection is often lost in movement. According to Shaw and Smith, “it is clear from accounts of his life that Cuthbert found great solace and true refreshment in walking. Travelling at a natural pace on foot allows time for contemplation and for cares and worries that surround us daily to be forgotten, for a while at least. Walking St Cuthbert’s Way can thus be enjoyed as a modern pilgrimage” (Shaw and Smith xxi). Every person is occupied in this life: there are jobs to be worried about, family members to be taken care of, and things to be paid for. Yet it is contemplation while moving in a place of natural beauty, with hundreds of years of history, which allows one to reflect and see a greater purpose that possibly was obscured amid the troubles of daily life.

The heritage of St. Cuthbert is thriving in the twenty-first century and can be seen in the life of the route, as well as the fame St. Cuthbert has achieved even in 2012. Cuthbert’s legacy is partly due to the British Library’s acquirement of the Gospel of John, or the St. Cuthbert Gospel. This Anglo-Saxon manuscript was found in St. Cuthbert’s tomb in 1104 and was housed at the Durham University Palace Green Library until the May 2012 acquisition by the British Library (“St Cuthbert Gospel”).

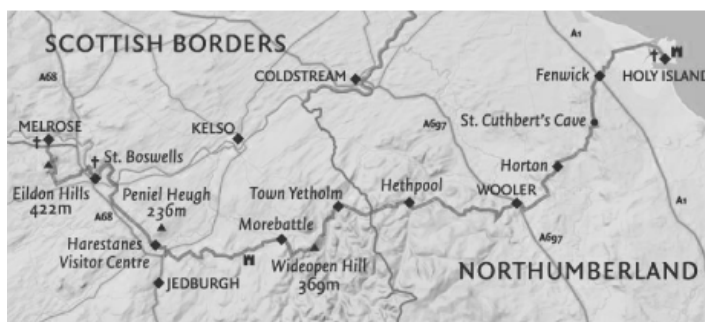
The manuscript is “the earliest surviving intact European book and one of the world’s most significant books” (“British Library”). Dame Lynne Brindley, Chief Executive of the British Library, commented on the acquisition of the Gospel: “to look at this small and intensely beautiful treasure from the Anglo-Saxon period is to see it exactly as those who created it in the [seventh] Century would have seen it. The exquisite binding, the pages, even the sewing structure survive intact, offering us a direct connection with our forebears 1300 years ago” (“British Library”). This Gospel will be displayed partly at Durham and London each year, allowing it to be seen at a prestigious museum while still being able to rest in the city so important to its history. The Gospel is indeed a mirror into the Anglo-Saxon world and St. Cuthbert himself, as one could imagine him reading and teaching from the Gospel of John.

St. Cuthbert’s Gospel and the Lindisfarne Gospels were on display in Durham in summer 2013, along with other relics from St. Cuthbert’s tomb (“St Cuthbert’s Gospel”). This exhibit was a “new contemporary interpretation of one of the nation’s most enduring stories, the tale of the North’s most famous saint – St Cuthbert, and one of the world’s greatest books – the Lindisfarne Gospels” (“An Exhibition”). This exhibit solidified the partnership between the Palace Green Library and the British Library, as well as to reveal the importance of Northern manuscripts being seen in their native home. This is the surviving heritage of Cuthbert, in that he is of importance to not only the people at Lindisfarne, but all across Northumbria and in parts of the Scottish Borders. He is an English saint, which accounts for most of his popularity being in Northern England. However, his name is everywhere. There are many churches dedicated to him, such as St. Cuthbert’s Church in Darlington. His image is on a stained glass window in St. Nicholas Church in Newcastle and there is also a statue of St. Cuthbert in York Minster. These are just a few tangible reminders of his legacy. Yet, there is more: “what can we find in Cuthbert’s life that is relevant to us today? His faith was without question, but it was a faith based on a deep knowledge and understanding of the natural world. He was never afraid of phenomena such as storms or winter snows, seeing them as a part of the seasonal round. He loved all wild creatures and befriended them” (Shaw and Smith xi). Cuthbert knew how to live a godly life in the world without ever being separated from it, in that same way that the message of pilgrimage is not to teach one how to live in isolation.



Pilgrimage is the kind of paradox that teaches one of silence, and walking, and rest, in order to know how to live better in the world. Dyas argues the following: “pilgrimage is not a single idea but a cluster of images which generate a variety of patterns . . . multiple understandings of pilgrimage have profoundly influenced patterns of living across many cultures, through many centuries, shaping art, architecture, history, literature, social interaction, spirituality and travel” (Dyas). And it will continue to do so, evolving as each subsequent generation walks St. Cuthbert’s Way, remembering both the namesake of the route and the purpose of pilgrimage.

## APPENDIX



**Figure 1.** “*St. Cuthbert’s Way*.” <http://stcuthbertsway.info/images/maps/st-cuthberts-way-full-route.jpg>. Accessed 18 Dec. 2012.



**Figure 2.** *Cuthbert’s horse finds him food* f.16, BL Yates Thompson 26. 12th British Library, London. <http://www.bl.uk/catalogues/illuminatedmanuscripts/ILLUMIN.ASP?Size=mid&IllID=1993>. Accessed 18 Dec. 2012. century.



**Figure 3.** *Ecgfrith visiting Cuthbert* g.51. BL Yates Thompson 26. 12th century. British Library, London. <http://www.bl.uk/catalogues/illuminatedmanuscripts/ILLUMIN.ASP?Size=mid&IllID=53093>. Accessed 18 Dec. 2012.





**Figure 4.** Melrose Abbey. Personal Photograph. 20 Jul. 2012.



**Figure 5.** Rainbow Arch at Lindisfarne Priory. Personal Photograph. Lindisfarne, England. 21 Jul. 2012.

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*GRACE*  
***CALVIN***

**GRACE CALVIN** .....

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Grace Calvin, a psychology major and music minor, will graduate in May 2014. A member of the Honors College and a student voice in academic policy, Grace is passionate about research and academic success for students at UMBC. She is also an active member of the Psi Chi Honors Society and the Phi Kappa Phi Honors Society. Grace hopes to pursue a Ph.D. in clinical psychology and to conduct research on factors that may influence mood disorder onset during middle childhood and early adolescence.

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# **ACCULTURATION, PSYCHOLOGICAL WELL-BEING, AND PARENTING AMONG CHINESE IMMIGRANT FAMILIES**

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I became involved in this research through my cultural psychology class during my freshman year. A graduate student from Dr. Cheah's lab recruited me, and I spent a year participating in the data collection and management in the lab before I proposed my Undergraduate Research Award research. This research has been a wonderful learning experience for me. Through my work with the lab I have developed skills in psychological assessment, recruiting participants, and leadership. The research we conduct serves a growing population of immigrants to the United States who come from China (U.S. Census Bureau, 2011). These immigrants are faced with the task of raising their young children to be successful in the United States, which is often an unfamiliar place to them. Thus, parents must adapt to the new culture well enough to provide their children the resources they need to succeed. The relatively large number of Chinese immigrants in the Baltimore-Washington metropolitan area makes this location an ideal one to investigate these families' adaptation and development. This population needs attention from psychology researchers because, although Asian Americans are portrayed to be "model minorities" and successful, they tend to experience high rates of internalizing problems, such as depression and anxiety (Qin, 2008).

## INTRODUCTION

Despite the rapidly growing population of Chinese immigrants and recent attention to their parenting, there is minimal research that examines Chinese immigrant parenting and its consequences for young children's outcomes (Cheah, Leung & Zhou, 2013). The present study aimed to explore potential factors that contribute to the parenting styles of Chinese immigrant mothers. Specifically, mothers' positive acculturative experiences (greater adoption of American culture) were expected to lead to higher levels of psychological well-being, which, in turn, would lead to a more positive parenting style. Chinese immigrant mothers in Maryland (N = 156) reported on their level of acculturation, psychological well-being, and authoritative parenting style (inductive parenting) and authoritarian parenting style (controlling parenting). As predicted, greater integration into the American culture predicted higher levels of positive psychological well-being which, in turn, predicted mothers' engagement in more authoritative parenting and lower levels of authoritarian parenting. The implications of these findings for child outcomes and the successful adaptation of these immigrant families are discussed.

In 2010, 40.3 percent of immigrants in the United States were from an Asian country, and since 2005 the percentage of immigrants from China has been increasing steadily (U.S. Census Bureau, 2011). Many of these families have young children to parent in an unfamiliar culture. Despite recent popular atten-

tion and heavy stereotyping of Asian parenting (e.g., the “tiger mothering” controversy<sup>1</sup>), there is still minimal research that investigates the predictors of Chinese immigrant parenting and its consequences for young children’s outcomes (Cheah, Leung & Zhou, 2013). Understanding the ways in which these mothers parent their children is critical to the improvement of outcomes for these families.

Thus far, several studies investigating Asian immigrant parenting have found correlations between mothers’ level of acculturation and their engagement in the authoritative or authoritarian parenting style (Cheah et al., 2013; Costigan & Koryzma, 2011; Tahseen & Cheah, 2012). However, other studies have not found support for this association (e.g., Hulei, Zevenbergen & Jacobs, 2006; Nguyen, 2008). In order to further understand the link between mothers’ acculturation and their parenting, the present study sought to examine the potential pathways that could explain this association. Research shows that acculturative experiences appear to impact psychological well-being such that immigrants who are better acculturated to the mainstream culture have better psychological well-being (Tahseen & Cheah, 2012). Therefore, the present study examined maternal psychological well-being as a potential mediator in the relation between maternal acculturation and maternal parenting style.

Maternal mental health has also been proposed to play a key role in determining parenting style (Belsky, 1984). A large body of literature exists to support this assertion, mostly focusing on the negative impact of poor mental health (e.g., depression, anxiety, and anger problems) in predicting harsher and less authoritative parenting (Baydar, Reid & Webster-Stratton, 2003). However, very little research has focused on the potential role of positive psychological well-being in promoting more positive parenting, especially among Chinese immigrants (see Cheah, Leung, Tahseen & Schultz, 2009 for an exception). Thus, the aim of the present study was to examine the means by which acculturation may influence parenting style through its effects on psychological well-being.

## PSYCHOLOGICAL WELL-BEING OF ASIAN AMERICANS

Asian Americans are characterized as being “model minorities,” where they are perceived to perform well in school and at work (Qin, 2008). However, there is evidence that Asian Americans tend to not fare well with regard to their psychological well-



being, experiencing more internalizing behaviors than their European-American peers (Qin, 2008). Internalizing behaviors (e.g. depression and anxiety) are behaviors that reflect an inward expression of psychological distress, in contrast to externalizing behaviors (e.g. aggression and conduct disorder). One reason Asian American immigrant children exhibit internalizing behaviors may be a tendency to take on the “positive” model minority stereotype and set high criteria for success, resulting in poor mental health outcomes and a negative attitude toward help-seeking behaviors (Gupta, Szymanski, and Leong, 2011).

One important predictor of immigrants’ psychological well-being is how they manage the acculturation process and adapt to the new American cultural context. Asian American immigrants’ risk for poor mental health declines with increasing time in the United States (Sue, Cheng, Saad, & Chu, 2012). For instance, Tahseen and Cheah (2012) found that immigrant Chinese mothers who displayed a separated acculturation style, whereby they did not engage psychologically and behaviorally in the American culture but remained within their heritage Chinese culture, exhibited poorer mental health than did those mothers who engaged in both cultures. However, Leu, Walton, and Takeuchi (2011) did not find any significant effect of acculturation on the mental health of Chinese immigrant women, although family cultural conflict and ethnic identity interacted to predict mood dysfunction.

## **PSYCHOLOGICAL WELL-BEING AND PARENTING**

Belsky (1984) presented a comprehensive model examining the determinants of parenting and suggested that parental psychological well-being is the most influential factor contributing to parenting. Within European-American families, poor maternal psychological health (e.g., “anger problems,” depression, and substance use) appears to be a risk factor for coercive or harsh parenting (Baydar et al., 2003; Bor & Sanders, 2004). Further, changes in depressive symptoms have been linked to more neglectful behaviors and higher parenting stress in lower economic status mothers of diverse ethnic background in the United States (Turney, 2011). Few studies have examined the effects of positive psychological well-being on the parenting styles of Chinese-American immigrant mothers of young children, but higher psychological well-being has been linked to more authoritative parenting behaviors in this population, when mothers ex-

perienced low levels of parenting stress (Cheah et al., 2009). Thus, more research to investigate the role of maternal psychological well-being in parenting styles is warranted.

The present study focused on authoritative and authoritarian parenting styles. Authoritative parenting is characterized as warm, democratic, and autonomy promoting, whereas authoritarian parenting refers to hostile, coercive, and punitive practices (Baumrind, 1971). Research on European-American families consistently shows that authoritative parenting is associated with children's positive socio-emotional outcomes (Almas, Grusec, & Tackett, 2011; Baumrind, Larzelere, & Owens, 2010). In contrast, authoritarian parenting has been found to be predictive of maladaptive outcomes in children, including internalizing and externalizing behaviors (Baumrind et al., 2010).

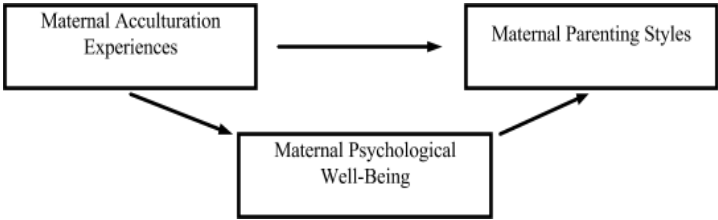
## THE ROLE OF CULTURE IN PARENTING

Parents and children exist within cultural contexts, and cultural beliefs and norms inform parenting beliefs, cognitions, expectations, and practices (Bornstein & Cheah, 2006). American culture is described as being predominantly focused on promoting independence, valuing autonomy and the unique contributions of individuals; in contrast, Chinese culture is described as being interdependence focused, promoting interrelatedness among its members and group goals over individual goals (Hofstede, 2001; Hofstede, Hofstede, & Minkov, 2010). Thus, the parenting within these two cultures likely reflects these broad overarching values (Harkness & Super, 1994). Individuals who have moved from one of these cultural contexts into another, for example Chinese-American immigrants, have the unique challenge of parenting to promote positive outcomes for their children in an unfamiliar culture. These families must adapt to the new culture's expectations and norms, through acculturation, in order to help their children succeed.

For immigrant families, acculturation has been found to predict parenting style, although not consistently (Cheah et al., 2013). Costigan and Koryzma (2011) found that the acculturation experiences of Chinese-Canadian immigrants were associated with their parenting behaviors. Specifically, warm, monitoring, and reassuring behaviors were positively correlated with a higher level of acculturation towards the Canadian culture (which, like American culture, values authoritative parenting). Mainland Chinese mothers have been shown to be

less warm and democratic than European-American mothers (Wu et al., 2002). What is less known is how these parenting practices might change with immigration. Chinese immigrant mothers have been found to express a desire to parent more authoritatively and have described how their parenting became more authoritative following their immigration to the United States (Cheah et al., 2013). However, another study did not find a link between acculturation and parenting style, though these researchers measured Vietnamese immigrant adolescents' perceptions of their parents' acculturation and parenting style, and most of the adolescents chose to respond about their fathers (Nguyen, 2008). Similarly, several studies have found significant but weak correlations between acculturation and parenting style, whereas other studies show no associations between the two (Cheah et al., 2013).

The inconsistent connection between these three factors (i.e., acculturation experience, psychological well-being, and parenting style) revealed by previous research is compelling and suggests a complex underlying process, engendering a need for further clarification. Parents' feeling of efficacy has been found to mediate the association between Chinese-Canadian mothers' acculturation and their parenting style (Costigan & Koryzma, 2011). This finding suggests the need to further explore other mediating factors that may explain the link between parents' acculturation and their interactions with their children. In the present study, we focused on mothers' psychological well-being (comprising of environmental mastery, autonomy, personal growth, self acceptance, positive relationships, and purpose in life) as a potential mediator between mothers' acculturation level and parenting style (see Figure 1).



**Figure 1.** Proposed model for pathway of acculturation's effect on parenting styles.

## CURRENT STUDY

The current study aimed to test the mediating role of maternal psychological well-being in the associations between Chinese immigrant mothers' level of acculturation towards the American culture and their authoritative and authoritarian parenting styles (Figure 1). We hypothesized that higher levels of behavioral acculturation towards the American culture would predict higher levels of psychological well-being, which would, in turn, predict higher levels of authoritative parenting and lower levels of authoritarian parenting. Authoritative parenting was defined here as greater warmth, regulatory reasoning, and autonomy promoting practices, whereas authoritarian parenting captured coercive, hostile, and punitive practices.

## METHODS

### PARTICIPANTS

156 Chinese-American immigrant mothers of three- to five-year-old children were recruited primarily from Chinese schools and churches in the Baltimore-Washington metropolitan area. The mothers had lived in the United States for an average of 10.47 years ( $SD = 6.34$ ), were on average 37.80 years of age ( $SD = 0.54$ ) and had children aged 4.50 years on average ( $SD = 0.90$ ). The majority of the mothers were married (94.4 percent) and first generation immigrants (95 percent). Many of the mothers immigrated for educational reasons (37.3 percent of all mothers in the study), or to follow their spouse, or to get married (28.6 percent of all mothers in the study). Most of the mothers achieved a maximum education level of a bachelor's degree (26.7 percent) or a graduate or professional degree (62.1 percent). Approximately half the children were male (49.7 percent).

### MEASURES

All the measures were translated and back-translated from English to Chinese to ensure cultural and linguistic equivalence. The original measures, in English, were translated by bilingual individuals into Chinese, and then different bilingual individuals translated the measures back from Chinese to English. The

two English versions (the original and the translated versions) were compared to ensure that the meanings of the items were equivalent in the translation. These measures had also all been previously shown to be valid in Chinese or Chinese-American samples (Lee, 1996; Tahseen & Cheah, 2012; Wu et al, 2002).

**Acculturation.** Mothers' level of acculturation was assessed using the Chinese Parent Acculturation Scale (CPAS-R), which is a self-report measure with two measured dimensions of acculturation: behavioral acculturation to the mainstream (American) culture and behavioral acculturation to the heritage (Chinese) culture (Lee, 1996). The present study only included the behavioral acculturation to mainstream culture dimension. This dimension assesses participants' engagement in American cultural behaviors in the following areas: (1) socializing with non-Chinese individuals (3 items; e.g., "When you feel happy or proud, how often do you share this with your non-Chinese friends?"); (2) proficiency in English (4 items; e.g., "How well do you read in English?"); and (3) involvement in American lifestyle (4 items; e.g., "How often do you listen to Western music?"). A five-point Likert-type scale was used for mothers to report on the frequency of involvement or degree of proficiency in the described behaviors (1 "*almost never*," 2 "*once a month*," 3 "*twice a month*," 4 "*once a week*," or 5 "*more than once a week*;" or 1 "*extremely poor*," 2 "*poor*," 3 "*average*," 4 "*good*," or 5 "*extremely well*"). Final scores were calculated by adding the Likert scores across the eleven items on the mainstream culture dimension. In the current study, the alpha was .75.

**Psychological Well-being.** The Ryff Well-being Scale (RWBS) is a self-report measure that is based in theory, defining six components of overall positive psychological well-being: self acceptance, personal growth, purpose in life, environmental mastery, autonomy, and positive relationships (Ryff, 1995; Ryff & Keyes, 1995). This measure was used to assess mothers' psychological well-being. The scale prompts participants to rate how much they agree with statements describing ways in which people might think about their lives on a seven-point Likert-type scale (from 1 "*strongly disagree*" to 7 "*strongly agree*" with 4 being "*uncertain*"). Sample items include: "I judge myself by what I think is important, not by what others think is important," "The demands of everyday life often get me down;" and "In general, I feel I am in charge of the situation in which I live." Final scores were calculated by adding the Likert scores across the 18 items after reverse coding where necessary. For example,

"The demands of every day life often get me down" would be scored as 7 for "*strongly disagree*" and 1 for "*strongly agree*" because higher scores correspond to higher levels of positive psychological well-being. The alpha was .78 in the current study.

**Parenting Styles.** The Parenting Styles and Dimensions Questionnaire (PSDQ) is a self-report scale of parents' endorsement of authoritative and authoritarian parenting practices, and was used to assess mothers' reported engagement in the authoritative and authoritarian parenting styles. Authoritative parenting style is comprised of (1) warmth expressions (e.g., "I give comfort and understanding when my child is upset"), (2) reasoning (e.g., "I give my child reasons why rules should be obeyed"), and (3) autonomy granting (e.g., "I allow my child to give input into family rules"); whereas authoritarian parenting is comprised of (1) verbal hostility (e.g., "I scold or criticize when my child's behavior doesn't meet my expectations"), (2) physical coercion (e.g., "I grab my child when being disobedient"), and (3) punitive practices (e.g., "I punish by putting my child off somewhere alone with little if any explanations") (Wu et al., 2002). Mothers reported on how often they exhibit each behavior described on a five-point Likert-type scale: 1 "*never*," 2 "*once in a while*," 3 "*about half of the time*," 4 "*very often*," or 5 "*always*." Final scores were calculated by averaging across the 11 items on the authoritarian scale and across the 15 items on the authoritative scale. In the current study, the alphas for the authoritative and authoritarian dimensions were .86 and .78, respectively.

## PROCEDURES

The mothers were recruited primarily from Chinese schools and churches in the Baltimore-Washington Metropolitan area through word of mouth, fliers, and recruitment presentations. On visits to the participants' homes, undergraduate research assistants administered the questionnaires to the mothers. All measures were administered in the mothers' preferred language (Chinese or English). Research assistants were fluent in the mothers' preferred language and available to answer mothers' questions and concerns.

## RESULTS

The basic descriptive statistics and correlations among the main variables are presented in Table 1. For all variables, higher

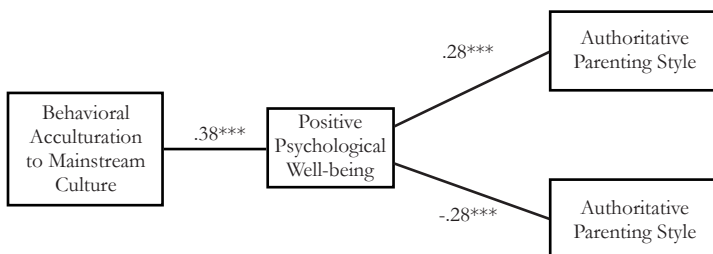
scores represent higher levels of the variable. The full-information maximum likelihood estimation (FIML) was employed to handle missing data (Enders, 2012).

Table 1: Descriptive Statistics

	1	2	3	4	M	SD	Min	Max
1. Acculturation	1	.39**	.002	.094	33.39	6.79	12	52
2. Well-Being		1	-.28**	-.29**	93.82	10.93	69	119
3. Authoritarian			1	-.20*	1.74	0.43	1	3.24
4. Authoritative				1	4.06	0.47	2.63	4.95

**Note:** \*\*  $p < .01$ ; \*  $p < .05$

Path analysis was conducted to test the proposed model. In order to test the direct effects of acculturation on authoritarian and authoritative parenting styles, the paths from behavior acculturation to the mainstream culture to the two parenting styles were constrained to be zero. The resulting model was compared to the just-identified model and the chi-square difference test showed that the more parsimonious model replicated the observed correlations as well as the full model did. Therefore, the more parsimonious (indirect effects only) model was retained as our final model (Figure 2), with  $\chi^2(2) = 2.46, p = .29$ , CFI = .99, and RMSEA = .04. Maternal behavioral acculturation had a very significant positive effect on maternal psychological well-being,  $\beta = .38, p < .001$ , which, in turn, had a very significant positive effect on endorsement of authoritative parenting style,  $\beta = .28, p < .001$ , and a very significant negative effect on endorsement of authoritarian parenting style,  $\beta = -.28, p < .001$ .



**Figure 2.** Retained model of indirect effects of behavioral acculturation on parenting styles. **Note:** \*\*\*  $p < .001$

The indirect effects of maternal behavioral acculturation to mainstream culture on parenting styles revealed significant ef-

fects in the predicted directions (authoritative:  $\beta = .11, p < .003$ ; authoritarian:  $\beta = -.10, p < .005$ ). These results partially supported the hypothesis. Specifically, higher levels of behavioral participation in the American culture predicted higher levels of psychological well-being which, in turn, predicted higher levels of authoritative parenting and lower levels of authoritarian parenting.

## DISCUSSION

Research on the predictors of the parenting styles of Chinese immigrant parents of young children is limited, and the little available research reports inconsistent findings. Specifically with regard to the role of acculturation, some studies indicate significant correlations between parents' acculturative experiences and their parenting styles; others report weak or non-significant associations (Cheah, Leung & Zhou, 2012; Costigan & Koryzma, 2011; Nguyen, 2008). This study provided insight into some of the inconsistencies in findings concerning immigrants' acculturation as it relates to parenting styles by examining one pathway through which acculturation might impact parenting styles.

We found significant indirect effects of Chinese immigrant mothers' behavioral acculturation towards the mainstream culture on their reported engagement in authoritative and authoritarian parenting styles through their psychological well-being. Therefore, Chinese immigrant mothers who were more engaged in the mainstream American culture were more likely to report more positive psychological well-being in the areas of autonomy, positive relationships, environmental mastery, personal growth, self acceptance, and purpose in life. In turn, mothers with more positive psychological well-being were more likely to engage in a parenting style characterized by warmth expression, regulatory reasoning, and autonomy promotion, and less likely to engage in a parenting style comprised of coercive, hostile, and punitive practices.

Engagement in mainstream American culture may promote a feeling of personal growth and environmental mastery in the course of these mothers' adaptation to a new way of life. Mothers who are more engaged in their new cultural context may feel better about their ability to function. Engaged mothers may also be more likely to form positive relationships with others in the larger cultural context and thus experience higher psycho-



logical well-being. This greater positive psychological well-being could then contribute to greater authoritative parenting practices as these mothers feel they are more capable and effective individuals. Mothers who feel on the whole more capable and open likely endorse parenting that includes more warmth, reasoning and autonomy promotion. Additionally, mothers with more positive psychological well-being also have greater psychological resources to be able to avoid engagement in hostile, punitive and coercive parenting and engage in parenting that utilizes more inductive and supportive practices in socializing with their children.

The indirect effects between the variables were significant, supporting the links between acculturation and psychological well-being, and between psychological well-being and parenting styles present in the literature (Cheah et al, 2009; Costigan & Koryzma, 2011; Tahseen & Cheah, 2012). Contrary to Costigan and Koryzma's study (2011) but consistent with some of the existing literature (e.g., Hulei et al., 2006; Nguyen, 2008), there was no overall direct effect of maternal acculturation on either authoritative or authoritarian parenting style. Thus, Chinese immigrant mothers' acculturation level towards the mainstream culture only impacted their parenting styles through its associations with mothers' psychological well-being. The supported indirect effects provide evidence for the importance of the role of maternal psychological well-being on mothers' parenting styles (Belsky, 1984).

Several limitations of the current study should be noted. First, Baumrind's (1971) parenting styles are primarily based on research conducted in European/Western cultures. Thus, there is some argument that practices derived from the specific culture of interest might be more culturally relevant to understanding parenting processes within non-Western cultures. Future research could investigate other parenting style classifications or practices that are more indigenous to the Chinese culture and determine their associations with mothers' acculturative experiences and maternal well-being. It should be noted, however, that the parenting measure in the current study has been shown to capture authoritarian and authoritative parenting styles in Chinese parents (Wu et al., 2002) and can be considered a reliable measure because the Cronbach's alpha for both authoritarian and authoritative parenting styles were larger than .70 (Buck, Clarke, Powell, Tiffin, & Drewett, 2012; Streiner & Norman, 1995). Therefore, this concern may actually explain possible

incongruities between our findings and some others in the literature that may not have used such culturally sound measures.

The present sample comprised families of high socioeconomic status with high levels of education. These families are representative of Chinese immigrants to the Baltimore-Washington area, which is one of the wealthiest and best educated metro areas in the country (*The Washington Post*, 2012; U.S. Census Bureau, 2000). However, our findings may not be generalizable to Chinese immigrant populations in other regions of the United States or those of lower socio-economic status. Further, many of the participants were recruited from Chinese schools and churches, representing a subgroup of Chinese immigrant families that may share certain characteristics, such as a stronger valuing of Chinese cultures or certain religious beliefs. Future samples could be more representative of the larger Chinese-American immigrant population.

Finally, the present study was correlational in design. Thus, no causal conclusions can be made. A longitudinal design is needed to clarify the directions of the associations among the variables and to provide a stronger case for causal relations.

Despite these limitations, the current study contributed significantly to our understanding of the parenting of Chinese immigrant mothers and the factors that can contribute to their parenting styles. Our findings emphasized the implications of more positive integration into the larger American culture on Chinese immigrant mothers' psychological well-being and parenting behaviors. Recent research is revealing that the socio-emotional development of children within this rapidly growing group of immigrants has been neglected. It has been found that positive parenting can enhance children's socio-emotional development and adaptation in the United States (Qin, 2008; Cheah et al., 2009; Cheah et al., 2013). Our findings suggest that increasing Chinese immigrant mothers' acculturation to American culture is one critical pathway to promoting these mothers' psychological well-being, which may result in more adaptive parenting styles, and promote optimal developmental outcomes in their children.

## ENDNOTES

- 1 Amy Chua's book, *Battle Hymn of the Tiger Mother* put forth the idea of "Tiger parenting," a strict and harsh style of parenting which she claimed is endorsed by Chinese parents. Chua also endorses "Tiger mothering" as superior to more lax "Western parenting." The book generated much debate about what constitutes "Chinese parenting" and how "Tiger parenting" may impact children (Cheah et al., 2013).

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*ABIGAIL*  
**FANARA**

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Abigail Fanara completed this research in fall 2012 during her final semester at UMBC. She received her Bachelor of Arts in Media and Communication Studies and plans to work towards a Ph.D. in Cultural Studies. She would like to thank Dr. Rebecca Adelman of the Media and Communication Studies department for her support, wisdom, and patience throughout the research and writing processes. She would also like to thank Dr. Jason Loviglio of the Media and Communication Studies department for his optimism and encouragement.

# A DIAMOND IS FOREVER: THE CREATION OF A TRADITION

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During a Media and Communications senior seminar class discussing the “culture of sentiment,” the class engaged the topic of diamond rings. As someone who has never paid attention to the subtle, yet apparently important, differences between diamond rings, I had a hard time understanding how they could “capture a relationship.” I wanted to know why the diamond was so important to a large portion of modern American society. As I completed more of my research I found the diamond was assigned its meaning and value through, essentially, a successful marketing scheme. The diamond was only a “rare” stone because De Beers controlled the supply and created a false scarcity. Diamonds became an eternal symbol of love and unity because an advertising agency proclaimed that they had been for centuries. The diamond may truly be a meaningful symbol to some people now, but the main reason it is seen that way today is because at one point N.W. Ayer and Son Inc. was a magnificent advertising agency and De Beers Diamond Co. a powerful monopoly.



## INTRODUCTION

Why is it important to know how this tradition began? Some criticize the marriage industry and say that it pollutes the ceremony, destroys the authenticity of sentiment and purity of emotional expression. While these opinions may be valid, I am not out to protect the sanctity of marriage or the purity of sentiment. I am unsure as to whether either of those things can exist without some sort of blemish. I wish to explore the creation of societal norms that may intimidate society to abide by claiming some sort of ancient historical credibility. I believe these norms cause a destruction of creativity as well as public disapproval of those who may choose to reject the practice, which in reality, is not rooted in any sort of mythical or ancient ritual as it suggests. I can recall one incident when some coworkers and I gathered around an engagement ring that was just a plain silver Claddagh ring (a traditional Irish ring). When the bride-to-be left the room, everyone began to talk about how terrible the ring was and questioned why she didn't go with a diamond (some thought her fiancé simply couldn't afford one). There is little tolerance for deviations from this "tradition."

The intolerance of personal choice directed towards those who don't feel these "traditions" are for them is typically baseless and must be critically examined. Researching the origin of certain traditions and societal rituals allows us to demystify these

practices and expose their very plain and sometimes disappointing characteristics. Traditions and rituals that have to do with love and marriage, like the practice of giving diamond engagement rings, almost all have some connection with consumption. Knowing that these connections have essentially been “made up” can allow us to remove social pressure to express ourselves in an established and “acceptable” way, and also be free to express our feelings in more creative and individualized ways. By not choosing a diamond, we can reject the commodification of emotion and explore different and better methods of expression.

## METHODS

Included in the first few sections of this essay is a condensed history of the De Beers Mining Company: how it was started as well as how the company eventually rose to control nearly all of the world’s diamond supply. The beginning sections of the essay also include a roughly chronological summary of the implementation, marketing, and design of the advertising campaign of N.W. Ayer & Son, the North American advertising agency used by De Beers.

Epstein’s book, *The Rise and Fall of Diamonds*, is a leading authority on the topic of diamond rings and, more specifically, De Beers Mining Company. Most of the discourse surrounding diamond rings involves the practices used in generating the supply by South African mining companies (especially including De Beers) and the unjust treatment of miners. The conversation about “blood diamonds” is an important example of some of the negative press that De Beers was able to overcome. Because of this diamond mining company, diamond rings are so ingrained within western society that either by ignorance or cognitive dissonance, De Beers, a company that was largely responsible for the loss of many lives in South Africa, is still a functioning business today. This research focuses on the idea that diamond engagement rings were a successful creation of the diamond industry due not only to its place in history but also its ingenious marketing rather than a tradition rooted in history, religion, or culture. Because of this, information included will focus mainly on the time period in which De Beers and N.W. Ayer & Son tried to insert the practice into mainstream ideology and culture. The essay begins with the late 1930s and stops after the 1980s.

Following the background of De Beers and the overview of the North American diamond advertising campaign is an analysis of the marketing efforts and choices made by N.W. Ayer and De Beers and an evaluation of the campaigns success as well as an analysis of primary sources. The analysis of this advertising campaign will be tied into the works of three different cultural theorists: Roland Barthes, Guy Debord and Barry Shank. Pieces of Debord's book *The Commodity as Spectacle* will be used to highlight the similarities between the "diamond invention" and the invasion of commodities into social life, ultimately concluding that the diamond itself is a spectacle. A chapter entitled "Vicious Sentiment" from Barry Shank's book *A Token of my Affection: Greeting Cards and American Business Culture* identifies a connection between the market revolution, the creation of the middle class with a type of sentimental consumption that used elaborate valentines to represent ones' value and class standing will be used as a comparison to show how N.W. Ayer social exploited desires of people during changing social and economic periods to ground themselves within the growing middle class. Barthes' essay "Myth Today" will be used to connect diamonds to the idea of the "myth" and to address the evaporation of De Beers' history as a company and subsequent creation of a history of diamond rings by N.W. Ayer to establish the choice to use diamonds as "common sense" within society.

## HISTORY

De Beers Consolidated Mines, a South African diamond mining company, was founded by Cecil Rhodes in the late 1800s. Rhodes named the company after the two brothers who had sold him the land. It was on their former farm in Kimberly, South Africa where a large diamond mine had just been discovered. Rhodes, not particularly interested in diamonds, but in "the absorption of the greatest portion of the world under [British] rule," would do anything to accrue enough wealth to effectively control and he hoped, to colonize, South Africa. (Epstein 69). Until the discovery of the Kimberly mines, diamonds actually were somewhat of a rarity found mostly in India and Brazil (Epstein 11). From the beginning of his time at De Beers, Rhodes was involved in convincing bankers such as Rothschild to aid him in establishing control over the global diamond supply (as diamonds value would significantly decrease

if competition grew), and conning competition into giving him nearly total control of the company through stock and share manipulation. (Epstein 69). After Cecil Rhodes' death in 1902, Ernest Oppenheimer, a young De Beers shareholder, took over the company (Epstein 82).

In the late 1930s De Beers viewed the US as a prime marketing landscape; or, the only marketing landscape as, at the time war seemed to be creeping up on many European countries and cheaper diamonds had been selling in the US even throughout the Depression (Epstein 122). At this point, it was not mainstream to use diamonds, and when people did choose them, they chose relatively cheap ones. (Epstein 122). The challenge for De Beers was to figure out how to market more expensive gems and convince Americans that buying diamonds for engagement and that using them as expressions of love was the marriage tradition. Because De Beers could not physically operate in the United States due to anti-trust laws and fear of an American investigation, they needed to outsource their American marketing tasks. (Epstein 13). Based out of Philadelphia, N.W. Ayer was one of the first independent advertising agencies, as advertising itself had only recently become a marketable good. De Beers solicited their services and together the companies began to look at challenges they would need to overcome, such as the need, "to transition diamonds from being merely goods to quantification of emotional expressions." (Ghilani 232). If diamonds became integral components of courtship they would be both trend and recession-proof. Harry Oppenheimer, who at the time was the chairman of De Beers in the late 1930s, hired N.W. Ayer & Son to "investigate the possibilities of creating such a diamond mind." (Epstein 121). The close relationship between De Beers and Ayer was formed, and the "investigation" of the market and shaping of the consumer mind began.

## THE CONSTRUCTION OF A TRADITION

In order to maintain a successful monopoly, De Beers not only needed to control the supply of diamonds, but also the demand. De Beers and Ayer knew that in order to successfully do this, they had to create a diamond that would transcend "economic conditions or fashions." (Epstein 121). The purchase of diamonds had declined since WW1 by about 50% (not yet re-

cession proof) so Ayer and De Beers knew that they had some challenges to overcome (Epstein 122). Although diamonds were still purchased during the Depression, the amount money spent on diamonds before World War 1 was 100% greater than during the Depression (Epstein 122-123). In a memo sent by some Ayer researchers, this significant drop was attributed to, “the economy, changes in social attitudes and the promotion of competitive luxuries.” (Epstein 123). N.W. Ayer needed to turn the diamond ring into a public expression of not only love, but a symbol of status that would be as competitive a luxury as a car or household appliance.

Ayer and De Beers decided to target young men, since they were the main consumers of diamond engagement rings, stating that it would be “crucial to inculcate in them the idea that diamonds were a gift of love: the larger and finer the diamond, the greater the expression of love.” (Epstein 123). They also had to convince young women that they should expect a diamond from their significant other. They did this in a number of ways. The duo went to movie producers and movie stars and tried to get them to change the names of some films and feature diamonds prominently on female actresses and in engagement scenes. They also sent jewelers into high schools to give lectures on diamonds, how to buy a diamond, and what makes a good diamond. Lastly, news stories were planted about diamonds that established them as a tradition of marriage and courtship. They were hard at work and it was paying off. Diamond sales significantly increased from 1938 -1941 by 55%. (Epstein 125).

With the early advertisements, (1941 – 1943) which appeared in magazines such as *Town and Country*, *Life*, *Vogue*, *The New Yorker*, *Time*, and more, Ayer writers attempted to create a history for the diamond tradition. They were attempting to make the choice to give a diamond engagement ring an obvious one, so ingrained within society that it was common sense. In one advertisement, a writer for N.W. Ayer stated, “For centuries, diamonds have been the gift of love.” In another advertisement, a writer for Ayer asserted that diamonds had always been a part of the tradition of familial remembrance and heritage.

Rather than having a linear, vague, and simple story set during the mystical ages of antiquity as De Beers wanted consumers to believe, diamond rings have had a rather complex involvement within the tradition of marriage, as wedding and engagement rings (not only diamonds) have been introduced,

and then taken out of ceremonies off and on (Howard 36). For example, in Christian weddings, the ring was inserted in the 15th century and later removed during the 16th century by John Calvin, only to be brought back into the ceremony soon after due to “popular pressure” (Howard 36). During the 17th century, Puritans in America took the ring out of the ceremony once again until society grew less “orthodox” (Howard 37). Finding a clear lineage of the diamond ring’s insertion into the tradition of marriage and engagement is impossible as “customs varied widely by religion, region, and time period.” (Howard 35) This is because diamond engagement rings did not play a large and stable role in marriage until, arguably, after De Beers’ and N.W. Ayer & Son’s advertising efforts. Because a history of diamonds was difficult to find, De Beers and Ayer were able to create one out of nothing, making their story romantic. In many early advertisements diamonds are described as magical gifts with ancient roots.

The vague history that Ayer provided the public was convincing enough to be rewritten in etiquette books and the “tradition” was growing fairly rapidly. After establishing the practice, Ayer was able to focus on other things. They began to put out advertisements with famous paintings by Picasso, Dali, Maillol and other famous artists captioned “From the De Beers Collection” and placed next to text about diamonds as magical creations. One advertisement with a Dali painting refers to diamonds as a “future talisman from [the] past.” These advertisements, featuring text juxtaposed with famous artwork presumably owned by the De Beers company, were published in *Fortune* magazine, *The New Yorker*, and a few more elite publications. The spreads were supposed to represent the diamond as a “unique work of art.” (Epstein 125). One advertisement in particular featured a reproduction of a Pablo Picasso painting next to text addressing mothers, that read, “Early in their life, she finds that her jewels are faery flames of perpetual fascination to their baby eyes. And so she uses them, wisely, to awaken appreciation of beauty. Diamonds traditionally are the bearers of noble sentiments. See that yours are chosen to hold in their brilliance the inspiration of all you want them to remember.” This seems to suggest that diamond rings could be used as aids in teaching children (particularly of the elite) about taste and beauty.

In 1948, an employee of N.W. Ayer created the slogan that officially branded De Beers. It was the message that De Beers

had been trying to send since the early 1930s: A Diamond is Forever. This slogan was so effective in shaping the diamond mind because it played on the fears of every man and woman about to tie the knot: will the marriage last? After bringing to the surface the insecurities of couples, it provides a solution through consumption: if a diamond is forever, a symbol of eternal love, then it must reflect (and reinforce) my love's eternity, 'til death do us part. The diamond tells the receiver that the giver is in it for the long haul.

Together, De Beers Diamond Co. and N.W. Ayer have been able to convince many Americans that diamonds are rare and have always been precious expressions of love. They have done this by carefully monitoring culture – looking at amounts of projected engagements, average income left after taxes, and the state of the economy as well as boldly trying to shape public thought through advertisements, conspiring with film producers and news sources, lecturing at schools, and, at one point, connecting diamond consumption with patriotism. Therefore the “tradition” of giving diamond engagement rings is not so much a tradition, but is rather a product of an enormously effective marketing scheme that was deceptive and arguably, an exploitation of insecurities surrounding class standing throughout economic and social changes in US history.

One of the advertisements released in 1954 in a magazine shows the back of a blonde woman in a wedding dress with a curtain silhouetting her groom to be. The text on the advert says,

How long is love? As long as tomorrow? As long as the solemn sounds of the wedding march linger in the heart? Is it as long as the babe's first thin wall is remembered? As the procession of days wanes into a tranquil sunset? Is it then, as long as a lifetime? No, says her engagement diamond, love is as long as eternity... for that is how long the light of your love will shine in my depths...captured, not merely for a lifetime, but forever. Your engagement diamond need not be costly, or of many carats, but it should be chosen with care. Remember, color, cutting and clarity as well as carat weight, contribute to a diamond's beauty and value. A trusted jeweler will help you find a stone of fitting size and quality and style for what you wish to spend. Divided payments can usually be arranged.

Ayer was establishing the diamond as the authority on how long love will last. The other moments are just that: simply moments in a span of eternity. The diamond, supposed to be “invincible,” is going to outlive you and your spouse. This advertisement also came out around the time that different color diamonds were being discovered. In order to get more people to spend more money on diamonds, De Beers not only asserted that the man would not have to spend more than he “wish[ed]” but also that the payments could be divided. This encouraged the purchase of higher priced diamonds.

A second magazine advert from the 1950s features a blonde woman sitting in what looks to be some sort of ancient Greco-roman ruins, as she is looking out to sea. At the head of the advert is printed, “A Diamond is Forever” and the text below the woman says,

Along love's way...Always her engagement diamond will shine like a little sun, reflecting the hopes and faith of two in love. Its magic lights will help to draw him near, in dreams, when they're apart. Its flashing beauty will echo their gallant sharing of responsibilities, their happiness in sons and daughters, the growing richness of their years. For them, and for those who come after them, it will be a lovely, lasting record of their light and their devotion.

In this advertisement it seems that Ayer and De Beers are not only asserting the diamond as a large part of the relationship between the spouses, and in fact, almost a support for both of them, it is also trying to turn the diamond into an heirloom. According to the ad, the diamond will last beyond your years and be kept in your family forever as the principal symbol of your love and dedication to your family. This was another way for De Beers to control the amount of diamonds on the market. If diamonds became family heirlooms, people would theoretically pass them down rather than try to sell them.

When the United States began its involvement in WWII, Ayer took an opportunity to develop a type of wartime advertising that had never existed before. During the war, industrial diamonds were being used in different tools and machinery that produced electronics and radar equipment for the US military. (Epstein 88). In the advertisements of this period, Ayer claimed



that whenever consumers spent money on gemstone diamonds, the money they spent would go to support mining for industrial grade diamonds, connecting, in a profoundly linear way, consumption to civic duty. (Ghilani 230). Unlike many wartime advertisements that urged consumers to consume less and recycle or donate more, De Beers and Ayer encouraged the consumption of diamonds and rationalized it as an act of patriotism, in that each purchase would fund mining for industrial diamonds. At the same time these advertisements were running, Ayer covered all of its bases by ensuring consumers and jewelers that the gemstones they already had, the rocks that expressed eternal love, could not be transitioned into industrial diamonds. (Ghilani 229).

The “Fighting Diamonds” and the “Invincible Diamonds” advertisements both juxtaposed gemstone diamonds with industrial grade diamonds featured on the ends of drill bits. This positioning reflects the newly created type of consumerism encouraged by Ayer – civic consumption. (Ghilani 224). Much of the text accompanying these advertisements are very educational and explain how the industrial diamonds are used in military production and imply that “production levels hinged on new sales of jewelry” (Ghilani 238).

Because these industrial diamonds were so important to the war effort, the United States military wanted to purchase 6.5 million carats from De Beers. (Howard 51). Though De Beers did eventually allow the US to purchase a large portion of diamonds for military production, that agreement did not come easily. Because the success of the diamond mining company hinged on the amount of diamonds that were circulating within the market, owner, Ernest Oppenheimer, did not trust the United States to be in control of that large of an amount. After all, he had a monopoly to maintain and if the US started to sell diamonds after the war was over, De Beers’ entire operation would be disrupted. (Epstein 89). President Roosevelt eventually had to call on Winston Churchill and other members of the British government, and make threats to De Beers before Oppenheimer agreed to sell the US any diamonds (and he actually ended up selling the US less diamonds than they requested). (Howard 51). Curiously, there still remains today an unresolved question as to whether or not De Beers was supplying the Nazis with diamonds. Though the Nazis seemed to have a hearty supply, and De Beers controlled about 90% of all of the diamond mines, the British government, by the end of the war,

decided that the subject would be too sensitive to investigate. (Epstein 96).

Not only did N.W. Ayer & Son create a diamond mind where diamonds supposedly reflected the eternality and the uniqueness of every budding engagement, but the diamond also grew to reflect the status and wealth of the couple, which really meant, the status and wealth of the man. If the purchase of the diamond meant that a man had to spend two months salary, the more expensive the gem, the more money the man brings in each month. De Beers established the two months salary rule because, by not putting a specific amount to spend on diamonds, the cost will adjust to inflation. After the end of the Second World War, the economy experienced a huge upswing and classes began once again to shrink or expand. As a result, many Americans (mostly white) began to move into the growing middle class, for many people, the post-war economy gave them opportunities they never thought they would see. For those who experienced little to no economic change after the war, it only highlighted inequality, as the gaps between the classes grew larger. During this economic shift, N.W. Ayer and De Beers launched an aggressive advertising campaign that fed upon the insecurities of men in a changing economy. Each of these advertisements implied (and one directly stated in bold font) that the ring is not merely a symbol of the man's affection, but also represents the man's status in life and ability to support his wife, the man's taste and knowledge of beauty, and the quality of his judgment. Not only did this encourage men to buy finer diamonds, it also implied that most of the responsibility for choosing the diamond should be placed on them. These advertisements directed towards "upwardly mobile men," according to some Ayer employees, "should have the aroma of tweed, old leather, and polished wood which is characteristic of a good club" (Epstein 130). N.W. Ayer got the idea to take advantage of this economic shift from Thorstien Veblen's theory of conspicuous consumption, the idea that motivation for luxurious purchases comes from the desire to publicly express one's wealth and status (Epstein 129). In reviewing their work since 1939 toward the end of the 1950s, Ayer boasted that diamond engagement rings were now "a necessity to virtually everyone." (Epstein 131). They also noted that rather than getting a different stone or symbol for marriage ceremonies, many couples at the time waited to marry until they could afford the purchase for the perfect diamond. (Epstein 131).

During the 1960s Russia discovered diamond mines in Siberia and Harry Oppenheimer, worried about the diamond supply, quickly made a deal with the Soviet Union to buy all of the uncut diamonds coming from Siberian mines (Epstein 255). These diamonds were much smaller, so Ayer had to drastically change the diamond mind from wanting large diamonds, to desiring smaller, less “flashy” ones (Epstein 135). This had a negative impact for De Beers. Since smaller diamonds were cheaper than larger ones, consumers were more inclined to purchase those instead of the larger and more profitable diamonds (Epstein 137). To reverse this oversight, Ayer introduced another element into the etiquette of giving diamonds: the surprise. N.W. Ayer market researchers found that women, when involved with the purchase of their engagement ring, were more likely, out of guilt, to choose the smaller, less expensive rings or to not accept a ring at all. Ayer began to encourage men to exclude women from the decision altogether (Epstein 136). N.W. Ayer compared the guilt or unwillingness of a woman to proudly choose for herself a diamond, with Victorian era ideas about sexuality. One disturbing psychological study used by the Ayer advertisers, explained that, “the element of ‘surprise, even if it is feigned, plays the same role of accommodating dissonance in accepting a diamond gift as it does in prim sexual seductions: it permits the woman to pretend that she has not actively participated in the decision. She thus retains both her innocence—and the diamond.” (Epstein 138). This type of thinking, that became the basis for what is considered a grand romantic gesture, reinforces ideas about female sexuality and desire, mainly, that women don’t want to be given any sort of choice in the matter of sex, and in this case, the choosing of an engagement ring.

Not only did the diamond reflect the success of the man, it also established some other “basic human wants.” (Epstein 130). A 1970s advertisement for De Beers features a white man and white woman riding on a vintage motorcycle with a lion in the sidecar. The text of the advertisement reads, “A man who is his own man is my love/strong and proud and sure/and now he’s going to share his life with me/a diamond is forever.” This advertisement describes the kind of man that would, not only buy a diamond, but who would also be desirable for all women; the type of man who women would love to share a life (of success, wealth, and pet lions) with. As a part of an elite class, this man is who De Beers wanted the public to connect themselves with as they chose to buy a De Beers diamond.

In another advertisement from the 1980s, a ‘beautiful’ woman is featured in the center, with her hand held up and her “ring finger” adorned with a relatively large diamond. The top of the advert reads, “2 months’ salary showed the future Mrs. Smith what the future would be like.” This reinforces the idea the value of the stone reflects the value of the relationship (and the man). The advertisement goes on to say that it reflects the value of the woman. Written in the voice of a man talking with, presumably, other men, the bottom of the advert reads, “You can’t look at Jane and tell me she’s not worth 2 months salary. I mean just look at her. So I wanted to get her a diamond engagement ring that said just that, ‘Just look.’ I found out that a good spending guideline today is about two months salary. That got me the biggest and best diamond I could afford, without breaking my budget.” Now the only thing that other men ask her is, “When’s the wedding day?” This also reinforced the notion that by now, diamond rings were a widely recognized symbol of engagement in the US.

The text in the advertisement equates women (and only “beautiful” women) with diamonds, and makes them worth two months salary, but also in this equation is the commodification of the woman along with the diamond. You buy a diamond, you buy a woman. Simple. It also plays on the fear and insecurity of the consumer. It suggests that the man bought the engagement ring partly because the woman was pretty, too pretty to not put his brand on, too pretty to let get away. Now everyone reads the diamond as “taken.” It is as if the diamond has solved this man’s problem of other men flirting with his girlfriend. Now he “owns” her and he doesn’t have to worry about other men encroaching on his property.

Today, diamonds are a huge part of marriage, and looked at as a tradition firmly rooted in history. Receiving a diamond in some ways is a type of rite of passage in North American culture. The fact that diamonds are still a hot commodity has baffled economists. A study done in 2009 by two economics professors at the University of Kentucky titled “Pricing Anomalies In The Market For Diamonds: Evidence Of Conformist Behavior” found that,

Individuals’ actions signal their predispositions and therefore affect status. In our case, the individual in question is the prospective groom, who wants to be perceived by his fiancé and perhaps by her family and

close friends, as a good marital prospect. The prospective groom signals his type by taking an action—buying an engagement ring. The status accorded to the groom is affected by his action, that is, how big a diamond ring he buys...We conclude that the diamond market exemplifies conformist behavior, wherein prospective grooms influence their fiancé's perception of them as a marital prospect through the size of the engagement ring they purchase. (Scott and Yelowitz 354)

Today, the effects of the brilliant advertising venture of N.W. Ayer & Son can still be seen and consumer proclivity to associate sentiment, status, and wealth with commodities persists just as strongly as it did when De Beers began its North American marketing campaign in the 1930s.

It is doubtful that N.W. Ayer and Son and De Beers were concerned with making any statements about race, gender, or heteronormative ideals. Rather, they were playing off of the cultural atmosphere of the times. As long as people were getting married and involving diamond rings in the solidification of their marriages, these companies were satisfied. This is evident by their attempt to introduce the male engagement ring, which inevitably flopped. (Howard 48). For these reasons, the analyses of the advertisements will not focus on these topics, though the advertisements clearly reflect ideas of binary gender, gender roles, white privilege, and heterosexuality. Instead, analyses will focus on the creation of “diamond tradition” in relation to three topics derived from cultural theory: the commodity as spectacle, the culture of sentiment, and the myth.

## THE DIAMOND AS SPECTACLE

In Guy Debord's *Society of the Spectacle*, he writes that the society of the spectacle is “the decline of being into having, and having into merely appearing” (Gigi, Durham, and Kellner 120). Debord is concerned with decline of society into passivity caused by the domination of social life by the economy and aggressive mass media. All that becomes important in a society is having (possession of a diamond ring), and what you have becomes a symbol of who you are and what your status in life is (the bigger the ring, the wealthier the groom).

The idea of the spectacle is seen in all sentimental consumption. Sentimental consumption according to Barry Shank

is the ability to place one's "interior self" into the public sphere (Shank 22). This can be a transformation of a feeling into a purchase of some sentimental expression. In many later De Beers advertisements, it is suggested to the consumer to let the diamond do the talking for them. As if the diamond could express the deepest and innermost feelings without any help. Not only has a feeling been transformed into an object, this object now represents to the public a clear meaning. The diamond and what it represents has become the spectacle and, "the spectacle presents itself as something enormously positive, indisputable and inaccessible...the attitude which it demands in principle is passive acceptance which in fact it already obtained by its manner of appearing without reply, by its monopoly of appearance" (Gigi, Durham, and Kellner 119). De Beers and Ayer ensured the monopoly of this particular spectacle. The phenomenon of its exchange is recognized as common sense and is rarely questioned.

According to Barry Shank, a professor of American Studies at Ohio University, the market revolution, a period in the US that experienced great economic change due to increased industrialization, in part created the culture of sentiment. During the market revolution the middle-class was created and growing and the consumption of valentines became one way in which people asserted their status in a time of shifting wealth (Shank 22). These valentines were lavish, expensive, articulate and thought to be inaccessible to uneducated and working class members of society. The purchase of eloquent and elaborate valentines publicly expressed one's wealth, education, and fluency of the complicated language of emotion which at the time was thought to be an exclusively middle to upper-class ability. This culture of sentiment follows what Debord postulated when he wrote, "In societies where modern conditions of production prevail, all of life presents itself as an immense accumulation of spectacle. Everything that was directly lived has moved away into a representation." (Gigi, Durham, and Kellner 117). We see again a change in economic conditions inciting the desire to establish one's status and class standing in the rise of diamonds, especially after the Depression and again after World War II. After the Depression, classes began to be reestablished and as stated earlier in this paper, between 1938 and 1941 diamond sales in the US increased by 55% (Epstein 125). N.W Ayer and De Beers were very aware of this type of consumption, writing that, "The substantial diamond gift can be made a

more widely sought symbol of personal and family success—an expression of socio-economic achievement.” (Epstein 129). They exploited the economic condition and social anxieties of the time and were successful. They did this again after the end of World War II when the middle-class once again grew. The advertisements after World War II were directed at men and blatantly connected their taste and wealth with their diamond purchase. Not only did De Beers strike when the consumer was most vulnerable, they perpetuated and encouraged the separation of class through conspicuous consumption.

The spectacle is a destruction of authenticity and the commodification of sentiment is perhaps one example of this. Debord writes, “The spectacle is the moment when the commodity has attained the total occupation of social life.” It is impossible to separate diamonds, valentines, and similar sentimental purchases from their underlying implications (class standing, education, power) whether or not the consumer is conscious of these entanglements. The diamond as a spectacle has also served as an instrument to highlight the separateness of class under the guise of unification under a common ritual. It is not enough to buy a cheap diamond; according to the De Beers advertisements, the type and size of diamond purchased are instrumental in demonstrating one’s refinement and wealth. Even though diamonds are worn by most members of society, they still offer the ability of differentiation between classes.

## THE DIAMOND TRADITION AS MYTH

In Roland Barthes *Myth Today*, Barthes challenges the origins of ideology. He refers to the world of the bourgeois as a “pseudo-physis”, an imagined idea of reality. Pseudo-physis, Barthes says, “defines the dream of the contemporary bourgeois world.” (Gigi Durham, and Kellner 100). One of the main messages that Barthes is trying to get across is that things are not always as they seem, certain practices cannot be written off simply by “human nature” or “tradition.” Barthes refuses to accept these terms as explanations of ritual or common behaviors present in societies. Ideological practices are not necessarily facts of life but Myths. He lists several principal elements to the creation of pseudo-physis and the imagined bourgeois reality. One key element is that of the “privation of history.” Barthes writes, “Myth deprives the object of which it speaks of all History. In it, history evaporates...all that is left for one to do is to



enjoy this beautiful object without wondering where it comes from. Or even better: it can only come from eternity: since the beginning of time, it has been made for bourgeois man.” (Gigi, Durham, and Kellner 101). This evaporation of the diamond engagement ring’s history allows for the creation of a new one, which excluded the parts about exploitation of labor in South Africa, the manipulation and illegal business practices that led to a monopoly, and the probable involvement with the Nazis during WWII among other charming narratives of De Beers’ past and the origin of the diamond tradition.

De Beers attempted to root its diamond rings in antiquity. In several early advertisements, the consumers are told that diamonds are the symbol of love and have been for centuries. The actual history of the diamond ring, because it has no linear connection to marriage rituals (as stated earlier) does not exist until after the marketing campaign of N.W. Ayer and Son. Engagement rings themselves hardly have a history in that context, let alone diamond ones. Yet because of this lack of history, De Beers was able to create its own story.

One advertisement, featuring a Picasso painting, exemplifies N.W. Ayer’s attempt in print media to establish diamonds within some abstract, far-back, history, as it states, “Diamonds for centuries have been the messengers of the unspoken secrets of the heart.” Another advertisement states, “And so it happens that men inevitably turn to the diamond, the one rare spark of immortal fire left on earth.” Here the geological presence of diamonds in the earth is alluded to in order to support not only their immortality but also their before-time-like presence in history.

The advertisers at N.W. Ayer & Son were (as usual) aware of what they were doing, saying in a memorandum, “...we keep people thinking of the diamond as the traditional symbol of the pledge to wed. The tradition itself is kept before them—its origin, its meaning, its history. Told in different forms, in articles, in short ‘filler’ items, in pictures, this story goes from our desks to appear in books, magazines, and newspapers.” (Epstein 128)

The Myth manifests in print media and also penetrates educational institutions. N.W. Ayer had its own special team of diamond lecturers that would go into schools with information about the history of diamonds, the process of mining, and the etiquette of giving and receiving diamonds. (Epstein 127). They would send films made specifically for De Beers for jewelers and lecturers to bring into schools. Films such as, “The Eternal



Gem,” and “In a Diamond’s Glow” were shown as entertainment and education.

The diamond Myth has truly become a part of bourgeois life and not many people seem to question its authority or authenticity. Roland Barthes, in his book *Mythologies* discusses the role of the Myth and how it affects society. He wrote,

Thus, every day and everywhere man is stopped by myths, referred by them to this motionless prototype which lives in his place, stifles him in the manner of a huge internal parasite and assigns to his activity the narrow limits within which he is allowed to suffer without upsetting the world: bourgeois pseudo-physis is in the fullest sense a prohibition for man against inventing himself. Myths are nothing but this ceaseless, untiring sollicitation, this insidious and inflexible demand that all men recognize themselves in this image, eternal yet bearing a date, which was built of them one day as if for all time. For the Nature, in which they are locked up under the pretext of being eternalized, is nothing but an Usage. And it is this Usage, however lofty, that they must take in hand and transform. (Gigi Durham, and Kellner 104)

## CONCLUSION

The exposure of a myth, gives us the freedom to choose whether we want to accept that myth or not. For those of us who believe that the diamond engagement tradition is not for us, we may be free from the worry of wondering whether or not to take part in a “tradition” because we have a clear explanation and knowledge that it is merely something created by very clever advertisers. We can debunk the myth. In doing that, as Barthes, puts it, I believe we can be free from the “prohibition for man against inventing himself.” (Gigi, Durham, and Kellner 104). The choice to use public consumption (buying a ring and then wearing it to symbolize engagement) is no longer an obvious one. The acknowledgement of the myth empowers us to express our emotion in original ways, as our creativity is no longer stifled by “common sense.”

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*LESLIE*  
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# **“THE LAW WON OVER BIG MONEY”: TOM WATSON AND THE LEO FRANK CASE**

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In the spring semester of 2013, I enrolled in Dr. Rubin’s course, The American South Since Reconstruction, in which I was assigned to conduct a research paper related to Southern history and Southern culture. A significant historical and cultural occurrence that is mostly associated with the South is lynching, particularly from the mid-nineteenth century to the early twentieth century. During this time period, a majority of lynchings occurred against African-American men however, the most infamous case of a white man being a victim of a lynching was the case of Leo Frank, a Jew, who was lynched in 1915. In studying the Leo Frank case, I decided to focus my research on the question of was the lynching of Frank anti-Semitic? During my research, I discovered that with the involvement of Tom Watson, the Populist leader, in the Frank case, Watson combined populist ideology with anti-Semitic rhetoric. Interestingly, as I was conducting this research paper, Towson’s White Student Union had posted a blog entry about the Leo Frank case which reflected the rhetoric of Tom Watson.

On August 21, 1915, an editorial in *The Baltimore Afro-American* declared that the lynching of Leo Frank “presents to outraged Americans an entirely different spectacle from the fifty other lynchings of the year.” Moreover, “the incompetency and the connivance of the state officials have been proved by the mob spirit, the true Georgia spirit.”<sup>1</sup> *The Baltimore Afro-American* editorial deplored the act of lynching but, the national reaction to Frank’s lynching, since a majority of lynching victims during this time period had been African-American men, did not trigger a similar outrage.

During the late nineteenth century into the early twentieth century, lynching mainly occurred throughout the South in which a majority of African American men had been victims for the allegation of raping white women. Lynching as defined by historian, Manfred Berg, is an “extralegal punishment meted out by a group of people claiming to represent the will of the larger community and acting with an expectation of impunity.”<sup>2</sup> The toll of mob violence outside the South, however sizable, is greatly overshadowed by the estimated 723 whites and 3,220 blacks lynched in the South between 1880 and 1930.”<sup>3</sup> Between the early 1880s and World War II, of the 4,700 people lynched in the United States, 73 percent of the victims were black and more than 80 percent of lynchings occurred in the South, black deaths represented 83 percent.<sup>4</sup> Although a majority of lynching victims had been African-American men, the

most infamous example of a white man being lynched was Leo Frank. During the Leo Frank affair, between 1913 and 1915, anti-Semitism was displayed since Frank was Jewish. For instance, on August 22, 1915, Andrew Jordan Green declared “if the rich New York Jews had kept their money out of the Georgia case their Leo Frank would not have been lynched. The rich Jew is thereby laying the way to Gentile hate and future persecution. Money was always the power and the curse of the Jew.”<sup>5</sup>

Beginning in the nineteenth century, the United States simultaneously experienced massive industrialization and an unequal distribution of wealth. By 1890, the richest one percent of Americans received the same total income as the bottom half of the population and owned more property than the remaining 99 percent.<sup>6</sup> In reaction to the unequal distribution of wealth that a majority of Americans suffered from, the People’s Party or Populism, was formed with the aim to counteract and promote economic equality, especially for small farmers. Populism, according to historian Eric Foner, “sought to rethink the relationship between freedom and government to address the economic plight of farmers and laborers.”<sup>7</sup> For instance, the Populist Party Platform of 1892 declared that “the fruits of the toil of millions are boldly stolen to build up colossal fortunes for a few...and the possessors of these endanger liberty”<sup>8</sup> Furthermore, according to this platform, Populists aimed to reshape politics and democracy by ensuring that working-class Americans had control of the government.<sup>9</sup> In Georgia, the leader of the Populist movement was a lawyer named Tom Watson who advocated for the economic mobility of the middle and lower classes while criticizing the monopolies of wealth.<sup>10</sup> In 1890, Watson was elected to the United States Congress and in 1896 was nominated as the vice-presidential candidate on the Populist ticket with William Jennings Bryan, the presidential candidate. In the early twentieth century, the Populist movement failed to both enact significant economic political change and to gain a significant national support base. However, Watson remained a hero for the rural population in Georgia since Watson “continued to fight for the material welfare of the common people, above all the rural population” and “a stubborn defender of popular liberties.”<sup>11</sup> Watson remained the rural community’s disciple, who continuously defended the South from assaults by Northern industrialists.<sup>12</sup> In the early twentieth century, populist ideology and Watson gained national attention in the Leo



Frank Case, a Jewish factory superintendent who was convicted and lynched for the death of a young girl, Mary Phagan. After Frank's conviction, the Leo Frank case gained national attention due to the questionability of the partiality of Frank's trial. Watson started to defend Georgia's legal system which was rooted in populist ideology but, contained anti-Semitic rhetoric.

## THE MURDER

On April 27, 1913, thirteen year old Mary Phagan, an employee of the National Pencil Factory, was found murdered with a rope securely around her neck. The rope had sunken into the flesh while Phagan's face and hand had been covered with dirt which she inhaled.<sup>13</sup> In the description of the discovery of Phagan's body, *The Atlanta Constitution* declared that Phagan:

was first choked into insensibility, then beaten upon the head with a blunt instrument...she was horribly bruised and lacerated upon the face. Both eyes were blackened and swollen. The hands and fingers were distorted.... The clothing was torn and bloody.<sup>14</sup>

In the aftermath, the Atlanta media sensationalized the murder, referred to by *The Atlanta Constitution* as "the most extraordinary case that has ever shocked a city."<sup>15</sup> The reaction by the Atlanta news media was reflected in the response by Atlanta's citizens to Phagan's murder.

Immediately following the murder, there was a significant public demand by the Atlanta community to seek justice for the crime. For instance, Reverend Linkous demanded at Phagan's funeral that the police "bring the wretch that committed this act to justice."<sup>16</sup> Initially during the murder investigation, the police suspected Jim Conley, the African-American janitor of the National Pencil Factory. The Atlanta police shifted their focus on Leo Frank because he was nervous during questioning and Frank had admitted he had been the last person to see Phagan alive.<sup>17</sup> The sentiment of the Atlanta community to seek justice for Phagan's murder was seen immediately following the initial arrest of Frank and Newt Lee; *The Atlanta Constitution* reported that "a large crowd had thronged the place since dawn" and "it had grown to tremendous proportion."<sup>18</sup> The personal and economic background of Frank influenced why he became

a target by the authorities of Atlanta since Frank had lived in New York and was considered an “outsider” by the Atlanta community and became “the representative of Yankee capitalism in a southern city.”<sup>19</sup> According to historian, Leonard Dinnerstein, “the furor that erupted after the murder can largely be attributed to the deed having reawakened traditional southern resentment toward outsiders who violated southern mores.”<sup>20</sup>

## THE TRIAL OF LEO FRANK

During the Frank trial, the prosecution’s case, led by Hugh Dorsey rested solely on the testimony of Jim Conley. Conley was an African-American janitor employed at the factory, who testified that Frank admitted he had struck Phagan on the head and that Conley had assisted Frank in transporting her body from his office to the basement.<sup>21</sup> Conley, however, was a questionable witness due to his poor credibility since he was known to appear intoxicated at the factory numerous times which was corroborated by other witnesses during the trial.<sup>22</sup> Conley constantly contradicted his testimony and offered several different versions of events at the factory on the day of the murder.<sup>23</sup> In defense of Leo Frank, numerous witnesses testified he was “a man of unusually high character and devoted to his wife.”<sup>24</sup> Also, Frank proclaimed his own innocence and disputed Conley’s claim in which Frank declared that “I know nothing whatever of the death of little Mary Phagan” and “I never even saw Conley in the factory or anywhere else on that date, April 26, 1913.”<sup>25</sup> Another key aspect of Frank’s trial was the public sentiment that was exhibited in the courtroom against Frank, this resulted in Frank receiving an unfair trial.<sup>26</sup> For instance, according to *The Atlanta Journal* the courtroom environment was “charged with an electric current of indignation, which flashed and scintillated before the very eyes of the jury” and there was a mob outside the courthouse that was “ready to seize the defendant if the jury had not found him guilty.”<sup>27</sup> On August 25, 1913, Leo Frank was found guilty and was sentenced to death by hanging.<sup>28</sup> After Frank’s conviction and sentencing, Frank’s legal team appealed Frank’s case to higher courts within and outside the state of Georgia. On October 31, 1913 a motion for a new trial was denied which led Frank’s legal team to appeal to the Georgia State Supreme Court thus, on February 17, 1914, by a vote of 4 to 2 upheld Frank’s guilty verdict. In majority

opinion of the court by Judge Roan since the jury had found Frank guilty, it was his obligation to uphold the guilty verdict.<sup>29</sup> On March 7, 1914, Judge Ben Hill resentenced Frank to death by hanging on April 17, Leo Frank's birthday.

In 1913, after Frank's trial, the Frank case evolved into the Frank affair which gained national attention from outside the state of Georgia since the perception was that Frank had been a victim of injustice. For instance, *The Louisville Courier-Journal* wondered "do the people of Georgia realize that the mob spirit in Atlanta, set on by race prejudice, is about to send a man to execution of whose innocence of murder there are many reasons for believing and whose guilt has been by any means proved?"<sup>30</sup> As news organizations became critical of Georgia's handling of the Frank trial, the rural community in Georgia became defensive of their justice and legal system. The resulted in the activism of Georgia's populist leader, Tom Watson, who publicized the Leo Frank case which was ideologically linked to Populism.<sup>31</sup>

## POPULISM OR ANTI-SEMITISM?

Frank gained support outside the state of Georgia, as national organizations questioned the legitimacy of his conviction, Watson felt that he had to defend Georgia's legal system. During this period, Watson defended the outcome of the Frank trial since Watson believed that Frank had received a fair trial. For example, Watson asserted "legally, this man's guilt has been *adjudicated*" so, he must be executed and the citizens of Georgia should not allow "a clamorous minority" from attempting to "make a mockery of Justice, a farce of jury trial, a bye-word of our Laws."<sup>32</sup> Furthermore, Watson viewed the questioning of Frank's conviction and the campaign to overturn Frank's sentencing as a result of outside forces impeding on Georgia's right of self-governance, since in Watson's view, the Leo Frank case originated and should remain a state affair. As the Frank case became a national topic, the main issue focused on "whether Frank should be hanged as expeditiously as the law allowed or his death sentence should be postponed because of doubts about the justice of the trial." Furthermore, through the course of this case, Frank's defenders shaped the case as truth and justice against bigotry while Frank's enemies molded the case as justice against preferential treatment for the wealthy.<sup>35</sup>

Simultaneously while Watson defended the legal system of Georgia, again rooted in populist ideology, he believed that major financial institutions had funded the pursuit to appeal Frank's case. According to Watson, the "interest of Big Money has waged such a campaign of vilification against the State of Georgia."<sup>36</sup> While Watson's rhetoric contained Populist ideology, his rhetoric also contained anti-Semitism which integrated images that was distinctively linked to anti-Semitic ideology.<sup>37</sup> Furthermore, the anti-Semitic language that Watson frequently used against Leo Frank and organizations outside the state of Georgia was stereotyping associated with the idea of Jewish control in the banking and business industry. Thus, his rhetoric alluded to the idea that "Jewish control" was the reason for the campaign to overturn Frank's conviction and sentencing. For example, according to Watson, the questioning of the legitimacy of Frank's trial was due to a direct result of "every officeholder, or office-seeker, whose constituency embraces Jewish bankers, editors, or voters."<sup>38</sup> Thus, Watson's rhetoric combination of populist and anti-Semitic ideology, as historian Nancy MacLean noted, "the conservative dynamics of this populism were most obvious in the way class antagonisms ultimately were channeled into anti-Semitism" and "the hostilities of the popular classes toward large capital and its representative more and more took on an anti-Semitic cast."<sup>39</sup>

The Atlanta media and Watson provided polar opposite characterizations of Frank and Phagan. For instance, according to *The Atlanta Constitution*, Phagan was characterized as "the pretty victim" whose dead body was found "attired in a fresh summer frock of pink, trimmed in lace, and wore silk stockings. A big bow of baby ribbon was caught in the single strand of hair, arranged girlish fashion down the back" and "her pink parasol was found near the trap door through which the body had been lowered."<sup>40</sup> In contrast to "pretty" Phagan, Frank was characterized by the media as a "brutal murderer." *The Atlanta Constitution* alleged that Frank had planned to act on his own perverted, sexual desires upon Phagan prior to the murder.<sup>41</sup> Like *The Atlanta Constitution*, Watson described Frank as a "the typical young libertine Jew" who has "a ravenous appetite for the forbidden fruit—a lustful eagerness enhanced by the racial novelty of the girls of the uncircumcised!"<sup>42</sup> Therefore, according to Watson, Frank killed Phagan because "her resistance had the natural result of whetting his depraved appetite."<sup>43</sup> The fear of

Jewish male sexuality connected to the Southern myth of the “pure, virtuous, yet vulnerable White woman” and the desire of Southern white, males to protect and defend white womanhood.<sup>44</sup> Phagan’s resistance to Frank’s alleged sexual advances, suggested that she had died in order to preserve her virginity in which Phagan became the “weak, lonely little heroine *who died, for her honor*.”<sup>45</sup> The notion of sexual misconduct in this murder was overdramatized in Watson’s discussion on the Frank case and “the sexual angle played a role in his pronouncements that was nearly as important as the image of a rich man using his influence to escape justice.”<sup>46</sup>

When Frank’s appeal to the U. S. Supreme Court failed, his last ray of hope rested with Governor John M. Slaton, who could overturn Frank’s sentencing from death to life in prison. According to *The New York Times*:

the chief criticism that is directed against the Governor by his enemies is that he has broken down trial by jury in Georgia, and taken a step toward destroying respect for the courts, and in consequence really has encourage the rule of the mob.<sup>47</sup>

Watson, drawing upon populist ideology, believed the threat of commutation constituted another attempt to delegitimize Georgia’s legal system since according to Watson, “the most insidious, sinister and powerful pressure will be brought to bear upon the Governor, *to prevent the law from taking its course*.”<sup>48</sup> According to Watson, if the Pardon board or the Governor intervened in the Frank case, it would be understood by Georgia’s citizens as a condemnation of Frank’s guilty verdict.<sup>49</sup> Throughout his involvement in the Leo Frank affair, Watson’s rhetoric tapped into Populist ideology, and so Manfred Berg, contends that Watson shaped the Frank case as a struggle between Georgia’s citizens who sought justice for their ‘daughter’ which contrasted with a minority who considered themselves above the law.<sup>50</sup> Therefore according to Watson, “we have demanded his punishment as a protection to other *innocent Mary Phagans*, as well as a vindication of the law, *to strike terror into other Leo Franks*.”<sup>51</sup> What sort of punishment was Watson advocating for? Would Watson and Georgia’s citizens accept Governor Slaton’s commutation of Frank’s sentence? Was that an acceptable form of justice or would they attempt their own form of justice?

## LYNCHING OF A JEW

On August 16, 1915, twenty-five armed and masked men kidnapped Frank from a Georgia State prison in Milledgeville, GA at 11:40 p.m. The following morning, Leo Frank's body was found hanging from a tree in Marietta, Georgia, the hometown of Mary Phagan; his eyes were bandaged, his hands were cuffed behind him, a coarse sack had been tied about his hips, and his feet were dangling about four feet above the ground."<sup>52</sup> *The New York Times* described the lynching of Leo Frank as a "spectacle" since it attracted a massive crowd which included men and women, some women marched up to Frank's body dangling from the tree "without the quiver of an eyelash."<sup>53</sup> Why was Frank lynched? Why was Frank's commutation from death by hanging to life imprisonment not acceptable to "Mary's People?"

The justification of Frank's lynching was due to the idea that justice had been stolen from the citizens of Atlanta with Gov. Slaton's commutation of Frank's sentencing. In Michael J. Pfeifer's analysis of lynching, "mobs were impatient with the inevitable delays of legal process and disdainful of the alleged leniency of legal solution."<sup>54</sup> According to *The Marietta Journal*, the lynching of Frank was "an act of law-abiding citizens."<sup>55</sup> Reflecting *The Marietta Journal's* opinion, a local business man of Marietta, Georgia, in a candid interview with *The New York Times*, declared that Frank was lynched since Slaton's commutation had impeded on execution of the law.<sup>56</sup> The local businessman believed that the lynching of Frank was "done in the interest of a justice of which we had been denied by the man we put in office."<sup>57</sup> After the lynching of Frank, Watson declared that "*Democracy means, that ALL POWER IS IN THE PEOPLE*" which he defined as the right of the people to establish government, laws, and punish crimes.<sup>58</sup> In a democracy "the People *delegate* these powers, but never surrender them" since according to Watson, "our highest law declares that the People cannot surrender these inherent, inalienable powers."<sup>59</sup> Thus, since Gov. Slaton commuted Frank's sentence which from Watson's perspective demonstrated an elected official violating the "will of the people" and according to Watson "when high officials prove themselves to be unfaithful servants of the People" and "if officers of the Law persistently violate the Law, what are the People to do?"<sup>60</sup> This for Watson, the lynching of Frank was an act of "justice" enacted by "a Vigilance Committee, instead of

a Sheriff” who according to Watson, “carried out *a sentence which remained in full force and effect*.”<sup>61</sup> In Nancy McLean’s analysis of the Frank case, “Frank’s opponents viewed vigilante activity as a legitimate exercise of popular sovereignty when state policy no longer reflected the citizenry’s will” since they “equated the killing of Frank with a tradition of popular mobilization against the powerful in the service of ‘justice.’”<sup>62</sup>

In the aftermath of Frank’s lynching, the impact of Watson’s role in Frank’s lynching was questioned: was Watson to blame for the lynching of Leo Frank? For instance, Louis Marshall, founder of the American Jewish Committee (AJC), believed that Watson bore responsibility for the lynching of Leo Frank, since he “stirred up the agitation of which Frank was the victim for nearly three years before his death” and “*The Jeffersonian* bristles with vulgar, lies and the basest kind of misrepresentation, designed to excite an ignorant populace into committing murder.”<sup>63</sup> Echoing Marshall’s opinion, Thomas W. Loyless, president and editor of *The Augusta Chronicle* declared that Watson was the leader in the agitation against Frank since *The Jeffersonian* was highly circulated throughout Georgia, especially among the rural and working class.<sup>64</sup> The impact of Watson’s involvement in the Frank case can be viewed in the sales of Watson’s magazine, *The Jeffersonian*, which sold 87,000 copies a week during the height of the commutation controversy in June of 1915.<sup>65</sup> Despite the criticism against him, Watson continued to combine populist and anti-Semitic ideology in his defense of the lynching of Frank. Watson asked “why was Frank singled out for a national crusade against the State of Georgia,” answered Watson because “Frank belonged to the Jewish aristocracy” and that “the maddening thing to the people of Georgia, is that Jew Money has done for a foul Sodomite and murder, a thing that shatters all precedents, nullifies the highest law, sinks juries and courts into contempt.”<sup>66</sup> Watson’s view, “the ‘vigilance Committee’, the lynch mob, acted ‘in accordance with the sentence which had three times been pronounced from the bench’ thus, according to him, ‘the Law won, over Big Money.’”<sup>67</sup>

During the Leo Frank case, as organizations outside the state of Georgia questioned the partiality of Georgia’s justice system, the rural community in Georgia, as voiced by Tom Watson, believed that their sovereignty was being threatened. Throughout Watson’s involvement in the Frank case, two main characteristics of populist ideology were illustrated in his rhet-

oric: the idea of self-government and the anti-monopolistic financial institutions. However, as Watson deplored big business, his rhetoric called upon anti-Semitic ideology. Nearly a century later, remnants of Watson's rhetorical combination of populist ideology and anti-Semitism can be viewed today by members of Towson University's White Student Union. On Friday, April 26, 2013, members of this union at Towson University in Towson, MD wore black armbands and ribbons to mourn the 100th anniversary of the death of Mary Phagan. Similar to Tom Watson, Towson's White Student Union asserted that "the Northern media, liberals, and Jewish groups attempted to corrupt the justice system of Georgia" and "hundreds of these Northern agitators flooded into Georgia and raise immense amounts of money to try and set the child murderer free by manipulating public opinion." However, the White Student Union embraced the anti-Semitic rhetoric of Watson since according to the White Student Union, "the men and women of Georgia showed the world that they could not be bought off with thirty pieces of silver" and that "their child had been taken from them, and there would be justice."<sup>68</sup>



## ENDNOTES

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- 2 Manfred Berg, *Popular Justice: A History of Lynching in America*, (Chicago: Ivan R. Dee, 2011)
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- 4 Berg, *Popular Justice: A History of Lynching in America*, 92.
- 5 Andrew Jordan Green, "What Tom Watson Said," *The Baltimore Sun*, August 22, 1915.
- 6 Eric Foner, *Give Me Liberty! An American History*, second edition, vol. 2, edited by Eric Foner, (New York: W. W. Norton and Company, 2008), 601.
- 7 *ibid.* 639
- 8 "The Populist Platform of 1892," in *Give Me Liberty! An American History*, second edition, vol. 2, edited by Eric Foner, (New York: W. W. Norton and Company, 2008), A-24.
- 9 *ibid.*
- 10 Edward L. Ayers, *Southern Crossing: A History of the American South, 1877-1906*, (New York: Oxford University Press, 1995), 152.
- 11 Albert S. Lindemann, *The Jew Accused: Three Anti-Semitic Affairs (Dreyfus, Beilis, Frank), 1894-1915*, (New York: Cambridge University Press, 1991), 262.
- 12 Robert C. McMath, Jr., *American Populism: A Social History, 1877-1898*, (New York: Hill and Wang, 1993) 158.
- 13 "Split Court Denies New Trial to Frank," *The New York Times*, Feb. 18, 1914.
- 14 "Girl Is Assaulted and then Murdered in Heart of Town," *The Atlanta Constitution*, April 28, 1913.
- 15 "The Case of Mary Phagan," *The Atlanta Constitution*, May 4, 1913.
- 16 "While Hundreds Sob Body of Mary Phagan Lowered into Grave," *The Atlanta Constitution*, April 30, 1913.
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- 20 Leonard Dinnerstein. "Atlanta in the Progressive Era: A Dreyfus Affair in Georgia" in *Jews in the South*, edited by Leonard Dinnerstein and Mary Dale Palsson. (Baton Rouge, LA: Louisiana State University Press, 1973), 189.
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- 23 "Split Court Denies New Trial to Frank," *The Atlanta Constitution*, February 18, 1914.
- 24 Frey and Nancy C. Thompson, *The Silent and the Damned*, 49.
- 25 Berg, *Popular Justice*, 133.
- 26 "Justice Asked Now for Frank in Atlanta," *The New York Times*, March 11, 1914.
- 27 "Mary Phagan, The Victim," *The Atlanta Constitution*, August 26, 1913.
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- 29 "The Press on Frank Case: Editorial Protests Against Denial of Justice on Technicality," *The New York Times*, December 1, 1914.
- 30 Lindemann, *The Jew Accused*, 260.
- 31 Watson, "Rise! People of Georgia" in *Lynching in America*, 194.
- 32 *ibid.*
- 33 Lindemann, *The Jew Accused: Three Anti-Semitic Affairs*, 259.
- 34 *ibid.*
- 35 Tom Watson, "The Full Review of the Leo Frank Case," *Watson's Magazine*, January 1915, 140.
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- 37 Watson, "Rise! People of Georgia" in *Lynching in America*, 194.
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- 57 Tom Watson, "The Voice of the People Is the Voice of God!" in *Lynching in America: A History in Documents*, edited by Christopher Waldrep, (New York: New York University Press, 2006), 195.
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# OVERCOMING REPRODUCTIVE BARRIERS: MEMOIRS OF GAY FATHERHOOD

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Gay fatherhood identities are constructed in relational terms, which configure access to alternative reproductive practices as a means of negotiating the contradictory traits of gay and fatherhood identities. Contemporary rhetoric has policed the boundaries of appropriate families and reproduction to exclude gay couples from being active participants. A content analysis engaging two memoirs looks to critically examine how gay men speak regarding their assimilation of gay fatherhood identities through both adoptive and surrogate methods. While both alternative reproductive practices allow gay men to become fathers, the concept of multiple pathways to fatherhood is actualized as differential access to resources and procedures of child rearing cause divergent idealizations of being a parent. The analysis is self-reflective on the procedures that limit the authenticity of the memoirs as effective, yet complex texts. Recognizing the concept of multiple positions of fatherhood helps create legitimacy for same-sex parenting, but also to debunk the naturalized assumptions regarding who can participate in reproduction-based on gender and sexuality.



## INTRODUCTION

The construction of a fatherhood identity for gay men is complicated by the overt need for assistance and mediation from outside sources. Gay men must utilize alternative means of reproductive practice, such as surrogacy or adoption to become fathers. Both alternative practices require an understanding of the social positioning of individuals who have access to the resources built into having children because unique class-based foundations make it a privileged practice. However, couples must also negotiate the contradictory identities of gay and fatherhood. The division between being a gay person and a father is relevant in recognizing the political implications of constructing a gay fatherhood identity, both in terms of personal motivation and resistive knowledge. Surrogacy and adoption provide gay men with the ability to have children and construct this identity in divergent ways.

Gay fatherhood identity is achieved as children are brought into the relationship through alternative reproductive practices, but the paths to fatherhood are situated differently in each circumstance and provide for a differentiation of identities on the basis of participation. Fatherhood requires an *activation process* which not only causes an individual to want to have a child, but to recognize that it is a legitimate possibility through their

own means. The desire to have children, the ability to access the resources that produce children, and the recognition that outside sources are necessary to bring children into the relationship are all determinant factors for constructing a gay fatherhood identity. The process of memoir writing is a filter in which the experiential account of the alternative reproductive process is mediated reflexivity. The process of constructing a gay fatherhood identity is one that calls into question the interplay of bodies, privileges, and institutions which determine regulatory participation in the realm of reproduction.

Although adoption reaches the same end of providing children as an option for gay men, the ability of surrogacy to create genetic ties between a partner and the child is a singular experience that is distinct from the construction of fatherhood seen in those couples that adopt. Furthermore, the non-biological father in partnerships that utilize surrogacy mimics the parent-child relationship found in adoptive situations. Recognition of the differences in alternative reproductive practices is significant for our understanding of the complexity of constructing fatherhood identities, ones that are tied up in masculinity and sexuality discourses. The process of constructing a fatherhood identity is a social experience structured by privileges or disadvantages, and configured in a rhetoric that privileges heterosexual or pseudo-heterosexual reproductive means. Heteronormativity, a specific heterosexual privilege, is constituted in the fact that common practices and depictions are structured around male-female relationships that makes other relationships invisible. Fatherhood excludes gay men from the category because of the inherent belief that they cannot reproduce or bear children. The inherent belief illustrates the concept of internalization, where ideas are normalized to the point that individuals incorporate them into their own belief system. In terms of the current research, it is important to recognize how the complexity of fatherhood identity should be examined to illustrate how alternative reproductive practices can be utilized by gay men to construct a gay fatherhood identity.

Through the analysis of two published memoirs, this paper will examine how the language used in exemplifying the choice of pursuing a gay fatherhood identity is shaped by the alternative reproductive practice used to produce that identity. *Intended Fathers* and *The Kid* represent a surrogate procedure and an adoption process by which gay partners accessed reproductive

strategies. Moreover, these sources can be used to illustrate how the language in constructing these identities is a mediated process negotiated through alternative reproductive practices. The fact that these pieces are published representations of specific situational contexts points to aspects of the process that have sanitized or sensationalized the accounts of becoming fathers. Content analysis of these texts focuses on the representation of features in memoir writing involved to denounce or promote the differentiation of fatherhood identities. One challenge in this approach is navigating the unspoken partner's voice in pieces that were written by a single author. Ultimately, the language used in these texts will provide evidence of contextual differences in how fatherhood identities can be constructed through different methods.

## **HISTORICAL CONTEXT AND LITERATURE REVIEW**

I situate this research in a frame that views gay and fatherhood as contested identities by virtue of inclusive mutual membership. According to family studies theorist Binger, as well as Mallon and Stacey, the coming-out process for gay men has been equated with the recognition that fatherhood is no longer a possibility. Based on the responses of gay individuals, social work educator Mallon and sociologist Stacey presented evidence in the speech of interviewed gay men of an acknowledgement that being gay meant the assumed identity carries with it a situation of childlessness. One pervasive theme present in the coming-out narrative was how mothers often expressed how they would never have grandchildren because their sons were gay. These notions of perpetual childlessness for gay men are fueled by social scripts which regulate the definition of family to a narrow perspective requiring heteronormative family formation. It is in the inherent biological limitations of gay relationships that prevent reproduction, which constructs the justifications for viewing same-sex intercourse as sexual deviance. Sociologists Berkowitz and Marsiglio suggest that there needs to be an important recognition with "how gay men conceptualize their lack of traditional reproductive ability."<sup>1</sup> Grappling with the recognition that fatherhood is not an immediately obtainable identity, but one that requires outside assistance, means that gay men must understand that alternative reproductive practices are possible venues for bringing children into the relationship.

However, while Binger, Mallon, and Stacey speak to the divergence of fatherhood and gay identities, the authors fail to situate the individual experience in the greater socio-political climate necessary to recognize the limitation in choices available. Berkowitz and Marsiglio fill this gap with their historical overview of the Defense of Marriage Act (DOMA). DOMA has consequentially sparked an inconsistent validation of partnerships between states, but more importantly, the need to define what constitutes a legal marriage. Recognizing partnerships is a contestable platform because it entails the delineation of health, financial, and citizenship rights that constitute the bases of United States society. Therefore, the various branches of partnership may offer comparable, but not quite equitable, levels of recognition while still disadvantaging couples from accessing the same benefits heterosexual couples receive.<sup>2</sup> Concise attention to language has become a major concentration in trying to legitimize what constitutes personhood through marriage. Gay men who must fight for recognition of their partnerships are already at a disadvantage for bringing children into the relationship because their relationship is not consistently viewed as a valid union. Gay men and couples who are constructed as secondary citizens will have difficulty in establishing a position politically as adequate parents.

Founded in a traditional language system that is supported through biblical interpretation and a closely monitored gender construction of relationships, much of the rhetoric used to defame the queer community is based in heterosexual privilege. The basis of marriage has boiled down to language that designates the requirement of one woman and one man. Justifications for this assessment come from religious groups that utilize biblical verses whose interpretations designate God's desire to punish homosexuals because of their choice to engage in unsanctioned acts. These justifications are supported by claims that the recognition of gay relationships will lead to a slippery slope broadening to a variety of sexually deviant practices. These arguments get labeled as valid claims through the proposition that procreation is the only appropriate reason for sexual intercourse to occur, according to the word of the Bible. Giving sexuality a purpose, which must consequentially be for reproduction, severely limits the scope of gay relationships because of the inherent biological obstacles hindering child-bearing.

The rhetoric in political and religious institutions that surround the discourse of the gay community is relevant in understanding the expansion of reproductive capability to include surrogacy and adoption. Because gay fatherhood requires the assistance of a party outside of the relationship, the procedure by which it happens is heavily mediated by factors that can systematically limit control. Istar Le, Gianinoa, and Tuazon-McCheyne argue that parenting is always relational in that surrogacy requires the inclusion of a gestational body and egg donor because the male body alone cannot be a reproductive body. Although the inclusion of other bodies in the gay partnership expands the boundaries of the reproductive process into a piecemeal construction, it also is a reflexive moment by which the gay men define their fatherhood in terms of the context of social situation. The personal definition of fatherhood is deeply connected to the ways in which men experience the activation process of desiring children.

The secondary literature, which analyzed a series of interviews with gay fathers, has framed the arguments surrounding the complexity of constructing the gay fatherhood identity on intrinsic rewards and external barriers. Intrinsic rewards are on the basis of negotiating a gay identity with fatherhood. In some circumstances, gay fathers seek fatherhood to politically nuance the social scripts that dictate proper parenting, according to Tuazon-McCheyne, while authors such as Gianinoa suggest that others are introduced to becoming fathers because of their experience with children in non-procreative processes. An important caveat to these streams of research is the way in which gay men begin their parental pursuits; according to Gianinoa, gay men do not have the same affirmations of reproductive potential that heterosexual men have in their experiences of pregnancy or abortion, so gay men are primed through their exposure to children elsewhere or even through personal life revelations. Binger and Bergman also discuss the ways in which navigating fatherhood means coming to terms with the associations of sexuality because of the divergent definitions on which being gay is reliant. Hypersexual gay men, therefore, would be viewed as vastly inappropriate fathers because of their problematic interaction with children who would predominantly be viewed as asexual. The discussions presented in these pieces vary from those that focus on the external barriers because they rely more on the individual rather than the structural implications of gay fatherhood.

Framing the discussion on fatherhood in a discourse which focuses on external barriers relies on the ways in which the structural components of society limit the availability of means for gay men to pursue the alternative practices to have children. Patterson, Istar Le, and Dana focus primarily on the ways in which structural features limit the availability of surrogacy as an option for gay men. The literature concentrates on how men are kept out of the systems of adoption and surrogacy by financial and legal requirements that bar all but those who are privileged. Shanley elaborates that since gay parenthood is a minority perspective, it must over-function to produce an effective family system so it will be taken as a serious and appropriate family unit. External barriers differ from the intrinsic motivations because they relate more to the societal features that actively remove gay men from the possibility of constructing a fatherhood identity, but are reflective of norms and expectations. An important mediation of the external barriers denying gay men and the intrinsic motivations encouraging fatherhood is evident in the paradoxical relationship suggested by Berkowitz and Marsiglio, which tries to suggest that the pushes and pulls from the gay and fatherhood communities are often difficult to navigate and adequately find full membership. Gay fathers are often criticized by gay men for denying the perpetual singlehood relevant to the hook-up narrative, but also by fathers who connect fatherhood with a heterosexual narrative. Gay fathers do not get full membership in either category because of the lack of full participation.

Despite the framing of external barriers and intrinsic rewards, the contextual situation of gay fatherhood identity construction is primarily founded in structurally perpetuated homophobic perspectives that have become internalized. The gay community lives in a context where discrimination primarily focused on the basis of sexuality is evident. From the sensationalized homophobic bullying of gay teens who then committed suicide to the propaganda spread at the funerals of fallen soldiers, anti-gay commentary has been incorporated into colloquial language even so far as the phrase “that’s so gay.” The personal connections to the discriminatory process ultimately work as social sanctions to police the behavior of those in the gay community because there are no explicit regulations that tell gay men they cannot have children. Through the employment of stereotypes conflating sexuality with sex, as well as through verbal or physical abuse, homophobia is an ever-present force

that greatly influences the choices and options available to gay men, especially in recognizing fatherhood as a possibility.

A major issue with homophobia in terms of the gay community occurs when gays internalize messages that are constantly being pushed. Gay men may begin to believe that their lifestyle is immoral, a choice, or wrong based on the rhetoric used to deny the legitimacy of queer identity. According to Berkowitz and Marsiglio, “many childless men talked about their potential children’s futures in dealing with hardships, discrimination, teasing, and the issue of a mother.”<sup>3</sup> Gay men have taken in the beliefs surrounding homophobia, but also understand how the homophobia will negatively impact their children because of the stigma associated with the parents. Evidence of the internalization of homophobia can be found through the ideology that ex-gay camps are successful institutions to rehabilitate individuals into the normalcy of a heterosexual lifestyle. Internalized homophobia is problematic because it severely impacts the mental, emotional, and social state of an individual that may foster physical disruptions as well. The messages popularized that speak to the discriminatory view of hatred become incorporated in the individual’s perspective, which may cause self-destruction in pursuing personal pursuits.

Politics that surround the topic of gay parenthood rely primarily on the use of adoption or surrogacy as means of reproduction. Adoption relies primarily on the availability of the practice in the area in which the individuals reside, a lengthy interview process that validates the ability of the individuals to raise a child, and demonstrations of personal wealth to support both the child and the process of adoption. Surrogacy is a different process by which insemination occurs with the purpose of carrying a child to term. Traditional surrogacy relies on semen from one party that is used to fertilize the egg of the surrogate mother, ultimately tying her to the bond with the child that is being conceived. Another method of surrogacy is gestational, by which the surrogate mother is just the body in which semen from one party and an egg from another party are implanted after union. These alternative means of reproduction are utilized by couples that are not in a position to have children themselves. Berkowitz and Marsiglio argue that the queer community thus uses the alternative methods because it is a functional way by which to have children under the social conditions allotted. Surrogacy itself is a complicated procedure that nuances the typical social notions of reproduction.

The efforts to use surrogacy as a form of child rearing are complicated with the belief that surrogacy is a problematic market of exchanging bodies. From an objective standpoint, surrogacy calls for the financial support of a female body to carry a child to term which will then be given to the contributors. Surrogacy is often read as selling the body or child to an outside source, degrading the experience of pregnancy. As a market example, surrogacy is problematic because the gestational body is virtually erased after the process of birth and then there is little representation of the mother as a feature of the child's life, as illustrated by Berkowitz and Marsiglio. Utilizing surrogacy as an option requires a certain amount of economic privilege for the contributors to be able to support the female, but the recognition that the process is equated to the belief that children and bodies are being purchased is a necessary caveat. Although the bodies are questionably disregarded after the need for reproduction is over, the children stay as a lasting testament to the validation of fatherhood.

The capacity of reproduction is wrapped up in meanings of masculinity and fatherhood which serve to validate virility. Bearing children represents the continuance of family in name and genetics, leaving a lasting legacy. Gay men have questionable virility because they cannot produce children within their relationship, and this biological inefficiency is used to rationalize that gay men should not have children because they cannot make them. Roles of fatherhood are complicated in the changing face of masculinity across time and location because they are defined contextually. Generally, fatherhood appears to be representative of being able to provide and care for others financially and physically. Underlying the process of raising children is typically the notion that fathers are able to socialize children to understand gender conventions associated with masculinity (and femininity by antithesis). Fatherhood is also connected to heterosexuality in ways that the validation of sexuality is evident by ability to experience pregnancy, abortions, and miscarriages. Queer parenting is discredited as a valid representation of fatherhood because there is a contradiction constructed between gay perpetual singlehood and the heterosexual, long term relationship proposed by fatherhood.

Ultimately, the intersections of gender and sexuality in constructing a fatherhood identity complicate the process for gay men becoming fathers because of the mediated alternative reproductive practices. Structural and individual differences



situate gay men in unique positions that cause differential development of fatherhood identities. These identities are representative of the social privileges allotted to the couple, but also are shaped by the individual's perception of the relationship, the child, and their own sexual identity. In this respect, gay men who pursue a fatherhood identity actively must contest the personal contradictions of living as a gay man and becoming a father. Navigating surrogacy and adoption are empowering processes by which gay men actively must address social stigma and heteronormative conceptions of family composition, but these processes ultimately differ in the paths they take to a fatherhood identity.

## ANALYSIS

Through a content analysis of *Intended Fathers* and *The Kid*, I want to assess how the themes present in the secondary literature manifest in the speech of published memoirs regarding surrogacy and adoption. The primary research will focus on how the author's construction of a fatherhood identity is discussed through their accounts of navigating the alternative reproductive practices. The activation process for desiring children, as well as activating the fatherhood identity, the ability to access the alternative reproductive practices, and the unique configurations of each practice will be drawn from each text to illuminate differences between surrogacy and adoption for gay couples. Secondary research will focus on how the use of memoirs has influenced the process of research in terms of language and voice that limits the narrative to be an inclusive experience.

Michael Menichiello is the author of *A Gay Couple's Journey through Surrogacy: Intended Fathers*. The memoir is written as a narrative substantiated with diary accounts as Michael and his partner David pursue surrogacy. Michael finds Michelle through an Internet surrogacy website, and the narrative describes the complications of insemination, financial matters, and working with a surrogate mother. One constant issue throughout the memoir is travel: Michelle and the couple live on different sides of the country, causing Michael to travel frequently to meet Michelle throughout the endeavor. Lilly, their daughter, becomes the product of Michael's sperm and Michelle's egg.

*The Kid: What Happened after my Boyfriend and I Decided to go Get Pregnant* is the memoir account of Dan Savage's experience with adoption. In the narrative, Dan and his partner Terry

seek an adoption agency and are matched with Melissa, a gutter punk living on the streets. Melissa had gotten pregnant by Kevin (nicknamed Bacchus), but knew she could not adequately care for the child. When the baby is born, he undergoes a name change as he gets transferred guardianship from Melissa to the couple: going from David Kevin (the names of Melissa's best friend and the father of the child) to Daryl Jude (family names in Terry and Dan's respective families), but maintaining the last name Pierce, out of respect to Melissa.

These memoirs are used to look at the activation process for fatherhood, how access to alternative reproductive practices can be limiting, how fatherhood is an assisted practice for gay men, and how the memoir writing in itself is a problematic representation of gay fatherhood.

### ACTIVATION PROCESS

The activation process for having children is a distinctive experience that cannot be described as universal knowledge. Partners have varying opinions on the desire to have children and these desires are shaped by experiential knowledge surrounding child interaction, life satisfaction, and life-affirming events such as major catastrophes. Gay men do not have the same means of activation because they are not frequently put in intimate contact with the possibilities of reproduction such as pregnancy or miscarriage, so the activation process is modified. Founded within these differentiating processes are various positions situating men in relation to children, because some couples may not have an equally shared desire to have children. One father may be adamant about having children, whereas the other may be following the process for the sake of the relationship. The portrayal of an inclination towards wanting children is illustrative of a rearticulation of the limiting biological affirmation of homosexual reproduction, but also a renegotiation of sexual identity boundaries. Individual partners in gay relationships may have differential views on bringing children into the relationship, which may be a result of internalizing the rhetoric from the medical and social communities that present gay men with illustrations that they cannot become fathers. Men can have variant views because they may be at different stages in the self-actualization process of being gay. In a certain respect, the self-actualization process is a major factor in trying to negotiate the desire to have children because men need to recognize they are

capable of reproducing and create a counter discourse to the boundaries that had previously policed them.

*Intended Fathers* is illustrative of how the partners in the relationship had different views on bringing children into the relationship. The bio-father, Michael, suggested early in the memoir that September 11 sparked a new mindset for life: “I couldn’t help but wonder how many decisions they had been putting off, like we had been, or how many things they were going to do tomorrow, like we are.”<sup>74</sup> David, the other partner, was more hesitant to begin this journey and when prompted to express his standpoint on pursuing children, simply said “I guess...”<sup>75</sup> These variant views set the stage for how the path to fatherhood would be differentiated because Michael had a greater influence on the course of action, whereas David became the passive partner. The combination of Michael’s adamant drive to be the biological father and David’s hesitancy in even participating in the fatherhood discourse made the experience of surrogacy one sided. There was an underlying power dynamic at play because Michael pursued surrogate mothers and advertising without consulting David. However, David uses the relationship to gain leverage in mediating the fatherhood identity: when Michael is considering quitting his job, David tells Michael that “if you quit your job today... we cannot afford to have a child.”<sup>76</sup> David uses his position as a bystander in the pursuit of surrogacy to police Michael in an intimate way, which recognizes Michael’s control of the situation. Because the couple had different views on bringing children into the relationship, the journey towards surrogacy was a singling experience that focused primarily on the actions of the biological father, Michael.

*The Kid* suggests Dan’s drive to have children was due in part to his commitment to his partner, his desire to have something outside of the career he was in, and a personal advocacy act. Savage says that “I would want something meaningful to do with my free time,” “a self-actualization project for the parents involved,” which may have been pushed by “the same impulse that drives grown gay men to walk around holding hands.”<sup>77</sup> One of the main points of his reason to adopt was that it was a personal aspiration and one fueled by the belief that creating a family is a humanizing experience not confined to any particular sexuality. Dan chose adoption because, while he recognized that surrogacy or having sex with a woman was an option, having the mother-body involved would be complicated. Friends who had also pursued adoption spoke to the issues that surrogacy

presented, such as the legal complications in guardianship of the children when biological connections are involved: "Doing an open adoption ensures the birth mom an ongoing relationship with her child. She doesn't have to pretend she never had a baby or that her baby died, as birth moms who do closed adoptions are encouraged to do."<sup>8</sup> The couple agreed to have children to offer her better options, but they received criticism from both the gay and straight communities. The culmination of these factors is representative of a life affirming pursuit, but Savage's depiction calls into question the interactive component required to validate these beliefs. The process of bringing children into the relationship may be life-affirming, but insofar as their decision is considered a valid option socially cognizant of the influence of sexuality in the decision. If the pursuit of children is not validated socially, the process would be ultimately as rewarding for Dan in the same respect.

Becoming a father is arguably more than just having a child: it is the bond between that child and father that creates a connection. The activation process should be extended not only to the desire to have children, but to the activation of a fatherhood identity. The texts actively differentiate this regulatory role through the ways in which they speak about having children. In *Intended Fathers*, the bio-father, Michael, automatically assumes his role as father because of his participation within the pregnancy. The delineation of roles is made in the statement in response to who would be the sperm donor: "On the inside I was screaming me, me, me, damn it, I'll go first! That's when I realized... I had already taken it upon myself to figure it all out... I had always assumed I would go first. Why? Maybe it was that I had done all the work. I made the calls."<sup>9</sup> Michael says this when they conclude that surrogacy would be the best option for them, but that they needed to realistically decide who would be the first sperm donor. While Michael recalls that his feelings were "selfish," he reiterates these feelings when his sperm has not fertilized Michelle's egg and a friend suggests that they try David's sperm.<sup>10</sup> When this proposition is suggested, Michael says "It's completely selfish of me, I love David with all my heart, but I can't help but wonder if I would resent him or, worse yet, resent our child."<sup>11</sup> Michael requires the biological connection to the child to determine his position as a father and feels like any other role would not be fulfilling.

Relying on the fact that he supported the mother and had a genetic tie to the child, the bio-father did not question his role

as father that was so evident in *The Kid*. Fatherhood in the case of adoption was reliant more on the participatory roles that parents must accomplish in caring for their child, like changing clothes and being at events.<sup>12</sup> Dan uses this explanation to rationalize his lack of fatherly bonding the moment he met the child as opposed to his partner who instantly connected. The baby, who was first named by Melissa after she gave birth to him, was “not my baby... this was not flesh of my flesh, blood of my blood... This was flesh of my paperwork, blood of my checkbook.”<sup>13</sup> The adoptive fathers had to find ways to define the connection to the child, which reflected a fatherhood identity that differed from the use of surrogacy because the genetic tie is socially oriented to express a legal definition of parental rights. One step Dan and Terry took was their own renaming of the child after the paperwork for adoption was completed: they changed the baby’s name from David Kevin (two names prominent in the mother’s life) to Daryl Jude (names that were present in both partners’ families). These genetic and socially constructed roles of fatherhood manifest in participation with relational situations determining identity classifications.

Relational language is used to construct a fatherhood identity in the roles assigned to each partner. Both texts are similar in that when there is a father, the other partner will ultimately be designated as the mother. The mother figure in the couple is the partner who is primarily in charge of care, as well as staying home to care for the child. David is portrayed as watchful figure with unconditional and instantaneous love for the child. Typically, the legitimized father is the one who has genetic ties to the child or is there to support the child financially. Michael is more consistently aligned with fatherhood because of his financial stability being able to provide and his close proximity to the activities. Dan and Terry, however, seem to complicate these roles by consistently switching from solely being a provider to being a companion to the surrogate mother. While *The Kid* shifts from using the father-mother dynamic to one that expresses fathers and *Intended Fathers* uses a plural of father in the title, both authors articulate the necessity to differentiate the roles necessary in caring for the child. This designation falls onto heteronormative constructions of parenting which differentiate the roles of mothers and fathers to value practices based on hands-on care and management care. Incorporating heteronormative roles in parenting is problematic for gay couples because they will

not be able to completely fulfill the requirements and are setting a standard that disregards the embracement of same-sex parenting.

## ACCESS TO PRACTICES

Different social positions allow individuals different opportunities for alternative reproductive methods. These reproductive methods are uniquely situated for each individual, but are not available to everyone. Therefore, limiting factors severely hinder the progress in pursuing children due to financial, social, and legal implications. Accessing the procedures is also mediated by the ability to know that they are an option: because gay identities are synonymous with childless identities, many men are not cognizant of the fact that children are a possibility. Grappling with the ability to access these practices is an overarching mediating factor that regulates the reproductive capability of gay individuals.

Financial constraints ultimately became a deciding factor for the couple in *Intended Fathers*, by which money became burdensome as the bio-father and surrogate mother negotiate the fees of the procedures. The couple narrows down options based on the perceived cost of each mother featured on the surrogate site, but also on the moral consciousness that they do not want to be funding a mother who is using surrogacy as a means of supporting herself.<sup>14</sup> Michael and David both have the same realization that Michael expresses: "I don't mind or have a problem with compensating someone or paying for living expenses, or pain and suffering, but we don't want to feel as though we are taking advantage of someone either."<sup>15</sup> The couple does not want to become a full support for the mother who is only doing the procedure out of need for money. When Michelle hints to David that she needs money for gas mileage in travel and that she must stop working in order to take care of herself, consequently becoming more reliant on the checks from the couple to support the family, the couple has a greater sense of issue with the choice of surrogacy.<sup>16</sup> Surrogacy positions the father in a bread-winner role, requiring a perpetual connection between the surrogate mother and the couple to maintain the health of the pregnancy.

Written by an established columnist and writer, *The Kid* relies on the Dan's status as a well known individual to support

that he can adequately provide for a child in terms of financial wealth. While there are many mentions of the couple providing support for the birth mother in terms of food and housing, there is no indication that this is an issue for the couple financially. In one circumstance, the couple takes Melissa out to a steakhouse and when she says the meal is too expensive, the couple says “if we can afford to adopt a kid, we can afford to take you out for steak... it’s not a problem.”<sup>17</sup> Rather, there is a more extreme focus on the dynamic between the couple and the mother in economic divergence: those who have and the one who has not. Melissa is a gutter punk and constructed as a young girl who is perpetually homeless, whereas Dan and Terry proclaim themselves to be a DINK (double income, no kids) couple. Understanding the piece in this foundation equips the gay couple as better suited parents because they have not only proven themselves as capable of being self-sufficient, but also being able to care for the young mother. Children are set up as a product that can be accessed for the good of other individuals, “but for gays and lesbians, having children, like everything else, is regarded as a privilege, not a right. And privileges can be taken away.”<sup>18</sup> The structures of the choices that allow gay individuals to pursue adoption are severely limited based on the social situations which limit resources in conjunction with state prohibitions that limit access. The recognition of limited choices and access is a key point in understanding the relevance of gay fatherhood: it is in a state of outside control that can be easily mediated by an exterior source to limit, repeal, or constrict the realm of possibilities.

## ASSISTED PRACTICES

The process of each alternative practice is mediated, which can be used to explain differential paths of fatherhood development. Surrogacy and adoption represent ways in which the alternative reproductive processes are continually assisted procedures that require action from outside of the couple. On an individual level, this outside assistance is represented by the surrogate body or the birth mother; structurally, however, outside assistance is seen as the legal, medical, and social institutions that regulate access and police behaviors. Because of the inherent biological feature of reproductivity, gay fatherhood is heavily structured in terms of the choices allotted to create the



identity. Savage writes that “gay men didn’t have families – we were a threat to families.”<sup>19</sup> The recognition of a social stigma against gay people illuminates how the rhetoric has become ritualized as common sense. This is a rearticulation of the ways that coming out has become synonymous with not having children due to the internalized homophobia. The research here is not to disregard heterosexual reproduction as a feature that is not shaped by mediation, but that homosexual reproduction is totally reliant on functioning within the realm of possibilities. Heterosexual couples may pursue alternative reproductive practices when infertility or personal matters may lead the couple to the decision. Gay couples, however, must navigate these extra barriers in their pursuit of children regardless. The recognition of these barriers and the ways in which they impact the construction of a fatherhood identity differently situate partners in same-sex couples.

Surrogacy is a process that was mediated not only by an agency, but through personal searches of available mothers that bio-fathers may utilize. *Intended Fathers* illustrates the process of searching for a potential surrogate in ways that the father’s focus is driven towards qualities that make her an ideal partner. Michael relied heavily on the genetic traits of the mother that would be passed along to the child: “a surrogate that resembled me.”<sup>20</sup>

This attention to detail is important because it draws a focus on the qualities that are important in terms of reproduction that are put in consideration with the social environment the child will be raised in such as the gay household.<sup>21</sup> His desire to match his qualities to the surrogate illustrates reflexivity in the bio-father because it called him to question his own behaviors that would impact the health of the child, such as smoking.<sup>22</sup> Configuring the surrogate mother and the bio-father as an ideal match for a healthy child, excludes the partner from the discussion. The traits of the biological father (Michael) and the surrogate mother (Michelle) are highlighted, whereas David’s participation is primarily a spectator. The differing roles set up Michael and Michelle in a pseudo-heterosexual relationship which consistently gets illuminated through the perpetual absence of David. Because surrogacy is an assisted practice, the configuration of the relationship is renegotiated to be functionally relevant towards the main goal of bringing children into the relationship.



*The Kid* describes how adoption shifts the focus to the child in the respect that couples are searching for the best option available to benefit the relationship. Adoption is driven by the couple bringing a child into the family and thus shapes fatherhood identity by not having to frequently be involved in the process of pregnancy. When the couple was going through the adoption process, they had to undergo home interviews that tried to understand how the interior of the private sphere functioned and how it would impact the child. The father, however, expresses “even before we decided to adopt, we were having to answer a lot of questions from people who could’ve made us dads... but straight couples had expected to make the decision to have kids with absolute autonomy.”<sup>23</sup> The lack of privacy included in the process of alternative reproductive practices is constructed in a way that is similar to the experience of gay men who must constantly justify the legitimacy of their relationship to invasive outsiders. Heterosexuality, however, entitles couples to privacy in their relationships and Savage illustrates how these couples found the home inspection process a breach of privacy. While these inspections are put in place to validate that couples are able to adequately care for children, gay men are often constructed as subpar parents deemed appropriate for raising subpar children. Savage states that one of the frequent portrayals of gay fatherhood is centered on a discourse of damaged-good kids who illustrate “without exception, children in the custody of the state who were abused or neglected by their heterosexual parents... gay men are damaged goods, too, so why shouldn’t they settle for damaged goods.”<sup>24</sup> Gay men are validated as parents insofar as they take the children given to them without question.

The ways in which the focuses on the child and on the parent situate surrogacy and adoption differently structure the construction of fatherhood for gay couples. The surrogacy example presented in the memoir is dependent on the heteronormative relationship that is fostered by the bio-father and the mother to perpetuate the term of the pregnancy. Negotiating these boundaries helps determine the role of the bio-father to be a substitute husband for the surrogate mother, but also allows him to act as a stand in expecting father to the child. Adoption, however, is more dependent on the qualities of the child to determine the ability for parenting. A fatherhood identity is constructed around the child and his qualities, but on the ability of the couple to adequately fulfill the roles in caring for the

child. Relying on the child for the construction of identity is also tied up in recognizing the limitations of time: the couple must gauge their actions on when they believe the child will be born. In the case of the adoptive couple, which they said was common among many adoptive parents, they waited until the baby was close to being born before procuring any goods that were for the child's room in case the procedure fell through.<sup>25</sup> The rush of trying to adjust to the child means taking the child home to acquire the essentials that the baby needs to survive the first night. Therefore, in *The Kid*, the fathers truly begin to feel the bond of fatherhood when they take the child home and try to provide for him.

The different interaction with approaching the reproductive process situates how gay men assume the identity. Because surrogacy as expressed in the memoir forces the bio-father to structure a relationship with the surrogate mother, this forms a unique bond that allows him to have a comparable experience through the pregnancy. The pairing of the bio-father and surrogate mother leaves the non-bio-father and the adoptive couple to address their fatherhood in terms of the interaction with the child. Interacting with the child calls the gay man to recognize his position in relation to the child, but also in terms of the relationship with his partner. Therefore, gay fatherhood is unique because it is one that is structured both in terms of relationships with other institutions that enable pregnancy or adoptions and with the identity of the partner with which the procedure is taken. Sexuality is a major factor in the discussion of gay fatherhood because it is a relevant discourse that situates the partner in a position that differs from heteronormative constructions of fatherhood in which sexuality is seemingly erased. Based in anti-gay rhetoric that equates gay men with pedophiles or adultery, sexuality becomes a representative of an influential trait on the effects of parenting for children. Heterosexuality is not used in the same regard for couples because heterosexual parents are not critically assessed for their influence over their children in terms of sexuality, or appropriate sexual conduct.

## FILTERS

Memoir writing complicates the analysis in terms of couple's alternative reproductive practices because it is a single authored text that must abide by the standards of publication. Stone-Mediatore illustrates the problematic contention when using expe-

rience as a means of evidence while discussing Scott's disregard of experiential based knowledge: "Narratives that reckon with these [language and experience] tensions do not report spontaneous consciousness but create images and narrative forms for rearticulating experience in such a way that the narrated images enable the writer to confront those experienced tensions more constructively."<sup>26</sup> Through the analysis of these texts, I had to negotiate where the experience written in the narratives was representative and where the language used to discuss the experience created a differential story. These books must be relatable, understood, and encapsulate a perceived audience for them to be easily accessible as publication materials. However, it is also important to look at the language and visual text used throughout the piece and on the surface to recognize motivations of the authors or publishers. It is in this address that the purpose of each book can be seen as differently situated: the purpose of the memoirs becomes entrenched in the discourse it creates by the ability to be accepted as a piece of literature. Therefore, a memoir can be an advocacy piece insofar as it can be taken as a revolutionary piece speaking for the personal politics of reproductive practices.

*Intended Fathers* speaks for the bio-father who admits thoughts of selfishness if he were not the genetic father.<sup>27</sup> Throughout the piece, Michael uses his personal voice as narrative supplemented by diary entries written throughout the course of utilizing surrogacy. The couple is represented as a distinct entity, but the bio-father frequently uses the word "add" or "added" when he tries to discuss a suggestion made by the other father which situates his voice as secondary. Textually, the primary focus is held on Michelle and Michael as a pseudo-heterosexual configuration. The monumental situations of reproduction and pregnancy are centered on this couple while David remains absent. In the beginning, David is absent while Michael chooses Michelle as a surrogate mother and begins communicating with her about starting a relationship.<sup>28</sup> Michael becomes frustrated when the surrogacy agency is unresponsive to the needs of the couple, but focuses on the impact for him and Michelle: "Michelle and I are so aggravated with them we could strangle them."<sup>29</sup> The pregnancy was only announced directly to Michael, and finally, David was not even present when Michelle was giving birth. Rather, the scene focused on Michelle, Michael, and the new baby girl: "'Congratulations, Daddy!' the doctor said...My head hit Michelle's chest and we both burst

into tears... at the very same moment a stunned David walked through the door.”<sup>30</sup> These textual representations all seem disjointed in their depiction of the gay influence on becoming fathers because the primary focus is on the pseudo-heterosexual relationship of Michelle and Michael. The reproductive process in this piece is heavily structured around one partner of the couple and does not focus on the sexuality of the couple as a means of relevance.

The couple is highly desexualized throughout the piece both visually and textually. The only indicators of them being a couple are explicit mentions that they are together and a quickie when they try to get semen the first time for insemination.<sup>31</sup> The shift in focus between the couple and the bio-father and surrogate mother creates distinct and polarized relationships that illuminate the different sexual configurations of the relationships. Pictures depict them as separate spatially as they are divided by a fence or by other bodies. These pieces sanitize the memoir to highlight the bio-father and the surrogate mother’s experience in pregnancy (a heterosexual configuration) rather than how this impacted the gay couple deeply. This disregards the full title of the piece that delineates *A Gay Couple’s Journey through Surrogacy* and acts as a piece that only explores surrogacy. As a reader, it is difficult to really understand how the relationship between the couple was influenced or had influenced the process of surrogacy aside from the typical notion that the couple as a unit had faced discrimination.

The back of the book presents the author as an influential educator on understanding surrogacy and positions him in a knowledgeable place that can adequately answer questions of the reader, which makes this piece seem more of a textbook than a memoir. The disregard of sexuality in the piece negates the true power of surrogacy as a means of constructing a fatherhood identity. Rather than try to position sexuality in a context that influences the decision for fatherhood, the couple only recognizes sexuality in terms of how it would influence the child in school age.<sup>32</sup> The complete omission of gay identity in the piece speaks to the ways in which the memoir was sanitized for publication. The omission of sexuality tries to maintain a distance between the sexualized gay man and children of gay fathers because of negative portrayals of gay men in the past. These images have manifested themselves in a way that severs the ties between the parental relationship and the parent-child relationship instead of trying to maintain boundaries.

As another memoir published by a well-known author, advocate, and columnist, *The Kid* has automatic grounding in publication. Relying on this fact, the book has more standing for getting published because it has an author with the credentials to get past general publication regulations. The cover of the book has various highlighting factors which explicitly note the appearance of sexuality present in the author's life. Not only does he use "boyfriend" instead of "partner," which can be seen as a neutralizing word that negates the gay aspect of this adoption story, it also positions the couple as agents because they "decided to go get pregnant."<sup>33</sup> This agency is reliant on the participation of the couple as actors to adjust their relationship to follow through with the adoption process. The importance in the language used here is that the couple is primarily featured as a unit working together drawing a focus to the gay identity. Furthermore, it allows the reader to recognize the participatory role the couple had in the pregnancy process. The main title, *The Kid*, draws on the extreme focus of the child qualities in trying to understand how gay men try to derive identity.

The book is separated into three segments "fertilization," "gestation," and "birth." These titles are synonymous with the idea of children as an option, the process of selecting a child and helping support the mother, and the birth of the child – which would also be the birth of the fatherhood identity. These separating titles are important because they shift the focus of these biological functions as defining terms for men to construct their own identity. The participatory role of gay men in alternative reproductive practices is illustrated through the employment of these titles and should be seen as landmark designations that differentiate fatherhood identities. Therefore, multiple fatherhood personas can be accessed through different paths that are structured in a hegemonic position. Cultural notions of fatherhood situate each identity in value-oriented situations that are not free from societal constraints. Recognition of the different paths to fatherhood is detrimental for understanding that different fatherhood identities are not entirely responsible for the outcome of children, but also reflect a series of social situations that influence the choices possible for the couple. In this regard, parents construct their parental identity around the ability to create, execute, and maintain this identity in relational terms to the child. Gay fathers must use alternative reproductive practices to reach this situation of fatherhood, which varies from heterosexual conceptions of fatherhood, but

their ability to pursue these options is limited by access and availability of resources.

## CONCLUSIONS

Using memoirs to access the construction of fatherhood identities should be recognized as a limited perspective on the entirety of the situation. The voice severely limits the ability to gain an omnipresent knowledge of the social situation of each partner in the couple, but it allows for an insight into how the biological father and adoptive fathers may differ in reaching a state of fatherhood. The ability for a memoir to be published as a representative piece of knowledge does little to universalize the experience because it is not cumulative, but it does provide an insight of how the authors feel and insight into ways that the experience may be sanitized for publication. Therefore, the memoirs published are representative of how stories that are sensationalized (the martyr gay couple, the endangered babies, the difficult surrogacy) may disregard the true impact of the narrative. *The Kid* has a sense of advocacy because the language used embraces typical notions of heterosexual fatherhood while still maintaining a hold on the gay influence on Savage's life. *Intended Fathers*, however, removes the gay aspect from the influential motivations for bringing children into the relationship and is heavily grounded in the pseudo-heterosexual relationship between the surrogate mother and the biological father. While each memoir speaks to the use of alternative reproductive practices accessed by gay couples, only *The Kid* really represents a more encompassing view of this situation.

Constructing a fatherhood identity is a differentiated process that is reliant on resources and access. The complexity of alternative reproductive practices, however, leads to the construction of multiple forms of fatherhood through various paths. Recognizing the broadened form of fatherhood to be inclusive of diverse perspectives on what fatherhood constitutes allows for the legitimacy of gay men to parent children adequately. Social situations restrict access to differing alternative reproductive practices, but also in the ability for gay men to recognize that gay men have the ability to be fathers when the social rhetoric has disregarded their reproductive potential. Surrogacy is an important area of concentration because it allows for biological connections to the children, which complicate anti-gay rhetoric utilizing the gay gene and naturalistic arguments;

however, alternative practices themselves are structurally built into a society that has beliefs and values which restrict access or promote certain ideals (heterosexual identities). The ways in which the surrogacy story rearticulates a heteronormative narrative speaks to the idea that there is a problematic assumption of parenthood over sexual identity. Because gay men have had to negotiate the complexities of fatherhood, this research provides grounding for the recognition that there is not one construction of fatherhood, nor is there one path to achieve it. Rather, fatherhood is enwrapped in masculinity and sexuality discourses and needs to be adequately viewed through a lens that addresses how a father might arrive at a position of fatherhood regardless of moral appraisal.

## ENDNOTES

- 1 Dana Berkowitz and William Marsiglio. "Gay Men: Negotiating Procreative, Father, and Family Identities" *Journal of Marriage and Family* (2007) 368.
- 2 Ibid. 368.
- 3 Ibid. 375.
- 4 Michael Menichiello, *A Gay Couple's Journey through Surrogacy: Intended Fathers* (2006) 4.
- 5 Ibid. 7.
- 6 Ibid. 58.
- 7 Dan Savage. *The Kid: What Happened after My Boyfriend and I Decided to go Get Pregnant* (1999) 33, 34, 36.
- 8 Ibid. 47.
- 9 Menichiello 16.
- 10 Ibid. 17.
- 11 Ibid. 63.
- 12 Savage 224.
- 13 Ibid. 197.
- 14 Menichiello 34.
- 15 Ibid. 10.
- 16 Ibid. 37, 78, 91.
- 17 Savage 134.
- 18 Ibid. 65.
- 19 Ibid. 22.
- 20 Menichiello 11.
- 21 Ibid. 20.
- 22 Ibid. 76.
- 23 Savage 69.
- 24 Ibid. 56.
- 25 Ibid. 98.
- 26 Shari Stone-Mediatore. "Chandra Mohanty and the Reevaluating of Experience" *Hypatia* (1998) 128.

- 27 Menichiello 16.
- 28 Ibid. 27.
- 29 Ibid. 40.
- 30 Ibid. 66, 112.
- 31 Ibid. 51.
- 32 Ibid. 2.
- 33 Savage 11.

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*COMFORT*  
***AZUBUKO-***  
***UDAH***

**COMFORT AZUBUKO-UDAH .....**

Comfort Azubuko-Udah conducted this research in the 2012-2013 academic year, as an English major with a minor in psychology. She graduated with honors in May 2013, and plans to continue her studies in an English graduate program. She hopes to earn both a Master’s degree and a Ph.D. in the future. Comfort was accepted into the English Department Honors Program in spring 2012, where she worked closely with her advisor, Dr. Jessica Berman, to complete her thesis paper. She then defended her research in May 2013. Her research interest received an Undergraduate Research Award and she thanks the UMBC Office of Undergraduate Education for the award. Comfort would like to thank her advisor Dr. Jessica Berman, for all her support and guidance, her endless encouragement, and her relentless faith the research project. She also thanks Dr. Jean Fernandez and Dr. Lindsay Dicuirci for their helpful input and their interest in her work.

# INSCRIBING THE POSTCOLONIAL SUBJECT: A STUDY ON NIGERIAN WOMEN

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I have always been interested in post-colonial literature, and was particularly intrigued by the realization that fiction produced by writers from colonized countries is often laden with the cultural realities of colonization and its aftermaths. My interest heightened when I began reading about this subject. I came across the notion that writers indigenous to a colonized country often generate fiction that tells of the characters' personal experiences with events and phenomena that are part of the general history of the nation. These personalized stories often propagate the viewpoint of post-colonial subjects, and re-tells their history in their own words. My focus on Nigerian women was in part because they were, for me, the most accessible and relatable group, and also because they have been grossly underrepresented in Nigerian literature and literary scholarship. The UMBC Office of Undergraduate Education generously sponsored this research with the Undergraduate Research Award, and gave me the privilege to share my findings at the annual UMBC Undergraduate Research and Creative Achievement Day.

I almost immediately wanted to concentrate on female Nigerian writers alone because it seems a great deal has already been said about the works of male Nigerian writers. In the course of my undergraduate education I know of two academic courses where students are required to read Nigerian novels, and they are both written by men.<sup>1</sup> I have had the privilege of educating a dear friend of mine who was shocked to learn there were many of female Nigerian writers, because Achebe and Soyinka were all she had ever heard about. Her astonishment speaks to the fact that female Nigerian writers have not attained nearly the same level of prominence as their male counterparts.

A major reason for the relative obscurity of early Nigerian female writers is their depiction of political affairs rarely explicitly evoked nationalist themes. Their works were not always relevant to the nationalist discourse because, “the category of gender [did] not exist; it neither [could] be comprehended apart from colonialism, nor [was] it legible apart from the cultural nationalism that arose in response to colonialism” (Andrade 5). Early Nigerian nationalists failed to recognize the need to protest oppression against Nigerian women, who have often been characterized as being “doubly colonized.”<sup>2</sup> Consequently, women were often absent from literary works and scholarship. Susan Andrade notes that in Chinua Achebe’s famous *Things Fall Apart*, with its heavy nationalist themes, he notably leaves

his female characters unexplored, and in some cases, unnamed. Wole Soyinka's *The Lion and the Jewel*, which is centered on a woman, presents her as a mere commodity, and a means of conveyance for anti-colonialism sentiments. Early Nigerian writers, who were predominantly male, were concerned with issues of nationalization and sought to present the most powerful masculine image of the indigenous culture they could muster.<sup>3</sup> For instance, Achebe's novel presents an image of a hypermasculinized self-made Igbo<sup>4</sup> man. The objective was to produce a counter-discourse to the reality that "under colonialism, Africa...was seen in feminine terms. As part of the process of turning the colonies into the Other of Europe...[which] had to be seen as essentially weak, irrational, and feminine to the strong masculine rationality of the metropolitan power" (Krishnan 5). Minimizing, and almost eradicating the cultural role of women in the early nationalist fiction seemed imperative in creating a new masculine identity for the African Man.

Even when women began to write about the Nigerian domestic experience, their works were often neglected by literary critics, who did not seem to recognize their thematic nuances and therefore did not grasp the importance of such works. Men's literary pieces were studied more in-depth, because they were considered more relevant to national development.<sup>5</sup> Unlike male writers such as Achebe, who approached the nationalist drama quite directly, women writers in the early years of independence, were more wont to use allegories to subtly address these same issues, but these works were not assimilated into the literary historiography of the nation. Unfortunately, in the males' attempts to establish "structures of male domination" that would relieve them of colonial oppression, they "tended to reduce women to mere adjuncts of the male world" (Childs, Weber, and Williams 149). They completely disregarded the fact that, not only were women under colonial oppression along with the men, but due to gender inequity they are in fact twice-colonized.

Nigeria's first female writer, Flora Nwapa, published her first novel, *Efuru*, in 1966, eight years after Achebe's *Things Fall Apart*. In contrast to the widespread favorable response to Achebe's novel, critical reaction to Nwapa's was relatively underwhelming. Most critics emphasized her inattentiveness to nationalist issues and her focus on seemingly trivial domestic matters in a rural village.<sup>6</sup> In 1968, Margaret Lawrence insists on how much Nwapa's work illustrates a true and authentic African

community, with African women who “have a firm grasp of reality” and truly “belong in an Ibo<sup>7</sup> village” (Lawrence 190). The problem with Lawrence’s critique is that she merely acknowledges the traditional authenticity of the novel as a *village story*, and fails to see its veiled nationalist implications. More recent feminist scholars have argued “that it was precisely because she offers such a narrative of Igbo domesticity that she deserves a place in the African canon” (Andrade 55). Although some critics understand neither the depth nor the significance of her work, later critics hail Nwapa’s work for initiating the Igbo discourse on gender (Andrade 56). Another important female-authored novel, Emecheta’s *The Joys of Motherhood* (1979) is, in part, a response to Nwapa’s *Efuru*. Female African writers do present a different perspective of the pre-colonial past from their male counterparts, but still engage with the redefinition of local identity.

This different perspective is the base of African activist feminism, which “is rooted in the need to create a niche for the female African writer and critic within the contemporary literary tradition”<sup>8</sup> African feminism posits that the African woman’s narrative and perspectives are avenues for comprehending her experiences (Kalu 15). I will argue that African women use these experiences to re-read and re-write Nigerian women’s history and correct distortions and falsifications. In agreement, Andrade states,

If the act of writing is one of the most powerful ways by which women inscribe themselves into history, then the acts of female African writers inscribing themselves and re-inscribing their precursors into history functions as a powerful response to Hegel’s infamous dictum on the exclusion of Africans from history. (46)

The weightiness of the need to re-define women’s history makes it crucial that African women write. In writing, they etch their cultural progress as Nigerian women into history, through the experience-colored stories they produce.

A feminist critic, Ogundipe-Leslie, posits that the woman writer has two main duties: to tell about being a woman, and to describe reality from a woman’s viewpoint (57). Retelling the history of Nigerian women, from their viewpoint begins to correct false images of African women, who are frequently reduced to one facet of their womanhood. Marnia Lazreg states,

...academic feminists have generally denounced conventional social science as being biased against women both in its theory and its practice...[it reduces] women to one dimension of their lives (for example, reproduction and house work) and [fails] to conceptualize their status in society as a historically evolving phenomenon. (68)

Fortunately, women's narratives present nuanced images of the African woman's life - her roles and significance. They chronicle and explicate women's experiences under direct colonization in form of British rule in Nigeria, and indirect colonization in the shifting dynamics of power between men and their wives.

Consequently, female Nigerian writers do not just reflect the society in domestic, if non-nationalist spheres, but actively communicate and propagate their perspectives on the Nigerian woman's cause. In order to better see these reflections, Andrade advocates a change in critical approach:

If one comes to these novels by women with [the] understanding of the necessary implication of the domestic in the public, and with knowledge of the highly allegorical texts that dominated the literary scene into and out of which these women wrote, then one may better perceive how domestic life functions both literally and allegorically in relation to nationalism. (21)

Acknowledging the allegories will reveal the implications of these seemingly facile novels. Women writers *did* engage in nationalist discourses in their writing, but they did so from a domestic point of view. M. H. Abrams states that "usual recourse [for artists: in this case, writers] is...to cast about for objects which offer parallels to dimly sensed aspects of the new situation, to use the better known to elucidate the less known" (31-32). Using domestic allegories is, for a female writer, a process of tackling the unfamiliar through the familiar.

One may question the significance of studying a social matter, like the status of women in the society, through literature. Ogundipe-Leslie advocates the use of imaginative literature in the study of complex societal issues like the status of women, "theoreticians have articulated that art is not a simple reflection of reality like a mirror or a photogenic plate; that the artistic consciousness is a creative intervention into a world rather than



a mere reflection of it” (Ogundipe-Leslie 45). For instance, the texts I will analyze sometimes offer alternatives that undermine core systems of power (Nfah-Abbenyi 261). Thus, the works of female writers are not merely passive reflections on their experiences. They present a creative re-visioning of society.

In writing imaginative narratives informed by their experiences, female Nigerians feed literary historiography, writ large, with the knowledge and understanding of what it means to be a Nigerian woman throughout the history of the nation. I will study these unwitting reflections in Flora Nwapa’s *Efuru* (1966), which is set in early 20th century colonial Nigeria, Buchi Emecheta’s *The Joys of Motherhood* (1979), which spans a period of time from the late 19th century to the mid-20th century, and Chimamanda Ngozi Adichie’s *Purple Hibiscus* (2003), set in the 1990s. I will be examining three factors with which colonization interacts – pre-existing cultures and cultural values, family and community systems, and examples of female agency and power – to reveal the depth of influence social temporality possesses on the writers and their characters.<sup>9</sup> In analyzing some of the novels produced by Nigerian women I also hope to illustrate the utter mundaneness of facts that are transformed into vividly meaningful and personalized truths of women’s positions in Nigeria. These truths contribute to the propagation of the re-imagined history of the Nigerian woman.

## COLONIZATION AND ITS ROLE

Nigeria, as we know it today, was officially founded with the Amalgamation of 1914, whereby Sir Frederick Lugard combined the Northern protectorate, the Southern protectorate, and the Lagos peninsula to form one country (Afigbo xiii). Although Britain had been in power since as far back as the mid-19th century, the amalgamation marked the official commencement of the colonization of Nigeria. The British colonizers had first annexed the Lagos peninsula in 1851, and had slowly spread their influence and leadership throughout the geographic area that is now Nigeria (Falola xxi). There is no doubt that the effects of colonization were far-reaching and can still be detected in post-colonial countries up until this day. However, one focus of this study is to examine the ways in which colonization changed the culture of the nation, how these changes shifted the social statuses and roles of women in Nigeria, and how these changes can in turn be seen in Nigerian women’s literature.

Colonization brought a new religion, a new western culture, a new system of government and a host of other culturally divergent trends, which when they arrived, forever changed the way Nigerians lived and the way the culture evolved. Admittedly, culture is not a stagnant phenomenon; it is the ever changing and collective way of life of a group of people, a community, or a society. Although the cultures borne out of this contact were neither western nor traditionally African, they represented a hybridization that was there to stay. The introduction of western cultures, with imperialist and patriarchal ideals, set gears in motion and created an abnormally rapid change in the culture of Nigerians. Colonization interacted with several other factors, such as the pre-existing customs and practices, family systems, and female agency, to constantly re-define the statuses of women in Nigeria, including their roles, identities, and their political and economic power.

The positions of women in the society before colonization were often more dignified than they became during the colonial era, because of the flexibility that existed within their notions of gender.<sup>10</sup> Through colonization, this flexibility was eventually replaced “with the strictures of Victorian gender ideology” (Krishnan 4). Without idolizing pre-colonial gender relations in these communities, it must be mentioned that most of the flexible gender relations that existed then were rigidified during colonial rule and have become part of the post-colonial heritage in African societies (Nfah-Abbenyi 265). In other words, the colonial culture had serious permanent implications for Nigerians, particularly the women. The reformation of culture is certainly reflected and addressed, albeit sometimes unconsciously, in the imaginative works produced by Nigerian women.

## COLONIZATION AND PRE-EXISTING CULTURES

Motherhood and childbearing were significant components of Nigerian women’s identities throughout the pre-colonial and early post-colonial period.<sup>11</sup> Sometimes a woman is not identified as one until she bears a child, as is the case of Nnuego, the protagonist in Emecheta’s *The Joys of Motherhood*, who only identifies as a “real woman” after she conceives a child (Emecheta 53). Furthermore, a woman was not considered a full woman until she bore a son. This notion is illustrated in Nnuego’s reaction to her first child; “the fact that [the] child was a son gave her a sense of fulfillment for the first time in her life” (Em-

echeta 54). The implication of her thought is gender identity is biologically achieved through the birth and rearing of children, especially sons (Nfah-Abbenyi 37). Therefore, being a mother was an integral component of one's identity as a woman.

In some parts of Igbo land, a woman who bears a son for her husband is said to have been given "a kitchen stool" presumably to sit with the other women of the family. This implies that having a son is the ultimate indication that a married woman has irrevocably become part of her husband's household. In Emecheta's novel, readers are constantly reminded that Adaku, Nnuego's fellow wife, only has daughters and no sons. When she gets into a fight with Nnuego, the Ibuza men admonish her saying:

I know you have children, but they are girls, who in a few years' time will go and help build another man's immortality. The only woman who is immortalizing your husband you make unhappy with your fine clothes and lucrative business. If I were you I would go home and consult my chi to find out why male offspring have been denied me. (Emecheta 166)

Never mind that Nnuego was clearly at fault in the dispute, in the eyes of traditional Ibuza men, who see the birthing of sons as the crowning glory of any married woman, it made sense to rule in her favor since she is the more rooted Owulum wife. To Adaku, "The message was clear: she was only a lodger, her position in Nnaife Owulum's household had not been ratified" by a son (Emecheta 167).

Although women were expected to have as many children as they could, they were also expected to take care of the children, often using their own resources and hard-earned money. With the coming of colonialism, "we...find that although the economic position of women had changed [in most cases, for the worse], the ideologies which supported the economic centrality of women had not changed. Matrifocal notions and the ideology of hard-work were still associated with females" (Ama-dume, *Male Daughters* 162). In other words, despite the social and economic changes that women had encountered through colonization, they were still expected to honor their traditional responsibilities to their children. They were expected to care for and feed the children with little or no help from their father. As a result, women, like Nnuego, who moved to the cities and con-

tinued to have children as they would in the village, encountered severe difficulties and indigence as a result of having to cater to too many children on meager income.

## COLONIALISM'S WESTERN MASCULINE IMPERIALISM

The second way colonization brought about cultural change was through the clash between western masculine imperialism and the pre-existing balance between matriarchy and patriarchy. The gender binary that defines gender roles and identities in societies is such that one cannot conclusively examine females without ever referring to males or vice versa. Therefore, in order to understand how women's lives were changed, I must also examine the changes in men's lives. Family units moved away from being balanced between matriarchal and patriarchal units of power: The propagation of the Victorian concepts of a *lady* combined with African men's adoption of hypermasculinized behavior led to the development of rigid patriarchal families and communities.<sup>12</sup>

In pre-colonial and early post-colonial Igbo communities especially, household roles and duties depended largely on a person's position in the family, which was in turn dictated by the person's gender.<sup>13</sup> Each gender community had its own role to play and had parallel systems of power and justice. Women often had their own territory of power, where they made all the principal decisions. For instance, because they were in charge of markets, Igbo women often implemented and executed market-related laws. If one breached any of these laws, punishment was meted out regardless of gender. (Amadiume, *Male Daughters* 38-40). Women also had their own systems of assigning duties, taking care of each other, and in some cases determining inheritance. When combined, these systems make up the "concept of matriarchy, not as a totalitarian system...but as a structural system in juxtaposition with another system [Patriarchy] in a social structure" (Amadiume, *Theorizing Matriarchy in Africa* 83). Amadiume writes in this tone to address the false belief that pre-colonial African communities were strictly matriarchal.

Women in pre-colonial Igbo cultures not only had their territories of power, they also provided a system of checks and balances for the men's actions and decisions. Before the powers of the matriarchal system were diminished by the patriarchal ideals of colonialism, "the balancing matriarchal system acted

as a constraint on the patriarchal structure, checking development of totalitarian patriarchy” (Amadiume 96). The ideals of this balancing system are reflected throughout the novels, they linger in Igbo culture long after Independence. There are still traces of the subdued matriarchal balancing systems by the 1990’s which are evident in Adichie’s *Purple Hibiscus*. Eugene Achike - the oppressive and fanatically religious father of Jaja and Kambili, the narrator and protagonist - is often called out for his wrongdoings by his sister, Auntie Ifeoma. She endeavors to check his actions whenever she can. She is not afraid to lie to him when necessary, and actually manages to convince him to send his children to her house for a break despite his domineering need to monitor his family.

With the introduction of western imperialism, Africa “... was seen in feminine terms. As part of the process of turning the colonies into the Other of Europe, the colonial Other had to be seen as essentially weak, irrational, and feminine to the strong masculine rationality of the metropolitan power” (Krishnan 5). Under this system, white men were at the top of the hierarchy; the indigenous men were feminized and often infantilized to achieve the rigid hierarchy of masculine imperialism. This shift in social structure is represented in *The Joys of Motherhood*, where readers see the contrast between The protagonist’s second husband, Nnaife, who has had more contact with the colonizers and her first husband, Amatokwu, who lives in the village and has very little to do with the white men. Nnuego compares her former husband with her present one, when she describes Amatokwu as being “long,” “wiry,” and having “the healthy smell of burning wood and tobacco.” To her, the qualities are symbols of masculinity in her hometown, Ibuza. In contrast, she sees Nnaife as a feminized, “over-washed” pulp of a man, who is “short, fat, [and] stocky” and “look[s] like a barrel” (Emecheta 42-44). Nnaife’s unfortunate feminized image comes from his extended contact with the white colonizers. Cordelia, Nnuego’s neighbor comments, “Men here are too busy being white men’s servants to be men... Their manhood has been taken away from them... they don’t know it. All they see is the... shining white man’s money” (Emecheta 51). He appears to have worked for the white masters for so long that he has lost every traditional sense of masculinity. He is also infantilized by the white men as he is often referred to as “boy.” While working as a house help for Dr. and Mrs. Meers, his European employers, Nnaife lived in the “boys’ quarters” at the back of the main house where his master lived. His living location has a

significant implication of feminization because he is from a patriarchal background where wives live in segregated outhouses towards the back of the compound (Ogunyemi 255). In addition to his feminine mannerisms and characterizations, the location of his dwelling is the ultimate indication of his utter lack of masculinity.

As Madhu Krishnan states, “Colonialism led to a social perspective in which the feminine was demonized and the masculine valorized, leading to the suppression of discourses touched by femininity on the public stage” (Krishnan 5). As a result of masculinity being valorized, and their being feminized in relation to the white world, it became imperative that every African man assert his masculinity and assume the position of supreme head of the home. Allowing feminine systems of running the family, which included having strict matrifocal units,<sup>14</sup> was now seen as a symbol of shame and irresponsibility on the part of the husband or father. For example, Nnaife went to jail when the court discovered that his wife, not he, bore the responsibility for his children’s welfare. An African man’s need to assert his position as head and breadwinner of the family leads to the process of hypermasculinization – a term coined by Ashis Nandy to describe the overcompensation that colonized men indulge in, especially when they feel inferior to their colonizing counterparts.<sup>15</sup> The impact of Colonialism is compounded through feminizing African men, because “not only are women oppressed, so also are men, children, and the nation in an intricate dynamic in which the victim easily transforms into a victimizer” (Ogunyemi 255). Men, who have been robbed of their masculinity, try to regain some of their manliness in any way they can, even when it means victimizing fellow victims (women).

The notion of hypermasculinization is reflected in Nnaife’s behavior on his wedding night where “he demanded his marital right” until dawn (Emecheta 44). Nnuego acknowledges that his actions were a reflection of his inferiority because, “after such an experience, [she] knew why horrible-looking men raped women, because they were aware of their inadequacy” (44). In this case, not only was Nnaife “horrible-looking,” he was lacking in masculine valor. He repeatedly rapes her on their wedding night to assert his dominance, and establish his primacy as husband.

Eugene Achike, Kambili’s father in Adichie’s *Purple Hibiscus* also demonstrates a similar form of hypermasculine overcompensation. He seeks to be in control of everything that goes on in his house, and as a result of his obsessive need for order,

he becomes a tyrannical father and husband, bullying his own family into silent obedience. Kambili, the narrator of the story says this of his insistence on behaving as the white men would, “Papa’s sister, Auntie Ifeoma, said once that Papa was too much of a colonial product. She had said this about Papa in a mild forgiving way” (Adichie 13). Auntie Ifeoma’s characterization of Eugene Achike (Papa) is like that of a victim. His abusive violence can, at least in part, be attributed to this victimization and the hypermasculinization that stems from his need to overcompensate for being a “colonial product.” He was raised by white Catholic priests, and was often punished brutally for his “sins.” In turn, he brutally *punishes* his children and his wife whenever they breach any of his many rules and expectations. Eugene Achike is a reflection of the idea that “the victim easily transforms into a victimizer,” because he was similarly abused by the priests who raised him (Ogunyemi 255).

In taking away the balance between matriarchy and patriarchy, colonialism introduced a new system that undermined femininity and the place of matriarchy, thereby transforming Nigerian communities into primarily patriarchal societies.<sup>16</sup> In an attempt to compensate for the feminization and infantilization to which they had been subjected, many local men engaged in hypermasculinization, which ultimately redefined the way they related with their womenfolk. The narrator in *The Joys of Motherhood* comments on this shift, “In Ibuza, women made a contribution, but in urban Lagos [amidst the white colonizers] men had to be the sole providers; this new setting robbed the woman of her useful role” (Emecheta 81). The men, placed in inferior positions, could no longer allow the female community to have as much power as they had before.

## COLONIALISM AND FEMALE AGENCY: ECONOMIC AND SPIRITUAL POWER

Agency as a term in post-colonial theory refers to “the question of whether individuals can freely and autonomously initiate action, or whether the things that they do are in some sense determined by the ways in which their identity has been constructed” (Ashcroft, Griffiths and Tiffin 8). Despite their double colonization, Nigerian women were able to exercise agency through their ability to attain economic power and mobility, and their access to spiritual powers.



Women could either be impoverished by the unfairness of the new systems of trading and the new cash economy, or they could take advantage of the new systems, in a feat of female agency, and embrace westernization, at the risk of being vilified by other natives. With the coming of colonization in 1914, came the gradual economic disempowerment of women. In traditional Igbo society, women used to have absolute control over the market space. Unfortunately, the female-controlled market systems were egregiously destabilized with the coming of the British colonizers. The colonizers established companies that had monopolies over certain commodities like palm oil and palm kernels.<sup>17</sup> Although it favored some women in the urban areas, the “new cash economy” introduced by colonization disadvantaged most women in their trading. As a result, “not only did women lose some degree of economic independence and their monopoly over the processing and sale of certain food items, they also lost their power of applying economic sanctions in both domestic and public spheres,” which had given them some power over men in the market environment (Amadiume, *Male daughters* 141).

Regardless of these new strictures on the level of economic growth a woman could comfortably attain, under the colonial and pre-colonial family structures, Nigerian women were expected to have an income. The family structure was such that, each wife in a household was in charge of a matricentric unit comprising of herself and her children. She was responsible for her unit and invested whatever she earned into caring for her children, and in return she expected loyalty and gratitude. On the other hand, men’s profits were not re-invested into subsistence economy, but instead went towards personal advancement (Amadiume, *Male Daughters* 39). With whatever income they earned, however little, women were expected to take care of their children, as exemplified in *The Joys of Motherhood* by Nnuego’s hardships as the mother of a “string of children” living in a colonized city. Even when men became integrated into the new cash economy of the colonizers, women still had to work to supplement their husbands’ meager income or allowance, a practice also shown in Emecheta’s novel.

Flora Nwapa’s Efurú is a character bursting with irrepressible female agency.<sup>18</sup> She takes responsibility for the financial costs of her own marriage. Readers are repeatedly informed that Efurú is a very industrious woman, and makes a lot of



money in her trade. She gains a lot of wealth and influence in the community as a result of her hard work. In her village, barely touched by colonialism, Efuru's success is rarely looked down upon or curtailed by this new cash economy.

Adaptable and exceptionally hardworking women were able to make money and move up the socio-economic ladder in the new cash economy. Still Emecheta's *The Joys of Motherhood* portrays such a woman in a bad light. The discrepancy in the public's reaction to Efuru's and Adaku's success and agency is partly due to a change in values. Adaku, Nnuego's co-wife in *The Joys of Motherhood* definitely displays female agency by leaving her husband, but it vilifies her instead. The natives of Ibuza look down upon her because of her ambitious nature, her wealth, and her *inability* to bear sons for Nnaife. She is also not as generous or pliable as Efuru, or as willing to let a man take the credit for her work. Like Efuru, she was stigmatized for her *inability* to bear male children. However, unlike Efuru, Adaku is not capable or willing to take the rest of her family along in her climb of the economic ladder. Still, because of the new westernized culture, Adaku could afford to send her daughters to school to give them proper fighting chances in the newly birthed nation. Nnuego, in her moment of enlightenment comments on Adaku's action, "I am beginning to think that there may be a future for educated women...It would be really something for a woman to be able to earn money monthly like a man" (Emecheta 189). This statement gives a glimpse into changes that were taking place in terms of what positions women could attain or aim for in the society.

Another avenue by which women possessed agency and exercised power was through spirituality, such as the worship of a water goddess, or mammy-wata figure.<sup>19</sup> In Nwapa's novel, Efuru was selected to become one of the river goddess' (Uhamiri) worshippers. The women selected for this position of honor were instructed to observe a number of rules independent of their husbands. For instance, Efuru is commanded not to sleep with her husband on Orie days, which are sacred to Uhamiri.<sup>20</sup> Worshipping this goddess allows them some independence from their husbands' commands, because Uhamiri supersedes husbands in the hierarchy of authority.

Traditional spirituality also allows women the opportunity to find an identity that is almost independent of men. Madhu Krishnan characterizes the water goddess as the embodiment of womanhood in pre-colonial Igbo society saying that she

“represent[s] both the femme fatale, instrumentalizing masculine discourses through her seduction of men and their subsequent devotion to her, and the power of the mother-figure, totemic of fertility and the interior space occupied by the feminine” (Krishnan 2). She appears to be the epitome of total independence from men and female solidarity, therefore women that seek her out, worship her, or ascribe to her powerful attributes gain some level of independence from men.

Additionally, Beatrice, Kambili’s mother in *Purple Hibiscus*, embraces female solidarity and spirituality to exercise her agency after years of suffering under her husband’s tyrannous abuse and fanaticism. Dewar describes “the operation of poison” as one of the factors attributable to the effectiveness of professional witchcraft (Dewar). It is through this form of witchcraft, a kind of black magic often attributed to women, that Beatrice procures the poison with which she ultimately kills her husband. However, she only gets the opportunity to free herself this way through her friendship with her cook, Sisi, who has access to a native witch doctor. This act of female agency and solidarity displayed by Beatrice may neither be the ideal nor the moral one, however it does display the powerful effects of spirituality and female solidarity in the empowerment of Nigerian women.

## PUBLIC HISTORY DOMESTICATED

Chimamanda N. Adichie states that “Realistic fiction is not merely the recording of the real, as it were... it seeks to infuse the real with meaning... As events unfold, we do not always know what they mean. But in telling the story of what happened, meaning emerges and we are able to make connections with emotive significance. Realist fiction is, above all, the process of turning fact into truth.” (Commonwealth speech) Adichie makes a distinction between fact and truth by explaining that facts have to do with the way historical events are recorded for mass dissemination. For instance, one can know all the facts about the Nigerian civil war, such as when it started, and ended, how many people died from each side, etc. It is then up to realist fiction to illustrate the truths about these events; to demonstrate the ways in which individuals reacted to and were affected by these events. In so doing, the translation of public history into the domestic lives of the citizens is highlighted and magnified.

*Efuru* famously stays away from discussing issues at a national level, and instead dwells on domestic life in a rural part

of south-eastern Nigeria. As Susan Andrade puts it, “Nwapa is a classic example of an early female writer who was too timid to speak in the macro-political language of men... [She] appears to refuse engagement with nationalist politics altogether” (Andrade 45). Still, the novel portrays the situation of early colonial Nigeria, with some parts of the timeline falling in the late 1920s.<sup>21</sup> For example, the 1927 tax laws were famously protested by the Igbos who never had to deal with such involuntary periodic payments under their democratic and non-monarchic system of government. In Nwapa’s *Efuru*, readers get a reflection of these sentiments from Efuru’s friend, Nwosu, who reacts violently to the tax collectors. Before this time, colonization may not have been as much of a reality for them, because as the Lieutenant Governor states, “no native tribe...really appreciates that it is under control until the people pay taxes: so long as the people can evade taxes, they are under the impression that they have been able to resist conquest successfully” (qtd. in Falola 83). Therefore, the imposition of tax makes colonization a daily reality for the villagers. Similarly, they experience the conflicts between the new religion (Christianity) and the old traditional ones, as well as the disparities between the old system of justice and the new laws imposed on the people. Efuru’s father, Nwashiike Ogene, appears to sum up the sentiments of the villagers when he says, “Things are changing fast these days. These white people have imposed so much strain on our people” (Nwapa 7). The characters’ reactions to these strains placed on their cultures and traditions are part of the translation of public history into domestic experience. In this novel, public history is personalized through the people’s reactions to the new laws, especially taxation and the ban on locally made gin. Most of the characters in *Efuru* are outspoken about their opposition of the ban on local gin. They hide their stock from police raids, and try their best to avoid confiscation and possible incarceration. Their opposition indicates the defiance that is representative of the colonized in this novel.

In *Efuru*, the conflict between Christianity and the traditional religion is manifested in Enebiri/Gilbert, Efuru’s second husband. In a description of Enebiri’s background, the narrator explains that his parents sent him to school when he well into his teenage years, and when anyone got sent to school, he or she becomes a Christian automatically (Nwapa 103). Therefore, Enebiri has ample time to learn about the traditional culture and religion of his people before he converts to Christianity and

changes his name to Gilbert. As a result, he demonstrates some religious ambivalence. For instance, after he is robbed in the market, he has this conversation with Efuru his wife:

Immediately I returned, I told my mother and she sacrificed to our ancestors.” “How is that, you go to church?” [Efuru asks] “What about that? I shall give the pastor some money to thank God for [delivering me]” / “I see. I can never understand you Churchgoers... (Nwapa 139)

Enebiri reveals that he still practices both religions; he tries to keep his ancestors appeased and his pastor happy. In other words, although he cannot be seen engaging in pagan rituals as a Christian, or more aptly as a “churchgoer”, he still endeavors to keep both deities happy. This ambivalence is discussed by post-colonial scholars as a situation whereby “the colonized subject is never simply and completely opposed to the colonizer” and the subjects engage in “mimicry [that] is never far from mockery” (Ashcroft, Griffiths and Tiffin 13). Which means that the characters are neither completely on the path of mimicking everything their colonizers do, nor are they completely on the side of resisting the ways of their colonizers. This concept of liminality is personalized in Gilbert’s life.

The liminality is also demonstrated in Efuru’s life. She is a traditionalist, and goes to the native shrines in times of trouble. She even visits two different witch doctors with her father. However, she turns to the relatively new practice of western medicine during health emergencies. Efuru contradicts herself because while she is very distrustful of Christianity, believes in Uhamiri and the power of their ancestors, she incongruously has an unwavering faith in modern western medicine. This contradiction indicates a tension between Efuru’s mimicry of, and her resistance against western culture.

Buchi Emecheta’s *The Joys of Motherhood* also presents public historical events as they are translated into the domestic sphere. This novel also has a colonial setting which, begins about 1908 and continues until the late colonial period (1950s) when talks of independence were almost at fruition. Rural-urban migration was a huge phenomenon at this time. The narrator states that it “was robbing many areas of their able-bodied men” (Emecheta 141). People were moving from the villages to the big cities in search of often non-existent greener pastures. They went in

pursuit of the western bank notes that were in use in the cities, as opposed to the cowries being used in some villages. In the novel, Nnuego's husband, Nnaife, goes to Lagos in pursuit of a better life away from the hardships of farming.

The advent of this kind of rural-urban migration during this period of colonization meant that women had to buy everything from the market with money that was very hard to come by. But, as in the rural setting, Igbo women still had to be the primary providers for their children, although the new culture expected men to be the breadwinners. In *The Joys of Motherhood*, Nnuego experiences the full impact of this predicament while she is in Lagos, especially after her husband is arrested for attacking someone with a machete. In an attempt to defend Nnaife in court, under laws and a language that she has no understanding of whatsoever, Nnuego unwittingly sends her husband to jail. She says to the defense lawyer –

Nnaife is the head of our family. He owns me, just like God in the sky owns us. So even though I pay the [school] fees, yet he owns me. So in other words he pays” / “Oh, I see. And you clothe and sometimes feed the family too?” [The lawyer asked.] Nnuego nodded, not knowing that with that one nod, she had nailed the last nail in Nnaife's coffin. (Emecheta 217)

Nnuego believes she is defending her husband while she is actually condemning him. Nnaife had claimed that he took care of his family financially, and that was his only redeeming quality. Under the laws of her native Ibo, Nnuego's testimony would be a defense for Nnaife but as the lawyer rightly says, they were in 20th century Lagos, where no one had the right to carry a machete (Emecheta 218).<sup>22</sup> The fact that she does not understand the relatively new laws and the language in which they are written is a sad example of how a common fact of colonial life, like new laws, becomes the truth of an individual's life.

Another historical fact noted in the novel is the involuntary conscription of Nigerian men to fight in the Second World War. Nnaife is forced into the army, while Nnuego suffers extensively, having to take care of herself and five children in the absence of her husband and his income. The narrator states that “when Nnaife was away in the army for four years, [Nnuego] had only received two allowances, even though she then had five children to look after” (Emecheta 217). To demonstrate the divide

between the grand perspective and the personal perspective of events in this episode, consider this passage from Nnuego's conversation with Ato, her friend and neighbor:

But, Ato, on whose side are we? Are we for the Germans or the Japanese or the other one, the British?" / "I think we are on the side of the British. They own Nigeria you know." / "And Ibuza too?" Nnuego Asked not believing a word. "I don't know about that," Ato confessed. (Emecheta 98)

The characters' ignorance of the public political situation in this conversation is real and almost comical. Ato seems sure that Nigeria as a whole belongs to the British, but when Nnuego asks about Ibuza, a smaller and more personal geographic location, she loses her confidence. Although the common fact of the British owning Nigeria has been accepted, she cannot confront the implications which include a painful truth: by extension, the British own Ibuza too. Also, even though the suffering is tangible for Nnuego and the other characters affected by the war, the actual war and the reason their husbands were forced to participate makes no sense to them. They have very limited knowledge of that grand event, because they can only understand the ways in which the war is translated into suffering and hardship for them.

As a result of its later setting, the characters in *Purple Hibiscus* confront a different set of national phenomena. With its politically tumultuous backdrop of 1990s Nigeria, Chimamanda N. Adichie's is a novel whose young female protagonist, along with her mother and brother, manages to rise to freedom in defiance of an abusive father and nation. The era represented in this book is riddled with political unrest in the form of coups and military rule. As a result, the characters have to deal with the side-effects of political instability such as scarcity, petrol price hikes, constant fear and a state of insecurity. In the novel, readers are informed of a military coup that takes place, and about the subsequent announcement of the new "Head-of-State". This new Head-of-State who was later said to have "died atop a prostitute" is reminiscent of an actual Nigerian Head-of-State, General Sani Abacha – one of the country's most brutal and notorious military rulers.

During the regime of this formidable ruler, Kambili's aunty Ifeoma, a lecturer at the University of Nigeria, Nsukka endures

many hardships as the head of her family. They are plagued by strikes, which were ironically meant to persuade the government. Not only is her salary unpaid for months, some of Auntie Ifeoma's University staff privileges are cut off as a result of the workers going on strike after strike. When her father, Papa Nnukwu, who had been shunned by his wealthier son for not professing Christianity, is brought to Nsukka to receive better medical attention, she lacks the means to provide him with optimum care because the university hospital is on strike. Luckily she has a doctor friend who examines her father and recommends a series of diagnostic tests, but the lab staff was also on strike. It appears that the only people getting punished by these strikes are citizens themselves. The government refuses to appease its workers despite the strikes and riots. For example, the family is shaken up after a student riot protesting the appointment of what, Auntie Ifeoma's son, Obiora called "The university equivalent of a head of state" because "the university becomes a microcosm of the country" (Adichie 224). As if to corroborate Obiora's theory, the now military-run university exercises violent intimidation to keep its employees in check. Auntie Ifeoma is falsely accused of being one of the organizers of a university-wide riot. In an attempt to get rid of her or keep her docile using intimidation, armed men are sent to search their home, but the narrator says that "they scattered [the house], but they did not search," which goes to show that they were not really hoping to find anything (Adichie 231). After this episode, the family decides to try getting American visas and to leave the country.

As the widowed head of her household, Auntie Ifeoma has to make several adjustments to deal with the scarcity of petroleum, and the consequent increase in the price of foodstuffs. She also has to deal with the newly imposed poverty. For instance, while driving, Auntie Ifeoma turned into a street that was steep "and she turned the ignition off and let the car roll... 'To save fuel,' she said, turning briefly to [her nephew] Jaja and [Kambili]" (Adichie 129).

The women in this scarcity, as exemplified by Auntie Ifeoma, not only tighten their mode of living in order to survive, they also support each other. These women are in different positions, in terms of their socio-economic class, the situation at home, etc. However, it appears that in times of hardships like these, some women seem to form bonds of solidarity with each other as a system for survival. Mama Joe, a hair-dresser in



the local market, speaks of how Auntie Ifeoma had been kind to her in the past saying, “I would be naked but for [Ifeoma], who gives me her old clothes. Auntie Ifeoma helps Mama Joe by providing her with clothing, while Mama Joe styles her hair at a discounted price” (Adichie 237). Auntie Ifeoma also receives help from her sister-in-law, Beatrice Achike, who convinces her husband to send some relief to the household since the Achikes are better-off financially. In turn, Beatrice receives help with the emotional and physical trauma of being married to a tyrant.

The characters in this novel also have to discover ways of living with fear in a military-ruled country. Ade Coker, the ever-honest editor of the newspaper owned by Kambili and Jaja’s father, Mr. Eugene Achike, was killed by a “letter bomb” allegedly mailed to him from the State Government House. He had opened this letter while sitting at the dining table with his wife and his young daughter. His daughter became traumatized, and could not speak for several months. When Kambili expresses her thanks to God for making Ade’s daughter speak again, as Eugene would have expected her to, Jaja responds scathingly saying, “She will never heal...She may have started talking now, but she will never heal” (Adichie 259). In this passage, readers are made aware of the deep personal implications of Ade Coker’s death. In history, he will go down as another one of the regime’s casualties, but to his family, Ade’s death signifies the beginning of life-long trauma. His death gathers meaning through their personal experiences.

## CONCLUSION

Be it through Efurú’s experiences with the new western cultures, Nnuego’s encounters with the grand war and the befuddling laws, or Auntie Ifeoma’s confrontation with the reality of scarcity, these works demonstrate that there can be a vast difference between recorded historical events and their impact on individuals and domestic life. These novels accomplish the job of realist fiction by weaving historical occurrences into personal stories to illustrate emotional depth, imbue these events with meaning and significance, and bring the nation-wide happenings to life for readers.

Studying African women’s narratives enlighten us about their experiences, history, and identity. It will also further the cause to “create a niche for the female African writer and critic within the contemporary literary tradition (Kalu 5).”<sup>23</sup> The liter-



ary works produced by colonized Nigerian women reflect what they have encountered and the knowledge they have developed. These experience-colored tales not only solve the problem of absence from literary historiography, they also contribute to the reconstruction of the ever-changing multiple identities, roles, and statuses of Nigerian women. Because they are not only passive reflections of the writers' experiences and imaginations, these texts also "offer alternative scripts that subvert internal systems of power" (Nfah-Abbenyi 261). They intervene in societal issues.

Finally, these novels employ the ideas of realist fiction to convert history into stories, and facts into truths. A successful realist novel combines the realistic depiction of a social situation at a particular time and place with a textual network of discourse on the issues, thereby not merely mirroring the social problems, but also commenting on them (Furst 10). Nigerian women authors inscribe themselves, their predecessors and their history into literature and literary studies simply by writing, and making themselves and their stories known. By offering narratives from a female's viewpoint, they change the way readers understand. The works of these women writers eliminate many of the misconceptions surrounding their history and their identities while projecting and propagating new images of the Nigerian woman.

## ENDNOTES

- 1 Elechi Amadi's *The Concubine*, and Chinua Achebe's *Things Fall Apart*
- 2 "The notion of "double colonization": ...women in formerly colonized societies were doubly colonized by both imperial and patriarchal ideologies" (Ashcroft, Griffiths and Tiffin, *The Postcolonial Studies Reader* 233).
- 3 These included writers like Chinua Achebe, Wole Soyinka, Isidore Okpewho, and Ben Okri. Nwapa's influence also reached them, "Incredible as it may seem, in Nigeria [she] has insidiously influenced hitherto masculinist authors, such as Achebe and Soyinka...who now write with sensitivity on gender issues and other sociopolitical matters.
- 4 Igbo is one of the three major ethnic groups in Nigeria (Hausa, Igbo, and Yoruba). They mainly originate from the Southeastern part of the country.
- 5 A prime example would be Achebe's *Things Fall Apart*, which was the ultimate nationalist text, in the sense that it directly responded to the western portrayal of Africans in Joseph Conrad's *Heart of Darkness*.
- 6 "Early critics, most of them male, dismissed Nwapa's writing as trivial, useful only for understanding domestic village life" (Andrade 55).
- 7 Common way of spelling "Igbo" in the English language
- 8 "This approach develops out of years of silence and struggle that many African women scholars experienced in the academic arena. Many African women opposed the silencing which seemed supported by a male-dominated African literary analytical schema" (Kalu 5).
- 9 "Social temporality is related to the constitutive process in which social types arise...[it] establishes social relevance, since its related typifactory scheme unites the situation into a context" (Grathoff 77).
- 10 "sexual asymmetry is not as clearly distinct nor as universal as some theorists present it to be...Igbo women...drew power from the fact that male-female relationships were mediated by flexible gender ideologies" (Nfah-Abbenyi 265)
- 11 "The most important and vital role that women play in African traditional society is that of mother, because motherhood is central to all other roles...and it is because of women that men can have a patrilineage at all" (Steady qtd. in Nfah-Abbenyi 41).
- 12 I found some documents in the archives that focused on Adult Women's education in Aba – a town in southeastern Nigeria. The documents were addressed to the "Lady Education Officer" who was a British women in charge of establishing schools that educate local women on topics like "domestic science," "midwifery," and "needle-work." Women were encouraged to pursue this education, and their "eagerness" is recorded in the document.
- 13 Amadiume refers to this method as a "sexual division of labour" (*Male Daughters* 27).
- 14 See "Gender Division of Space" in Amadiume's *Male Daughters*, (91-93).
- 15 See Madhu Krishnan, pg. 5.
- 16 See Amadiume's "Theorizing Matriarchy in Africa: Kinship Ideologies and Systems in Africa and Europe."
- 17 These became major export commodities after the abolition of slave trade.
- 18 "My husband is not rich. In fact he is poor. But the dowry must be paid. I must see that this is done" (Nwapa 5).
- 19 mermaid
- 20 one of the four week days of the Igbos: Eke, Orie Afor, Nkwo

- 21 The imposition of taxes on the Igbos did not come until 1927, whereas the northern part of the country had been introduced to direct taxation by 1906, and the western by 1916 – 1917 (Falola 79).
- 22 A major city in Nigeria, and the nation's former capital
- 23 Using “the African woman's narrative and viewpoints as routes to understanding her experiences” (Kalu 15).

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*EDITORS/DESIGNERS*  
***BIOGRAPHIES***

## **DOMINICK DIMERCURIO II • EDITOR**

Dominick DiMercurio II is a member of the Honors College who studies biological sciences and mathematics at UMBC. Fond of scientific research, he works for the UBM program, an on-campus undergraduate research opportunity in biology and mathematics. Dominick is grateful for the many research experiences he has received at UMBC, especially his work as the STEM editor of this journal, where he participated in the behind-the-scenes aspect of research publication. Dominick hopes to continue his studies in medical school and to pursue a profession in medical research. He would like to thank fellow editors, Vanessa Rueda and Gagan Singh, for their tremendous effort, former editor Morgan Madeira for her suggestions and encouragement, and faculty advisor Dr. Susan McDonough for her overwhelming support.

## **VANESSA RUEDA • EDITOR**

Vanessa Rueda is a section editor for *The Retriever Weekly* and a Humanities Scholar graduating in May with a Bachelor of the Arts degree in English. During her second year as editor for the *UMBC Review*, she has expanded her editorial skills and has discovered a love and enjoyment for work in the publishing industry. Working for the journal made her consider pursuing a career in publishing and editing, which she will attempt after her graduation. Vanessa would like to thank her co-editors, Dominick DiMercurio II and Gagan Singh, for the continued support, dedication and time given to producing the journal. She would also like to thank Janet McGlynn, Devon Fick and the Office of Undergraduate Education for their funding and continued support throughout the process. Vanessa would like to thank Dr. Susan McDonough not only for her guidance and support as the faculty adviser, but also for her advice and candid talks that unknowingly supported Vanessa through uncertainties about her future after graduation.

## **GAGAN SINGH • EDITOR**

Gagan Singh is a senior Humanities Scholar and member of the Honors College at UMBC. She will be graduating with a Bachelor of the Arts in English. This is her second year working with the *UMBC Review* as an editor. These past two years working with the *UMBC Review* have taught her the importance

of interdisciplinary work. She feels grateful to be part of a journal that values student research in all branches of academia. Working for the *Review* has taught her essential skills and has given her a strong foundation in publication and editing, which she hopes to continue to apply to her careers after graduating. Gagan would like to thank her co-editors, Dominick DiMercurio II and Vanessa Rueda for their support and dedication to the production of this journal, a true team effort. She would also like to thank the Office of Undergraduate Education, Janet McGlynn and Devon Fick for their continued support and resources. Last but not least, Gagan would like to thank Dr. Susan McDonough for her endless guidance through the publication process, her dedication to the journal, and her constant availability. This journal would not have been possible without the support and combined efforts of all these people.

#### **MORGAN MANTELL • SENIOR DESIGNER**

Morgan Mantell is the Vice President of Design and Marketing for the UMBC Student Events Board, as well as a designer for Chartwells at UMBC. Morgan is graduating in May with a Bachelor of the Arts in graphic design, as well as a Bachelor of the Arts in media and communications studies. These past two years designing for the *UMBC Review* has been an enlightening, challenging, and fulfilling experience for Morgan, and she is grateful for her opportunity to spend half of her undergraduate career working with the *UMBC Review*. Morgan would like to thank her design assistant, Daniel Grove, for his support in the design process of the *UMBC Review*. Morgan would also like to thank her mentor, Guenet Abraham, for all of her support, hardwork, and dedication into making the *UMBC Review* a success. Morgan hopes that readers enjoy the 15th volume of the *UMBC Review*, and further wishes that it would serve as an inspiration for other undergraduate students to pursue research in their field of study.

#### **DANIEL GROVE • DESIGN ASSISTANT**

Daniel Grove is graduating in May 2015 with a Bachelor of Fine Art in graphic design and a certificate in web development. Daniel is grateful for the opportunity of being the design assistant for the *UMBC Review*, and looks forward to being the senior designer next year. He would like to thank the current designer, Morgan Mantell, for all of her advice, dedication,



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