

2017 | Vol. 18

**UMBC REVIEW**

JOURNAL OF  
UNDERGRADUATE  
RESEARCH

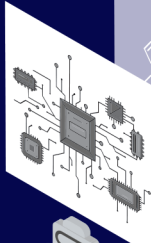
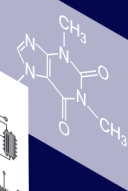
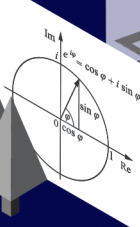
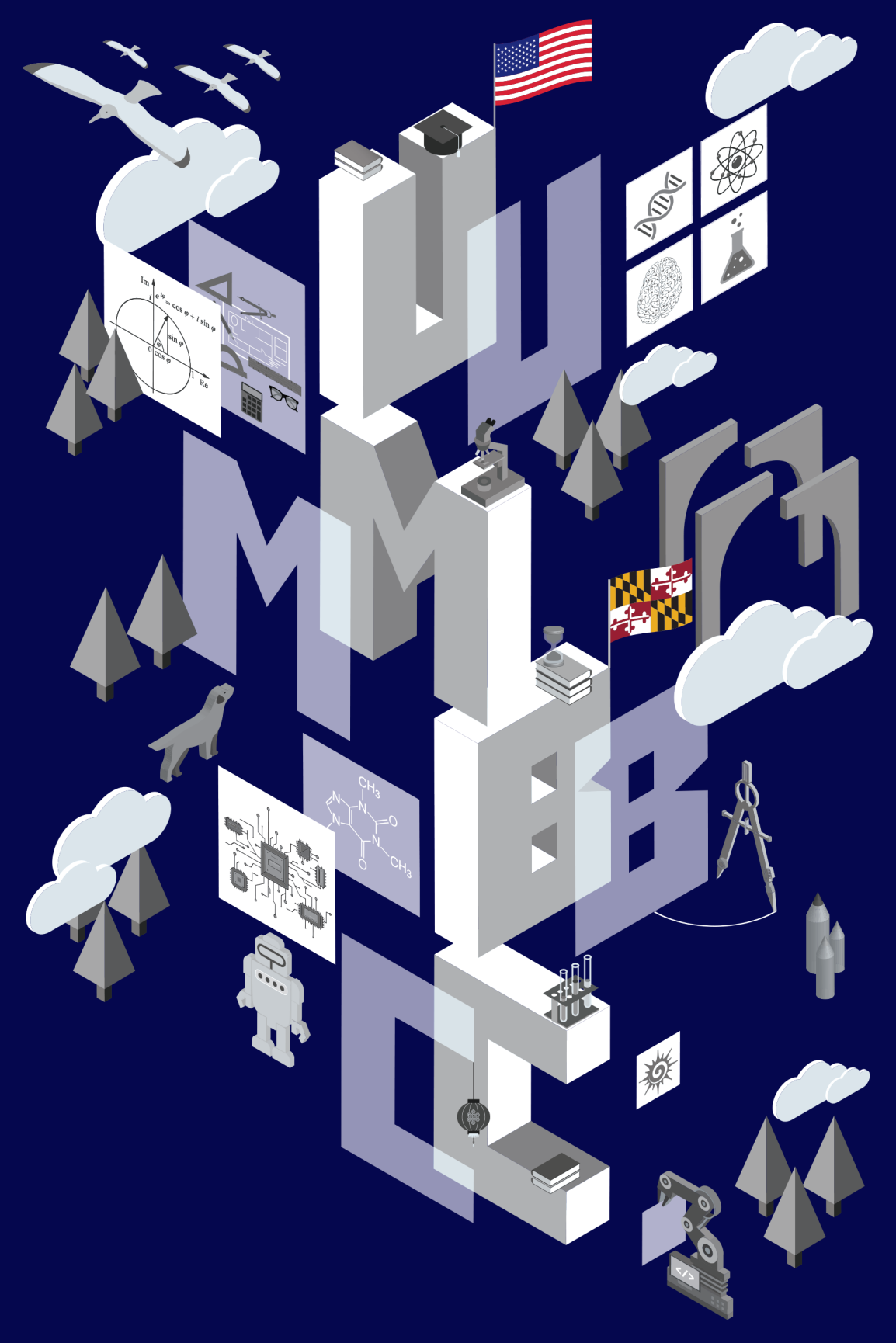
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# EDITORS' INTRODUCTION

The 18<sup>th</sup> edition of the *UMBC Review: Journal of Undergraduate Research* comes to you amid a time of great celebration at UMBC as the university celebrates its 50<sup>th</sup> birthday. As ground is broken on new campus building projects, the *UMBC Review*, just like Undergraduate Research and Creative Achievement Day (URCAD), continues to demonstrate the exciting research completed by UMBC students of all disciplines and majors.

This journal of undergraduate research is unique because it is managed and created by undergraduate students and because of the tight timeline it operates on. Editors begin receiving submissions in the spring, continue collecting them during the summer, and finish their solicitation efforts in September. The next three months consist of obtaining outside reviewers for promising papers, editing submissions, and preparing the written words that will make up the journal. In early January the design team receives these components and crafts the polished product you hold in your hands.

Being published in the *UMBC Review* is an honor only a few UMBC students will receive and we are pleased to be sharing their work with you. These papers are exemplars of the thoughtful and creative work completed by UMBC's undergraduate students. We hope you will join us in celebrating UMBC's 50<sup>th</sup> anniversary and the excellent work of our authors:

**THEOPHILUS ALUKO** analyzes the effect of leading-edge vortices on lift generation through modeling of the barn swallow.

**BRENDA GUTIERREZ** develops a biosensor to measure and explore ATP release from astrocytes in the brain.

**SAMANTHA FURMAN** expands on a mathematical model examining the effects of external stimuli on skeletal muscle cell atrophy.

**AMELIA HALLWORTH** investigates circadian clock genes that also play a role in controlling the plant immune response.

**JAMES LOY** studies improvements to quantum dot nanocrystals for their potential application in solar cell technologies.

**ABIGAIL WORGUL** examines the shape of the Temple of Vesta and its relationship with other buildings in Rome's Forum.

**MELINA LATONA** explores the alternative educational methods she observed in a small town in the valleys of Bolivia.

**JENNIFER WACHTEL** details how Jewish refugees from the Holocaust experienced victimization and demonstrated agency in Shanghai.

**RICHARD D. ELLIOTT** illustrates the correlation between the rhetoric of the Tea Party movement and mainstream conservative politicians.

**CAITLIN STONE** considers the impact of practicing Fangsheng on the environment and society of China.

# ACKNOWLEDGMENTS

These papers, and this volume, would not be possible without help from the UMBC community and beyond.

We would like to thank the faculty advisors and mentors of our student authors. These faculty advisors provided guidance to their students that allowed them to produce these fine research papers. Without their work, the *UMBC Review* could not uphold the standard of quality that we strive for in the research that we publish.

**DR. KATHY BRYAN:** AMERICAN STUDIES

**DR. BAMBI CHAPIN:** SOCIOLOGY AND ANTHROPOLOGY

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**DR. RYAN WHITE:** CHEMISTRY AND BIOCHEMISTRY

**DR. MEILIN YU:** MECHANICAL ENGINEERING

We also owe our deepest gratitude to the reviewers and proofreaders who contributed their time and effort to review papers for the *UMBC Review*. The reviewers, all of whom work at institutions outside of UMBC and are experts in their respective fields, were able to provide constructive feedback and assurance that these papers were relevant and novel to the field. In the interest of anonymity, we will not name these reviewers in print. We are also grateful to the proofreaders from across the UMBC community who lent us their perspectives during the editing process:

**DAVE ANGUISH**

**DANIEL BARNHART**

**TIM FORD**

**ABIGAIL GRANGER**

**KEVIN JOSEPH**

**JANET MCGLYNN**

**GREG ROEPKE**

**ANNE ROLAND**

**BRIAN SOUDERS**

**JOYCE TENNEY**

**BRIAN THOMPSON**

**BENJAMIN WOODWORTH**

We would also like to thank the following for their commitment to undergraduate research at UMBC and for their financial support of the *UMBC Review*:

**PRESIDENT FREEMAN HRABOWSKI**  
**OFFICE OF UNDERGRADUATE EDUCATION**  
**OFFICE OF THE PRESIDENT**  
**OFFICE OF THE PROVOST**

We are also indebted to the faculty mentors, Dr. Susan McDonough and Professor Guenet Abraham, who guided the editors and designers through the months of work that culminated in this publication. Their experience and support have been crucial to the creation of this journal.

Last but not least, none of this would have been possible without the aid of Ms. Janet McGlynn. This volume is Ms. McGlynn's last, as she retired in January 2017, and we recognize her countless contributions to the *UMBC Review*. For years Ms. McGlynn championed the *Review*, her dedication and hardwork integral to its continued success. We wish Janet all the best in her retirement and thank her for everything she has done for the *Review*.

We are excited to present Volume 18 of the *UMBC Review*, and hope that it is as enriching for the reader as it was for the editors to produce.

Best regards,

**DYLAN ROGERS ELLIOTT**  
Arts, Humanities, Social Sciences Editor

**EMILY HUANG**  
STEM Editor







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# Computational and Experimental Analysis of Lift Generation of a Model Bird with Stationary and Dynamic Wing Configuration

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**Meilin Yu**

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## **BIOGRAPHY**

Theophilus Aluko graduated in winter 2016 in mechanical engineering with a minor in music. His professional aspiration is to help improve safety and customer satisfaction in various fields of engineering and management, including commercial aviation. Aside from his research endeavors, Theophilus loves to spend time helping the sick, homeless, and needy, and he considers these the most rewarding experiences he has with interacting with people. In his free time he also enjoys playing piano. He is the co-founder of the UMBC Adaptive Sports Program, where he works with faculty, staff, students, student groups, and departments at UMBC to establish accessible sports options for students and staff with transient disabilities. Theophilus is grateful for the guidance, expertise, and thoroughness of his mentors, Ms. Jamie Gurganus (Professor G.) and Dr. Meilin Yu. He is also thankful to Dr. Drew Wilkerson from the U.S. Army Research Laboratory for reviewing his work in its initial stages. Lastly, Theophilus would like to thank and acknowledge God for the fortitude supplied when his work was the most challenging. The past two years of research have encouraged Theophilus to continue his desire to help improve safety and customer satisfaction in commercial aviation and to pursue graduate studies in related fields in the future.

# DEMYSTIFICATION

I started working in Dr. Meilin Yu's Computational Mechanics Laboratory the semester after I participated in a summer research opportunity with Dr. Haibo Dong, his colleague at the University of Virginia. While at UVA, I worked on a different biomimetic project, studying the aerodynamics and mechanics of a barn swallow. Towards the end of the summer, I became interested in how avian aerodynamics and mechanics can help improve commercial aviation and optimize the design of commercial aircraft. Fortunately, the Department of Mechanical Engineering at UMBC hired Dr. Yu around the same time as the end of my research internship. When I returned to UMBC in the fall, I applied for an Undergraduate Research Award (URA), and Dr. Yu agreed to mentor me throughout my project. With the support of Dr. Yu, Ms. Jamie Gurganus, another instructor in the department, as well as my Undergraduate Research Award, my project has been a success.

## ABSTRACT

This work studies lift generation of the barn swallow through the use of computational and experimental analysis by progressively meeting finite dynamic constraints such as flapping amplitude and frequency. The lift generation was standardized for comparison and analysis using a dimensionless property of flying bodies called the lift coefficient. In this study, the barn swallow was selected because of its superior maneuverability and high flight efficiency with wings that morph when acting. As a first step, a true geometry of the bird was built via a three-dimensional (3-D) scan of a representative bird specimen. A computational fluid dynamics (CFD) software, ANSYS Fluent, was used to perform the numerical simulation under a uniform flow environment. An animation of a simplified lifting process of the representative model, characterized by a fuselage with stationary wings, was produced to visualize the fluid dynamics of the actual lifting process. For the experiment, a physical aerial robot prototype that mimicked the takeoff process of the bird in its natural environment was constructed without sweeping actuation. With this physical model, the lift coefficient generated by the flapping structure was measured and compared with that calculated from the numerical simulation of a stationary structure. The lift coefficient produced by the stationary airfoil from the numerical simulation was 0.215, and that produced by the dynamic wing from the experiment was determined to be no more than 0.347. Our analysis and measurements support the hypothesis that the lift generation was affected by the interaction between the fluid flow and the dynamic wing.

In particular, we hypothesized that leading-edge vortices (LEVs) play an important role in lift generation and should be further parameterized for morphing-wing aerodynamics. This research can support the design of safer, more efficient, next-generation commercial aircraft with wing surfaces that can change shape or morph to improve flight control based on wing-flapping technology.

## INTRODUCTION

This work was conducted to verify that leading-edge vortices (LEVs) affect the flight of birds. LEVs can be further studied to design future commercial aircraft that are more stable and controllable. Aircraft control has been a problem in aeronautical engineering since the advent of the Wright flyer, when flexible structures were often used. Relying on flexible structures would sometimes cause the “tab effect” [1], a difficult-to-correct, involuntary rolling of the craft. These flexible structures are analogous to a bird’s wings, as they have varying interactions with the air. However, these structures can be overly influenced by the airflow instead of forcing the air to follow their profile like a bird’s wing does. Wings were made more rigid to regain control, but it should be possible to rely on non-rigid structures to simulate bird-like flight without the negative effects.

Recently, scientists discovered that flow dynamics around the wings of a bird have a huge impact on its flight characteristics [2]. LEVs are one of these flow dynamics, and they result when the angle of attack (AoA) of a wing against an oncoming stream of air is substantial enough to force air over and around the wings. As a result, the orientation of the wing body creates a vacuum and induces low air pressure above the wing and high pressure under the wing. This process is responsible for the upward tendency of the wing body at a given velocity of the oncoming air stream, which is characterized by the lift force as illustrated in Figure 1. Generally, the lift will increase when the angle of attack increases until a critical value (e.g., 20°). After reaching this angle, the lift will dramatically drop if the AoA keeps increasing, resulting in stall. Improving our understanding of the presence of LEVs in natural flyers will lead to the development of safer, more stable, and more efficient commercial aircraft.



Fig. 1. The swirling around the front, or leading edge, of the wing is a result of the vacuum created above the wing, and is tied to the occurrence of the leading-edge vortices that play a dominant role in the occurrence and study of aerodynamic lift and stability in birds and commercial aircraft.

In the past, studies on the aerodynamics of the barn swallow have been limited to direct experimental analysis of other flight parameters such as wingbeat frequency [3][4][5], downstroke fraction, wingspan, body tilt angle, and tail attack angle [4]. Current literature does not address the difference in lift production between the time when the bird's wings are stationary and the time when they are dynamic in a simplified manner, as done in this work, under similar environmental conditions. However, one relevant effort neatly characterized the change in average lift with changes in flapping frequency [6]. Pennycuick (2000) presented the changes in lift coefficient with air speed, while another similar work displayed how the lift coefficient varies with attack angles [7]. These works were beneficial in ascertaining the experimental constraints used in this study.

In this paper, we examined the differences between stationary-wing and dynamic-wing aerodynamics by comparing a barn swallow model with stationary wings to one with dynamic wings. We limited our study to the lift generation process. This comparison used the lift coefficient,  $C_L$ , a non-dimensional value that characterizes the lift production. The lift coefficient was calculated through use of Equation 1 for AoA-corrected lift force  $L$ , flapping frequency  $f$ , flapping amplitude  $\phi$ , air density  $\rho$ , chord length  $C_\phi$ , and wing span  $l$  [8].

$$C_L = \frac{3L}{(\pi^2 f^2 \phi^2 \rho C_\phi l)} \quad \text{EQUATION 1}$$

The methods section of this paper presents the two approaches adopted in this study: computation and experimentation. The experimentation consists of a computational study and robotic emulation testing. In the results section, the outcomes of the stability check, computation, and experimentation are discussed. To visualize and better understand the role of LEVs, the vortex structures and iso-surfaces (surfaces with a constant value of a parameter) are also displayed for the stationary-wing computation in the results section. Subsequently, the discussion section explains some limitations of this study and details that should be considered when regarding the results of this work.

# NOMENCLATURE

$u$	velocity in x-direction
$v$	velocity in y-direction
$w$	velocity in z-direction
$\rho$	air density
$p$	pressure
$\nu$	kinematic viscosity
$t$	time
$T_1$	torque of servo
$\theta_1$	angular displacement of servo
$\theta_2$	angular displacement at wing body
$N_1$	number of teeth of driving pulley
$N_2$	number of teeth of driven pulley
$N_3$	number of teeth of driving bevel gear
$N_4$	number of teeth of driven bevel gear
$J_1$	polar moment of inertia of driving pulley
$J_2$	polar moment of inertia of driven pulley
$J_3$	polar moment of inertia of driving bevel gear
$J_4$	polar moment of inertia of driven bevel gear
$J_5$	polar moment of inertia of driving one-wing body
$J_e$	equivalent polar moment of inertia
$K$	torsional spring stiffness
$s$	Laplace variable
$G(s)$	transfer function
$C_L$	lift coefficient
$f$	flapping frequency
$\varphi$	flapping amplitude
$C$	chord length (average)
$L$	wingspan
$V$	air velocity
$A$	area of experimental wing surface

## METHODS

The two methods adopted in this work were representative geometry and computation, and experimentation with robot mimicry. Figure 2a and 2b depict the two stages of this study.

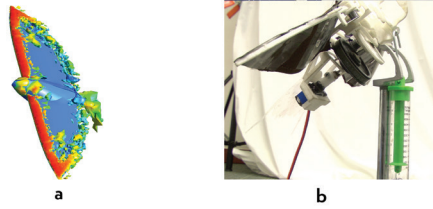


Fig. 2. The stages of the study after analyzing the barn swallow in its natural take-off position were (a) computational fluid dynamics simulation and (b) bio-mimetic robot assembly.

The representative geometry explained how the 3-D image was generated and remodeled for the computation. Included in the computation were the mesh generation and the solution setup used to arrive at the results. Included in the experimentation were the flapping mechanism, motion transfer function, check for stability, and experimental setup.

## REPRESENTATIVE GEOMETRY AND COMPUTATION

To animate the simplified stationary lift process of the bird without flapping, a representative 3-D model was scanned from the Smithsonian Museum of Natural History in Washington, D.C., as presented in Figure 3.

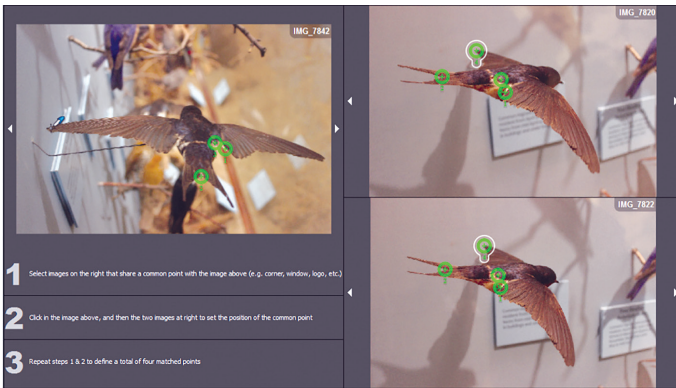


Fig. 3. A depiction of the 3-D scanning and image-stitching process. Pictures were taken around the bird in loop and then stitched together through the 3-D scanning software 123D catch.



Three modifications were then made to the model to optimize it for the computation:

1. As shown in Figure 4, the wing was remodeled as a lofted NACA 0012 airfoil cross-section that tapers at the tip to make a smooth approximation of the wing. This airfoil was chosen based on prior literature that demonstrated it to be a general approach for the NACA 0012 airfoil to be chosen when the exact shape of the wing is not known [2]. This remodeling was done using the Solidworks 3-D modeling software.

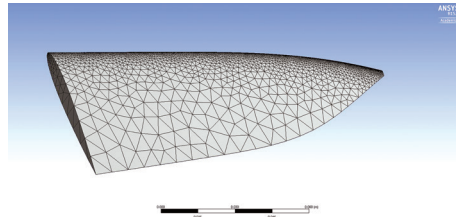


Fig 4. The wireframe structure of the remodeled airfoil.

2. The fork in the tail was deleted because the computation would require small mesh elements or cell sizes at such sharp points in the geometry. Retaining the fork would greatly increase the number of computational points as well as computational cost, while smoothing the geometry at this point would not dramatically affect the aerodynamics.
3. The beak was removed to improve cell sizing for similar computational reasons as removing the fork in the tail.

## COMPUTATION: MESH GENERATION

For the computation, a symmetrical half of the mesh structure was generated for the 3-D model with an ANSYS ICEM computational fluid dynamics (CFD) software and then fed into the ANSYS Fluent flow solver.

Figures 5 through 9 show the mesh structure around the surface of the model.

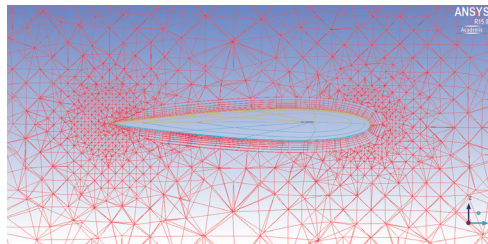


Fig. 5. A side view of the wireframe of the mesh structure around one wing.

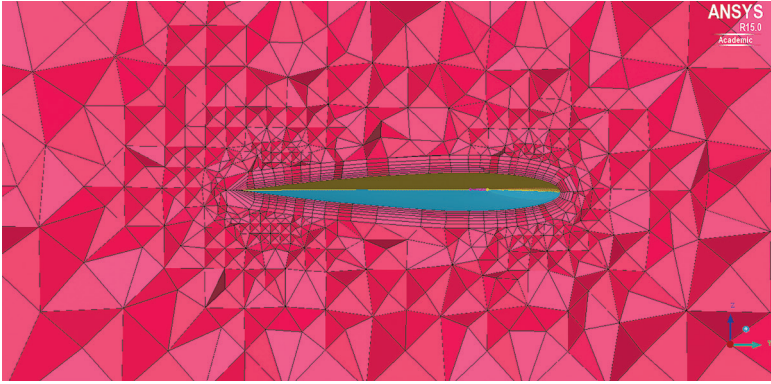


Fig. 6. A side view of the solid geometry, mesh structure of the wing, and mesh around the wing.

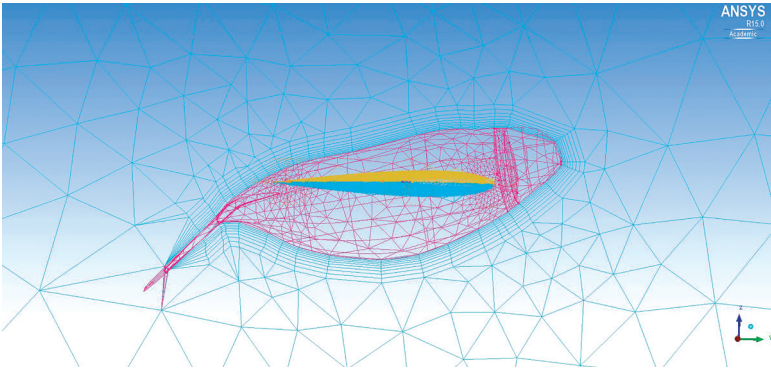


Fig. 7. A side view of the wireframe of the mesh structure around the body.

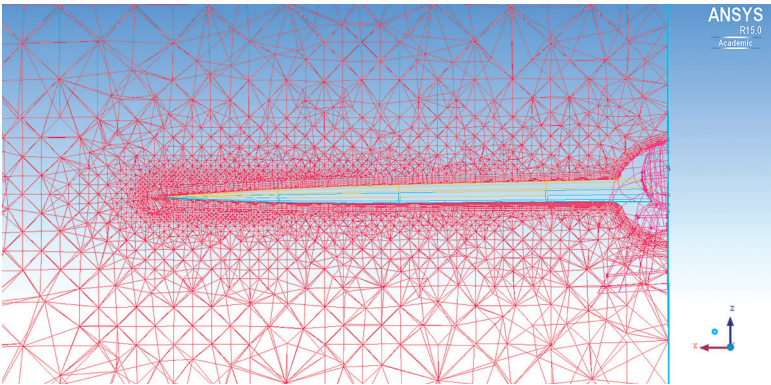


Fig. 8. A front view of the mesh structure around the body and wing, before symmetry reflection.

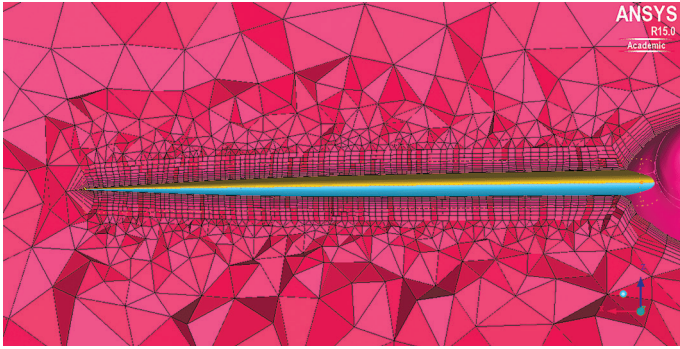


Fig. 9. A solid geometry and mesh structure of body and wing from the front view.

The mesh generation provided a system for computation and determined the accuracy of the computation. The parallel lines surrounding the surfaces of the geometry represent the boundary layer, which facilitates accurate computation of flow around the body surface and helps preserve the geometry of computation.

### COMPUTATION: SOLUTION SETUP

The computation was done using the ANSYS Fluent Solver with an angle of attack of  $10^\circ$ , and the experimental conditions and geometry constraints shown in Table 1 in order to calculate the lift coefficient for a stationary airfoil. The dynamic constraints were applied for the moving-wing physical experiment.

TABLE 1. EXPERIMENTAL CONDITIONS

Geometry Constraints	
Wing span-wise length	6"
Wing angle of attack	$10^\circ$
Body tilt angle	$21^\circ$
Tail spread angle	$45^\circ$
Dynamic Constraints	
Flapping amplitude	$91^\circ$
Flapping frequency	8 Hz
Max. wing sweep (morphing) angle	$60^\circ$
Environmental Condition	
Wind speed	4 m/s

The governing equation of incompressible flow can be expressed through the continuity and momentum equations below, where  $u$ ,  $v$ , and  $w$  are the velocities in the  $x$ -,  $y$ -, and  $z$ -directions, respectively. The continuity equation indicates mass conservation for the incompressible flow, and the momentum equations refer to conservation of momentum for all the velocity components.

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

$$\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} + w \frac{\partial u}{\partial z} = \frac{-1}{\rho} \frac{\partial p}{\partial x} + \nu \left( \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2} \right)$$

$$\frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} + w \frac{\partial v}{\partial z} = \frac{-1}{\rho} \frac{\partial p}{\partial y} + \nu \left( \frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} + \frac{\partial^2 v}{\partial z^2} \right)$$

$$\frac{\partial w}{\partial t} + u \frac{\partial w}{\partial x} + v \frac{\partial w}{\partial y} + w \frac{\partial w}{\partial z} = \frac{-1}{\rho} \frac{\partial p}{\partial z} + \nu \left( \frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} + \frac{\partial^2 w}{\partial z^2} \right)$$

There are three basic ways of solving this system: the SIMPLE-type (Semi-Implicit Method for Pressure-Linked Equations) method, the artificial compressibility method, and the low-Mach preconditioning method. The SIMPLE method is a pressure-based method where the computational software directly solves the governing equations of an incompressible flow. The SIMPLE method is used for solving the incompressible Navier-Stokes equations, and is the method used in this study. For the artificial compressibility method, a derivative with respect to pseudo-time is added to the governing equations to restore the hyperbolic property of the convection part of the general equation [9]. For the low-Mach preconditioning method, a pre-conditioner is added to the original compressible governing equation. The preconditioning allows the code, originally developed for simulating compressible flow fields, to be applied to nearly-incompressible, low Mach number flows [10]. The artificial compressibility and the low-Mach preconditioning methods are used in more complicated studies, and may be beneficial for future concerted investigations.

The current study used a pressure-based solver in ANSYS FLUENT to compute the solution for the incompressible flow, given a Mach number of less than 0.3. We also employed a transient solver in order to visualize the vortices. Rather than a turbulent model, a viscous, laminar model was used, due to the low Reynolds number of  $4 \times 10^4$ .

For the surrounding region, a velocity-inlet was specified in front of the geometry and around the far field. The velocity vector was specified such that it was resolved as a vector coming into the negative  $y$ - and pos-

itive z-direction, at an angle of  $10^\circ$  from the  $yx$ -plane. Behind the geometry, a pressure outlet was specified. In this simulation, the computational region consisted of the body and the wing of the whole bird.

For specifying the time step, it was first determined that it would take 0.0289 seconds for the air coming from the inlet at 4 m/s to cover a body length of about 0.118 meters. In order to allow about three progressive periods of flow computation through the body (because the body geometry changes significantly at the head, the wings, and the tail region), the time step was specified to be 0.01 seconds (roughly three times smaller than the time it takes to cover the distance of the whole body). In the results, the lift coefficient was averaged over 1.5 seconds, the time at which  $C_L$  evened out.

In order to calculate higher-order accuracy for the unsteady flow solution, a second-order implicit transient formula was employed.

## DESIGN OF A ROBOTIC BIRD

The wing-morphing positions of a barn swallow consist of an up-and-down flapping motion and a sideways-sweep motion. To simplify this initial study, we built a barn swallow bio-mimicry robot that portrays the flight of a barn swallow without the sideways sweep motion. We also attached this robot to an inverted spring scale attached to a leash on its neck in order to compute the lift force.

To effectively mimic the up-and-down flapping motion of the bird for this experiment, the robot was designed to meet dynamic constraints outlined in Table 1. The flapping amplitude refers to the total angle covered by the wing when it flaps in each direction, in degrees. The flapping frequency refers to the number of complete up-and-down motions the robot completes in one second, in units of Hertz.

### MECHANISM

As seen in Figure 10, the robot assembly was designed to mimic the barn swallow flapping without sweeping motion. To power the robot, a Tower-Pro MG92B servo with a stall torque of 3.5 kg-cm at 6.6 V and an operating speed of 0.48 sec/ $60^\circ$  at 6 V was used.

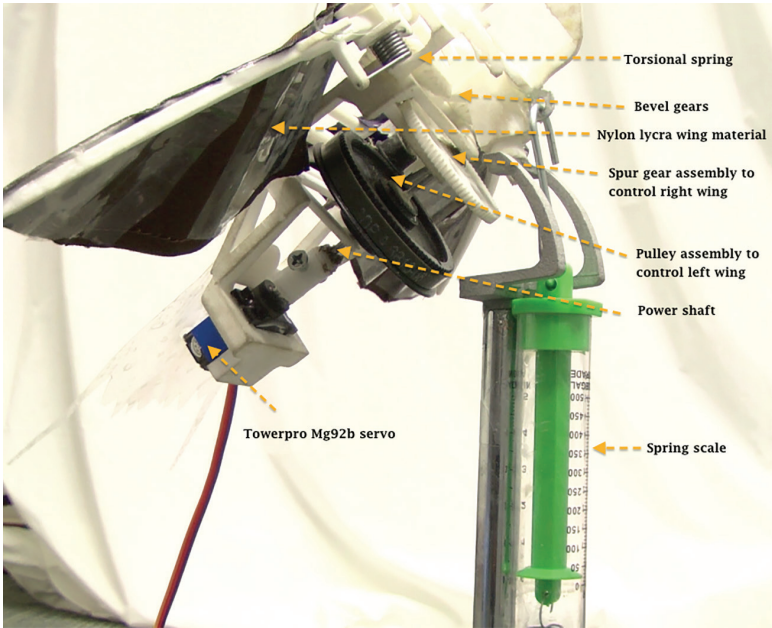


Fig. 10. A diagram of the experimental robot assembly. The four-bar linkage for the flapping mechanism consisted of a pulley, a spur gear assembly, and two bevel gears assemblies.

The assembly armature was 3-D printed from Shapeways, Inc., and other parts were procured from third-party vendors. To achieve the flapping amplitude of  $91^\circ$  as specified in Table 1, a four-bar linkage, illustrated in Figure 11, was modeled to scale to achieve that amplitude value and to be directly incorporated into the 3-D printed CAD-model.

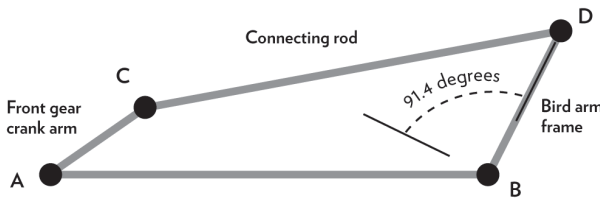


Fig. 11. Four-bar linkage for achieving flapping amplitude with points A, B, C, and D. Line AB represents the distance between the center of the front bevel gear and the pivot of the wing joint, line AC represents the crank radius of the front bevel gear, and line CD represents the connector between the crank arm and the follower BD.

Even though this experiment did not produce the sweeping motion, this motion was still theoretically analyzed. An idealized control system for the sweeping motion has been presented in Figure 12(a). The control system



diagram corresponds to the gear annotation in Figure 12(b).  $T_1(t)$  refers to the torque of the servo,  $\theta_1(t)$  refers to the angular displacement of the servo, and  $\theta_2(t)$  refers to the angular displacement at the wing body. These three quantities are functions of time.

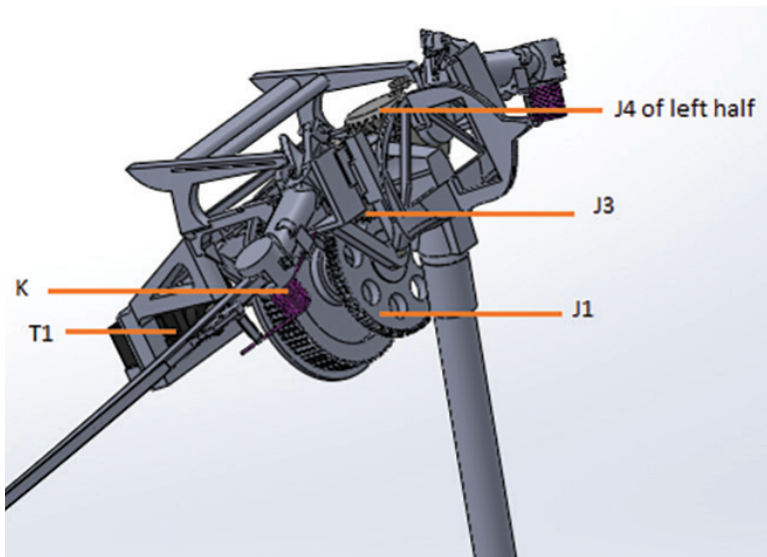
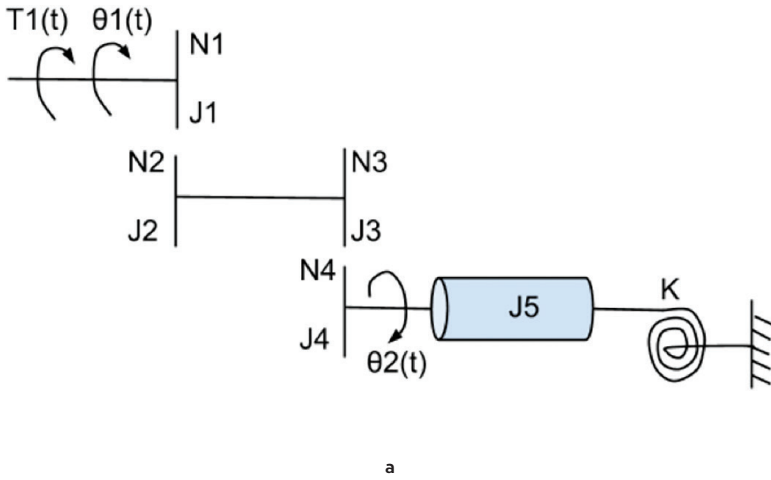


Fig. 12. (a) A control system diagram for the desired wing motion mechanism for each wing, and (b) corresponding gear notations (except spur gear, J2, which is not visible behind bevel gear J3).

## MOTION TRANSFER FUNCTION

For the system shown in Figure 12(a), the equivalent equation of motion (EOM) can be expressed by Equation 2 when transformed into the s-domain.

$$(J_e s^2 + K)\theta_2(s) = T1(s) \frac{N2N4}{N1N3} \quad \text{EQUATION 2}$$

Consequently, Equation 3 shows the transfer function for the system.

$$G(s) = \frac{\theta_2(s)}{T1(s)} = \frac{(N2)(N4)}{J_e(s)^2 + K} \frac{(N1)(N3)}{J_e(s)^2 + K} \quad \text{EQUATION 3}$$

where

$$J_e = J1 \left( \frac{N2N4}{N1N3} \right)^2 + (J2 + J3) \left( \frac{N4}{N3} \right)^2 + J4 + J5$$

## CHECKING FOR STABILITY

A system is stable if every bounded input yields a bounded output [11]. An unstable system can cause damage to the system itself, to adjacent property, or to human life. This is why a stability check was performed in verifying the design. To perform a stability check, the transfer function shown in Equation 3 is required. Transfer functions usually have a numerator and a denominator that can be directly manipulated to check for stability. Through a number of methods, it is possible to check the stability of a system, such as the flapping robot. For higher-order systems, the Routh-Hurwitz criterion would be useful to determine the presence of unstable poles without actually calculating these poles [11]. For systems of lesser order, it may be possible to determine the poles directly to qualify stability.

## EXPERIMENTAL SETUP

As seen in Figure 13, the robot was placed on a retort stand with an inverted spring scale calibrated to measure the lift force produced by the flapping structure in addition to the weight of the robot (about 110 g). The spring scale used in this experiment was an Ajax Scientific Plastic Tubular Spring Scale, 500g/5N Weight Capacity, with a graduation of 10 g. A box fan of 4 m/s was used to mimic a relative air speed of 4 m/s between the bird and the environment. This speed was verified using an anemometer.



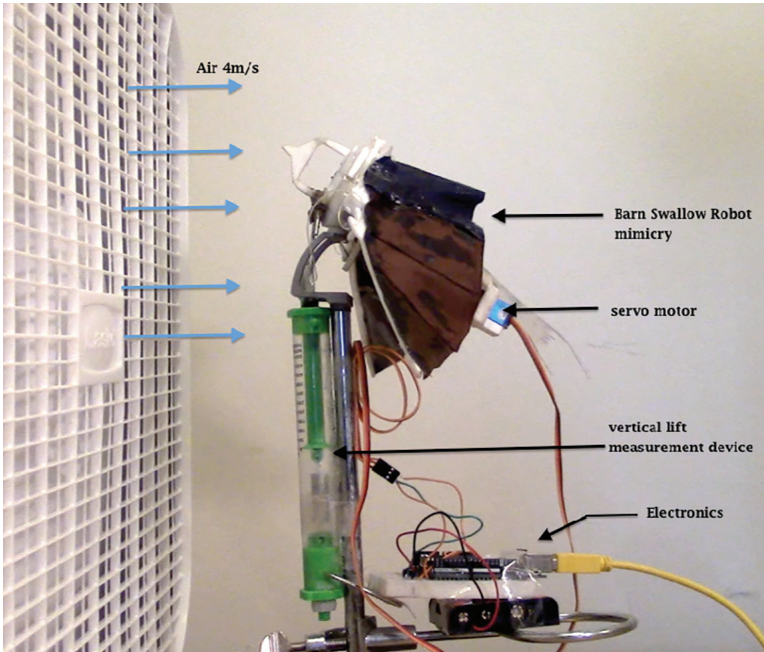


Fig. 13. Experimental Setup with labeled components

The robot was powered by a servo and an Arduino Uno controller. Once the system was turned on, the distance traveled by the spring scale determined how much lift force was derived from the experiment. For this experiment, little variation was observed in the lift force data (except that a limit to the force that could possibly be produced was determined) due to the weight of the robot and other factors. The total lift force was used to calculate the lift coefficient from Equation 1.

## RESULTS

### RESULTS FROM THE STABILITY CHECK

From the physical experimental robot assembly, the following values were substituted into Equation 3 to generate the numerical expression of the transfer function, which was then used to check for the stability of the system for one wing.  $N_1 = 80$  teeth,  $N_2 = 14$  teeth,  $N_3 = 25$  teeth,  $N_4 = 25$  teeth,  $J_1 = 5.0997 \times 10^{-6} \text{ kg}\cdot\text{m}^2$ ,  $J_2 = 2.14386 \times 10^{-8} \text{ kg}\cdot\text{m}^2$ ,  $J_3 = 7.73397 \times 10^{-8} \text{ kg}\cdot\text{m}^2$  and  $J_4 = 7.73397 \times 10^{-8} \text{ kg}\cdot\text{m}^2$ . Notice that  $J_1$  is the largest because for the left wing mechanism, the first (driving) pulley is the largest rotational mechanism of the four, and has the largest polar moment of inertia.

To check for the stability of the flapping mechanism, a numerical expression for the transfer function is first derived as follows:  $J_5$  is neglected for this gear mechanism stability check, and  $J_e$  for the flapping mechanism is calculated as  $J_e = 0.031(5.0997 \times 10^{-6}) + (2.1438 + 7.73397) \times 10^{-8} + 7.73397 \times 10^{-8} = 3.323 \times 10^{-7}$ . Consequently, the transfer function of Equation 3 is expressed as:

$$G(s) = \frac{\left(\frac{14 \times 25}{80 \times 25}\right)}{(3.323 \times 10^{-7})s^2 + 0.093325} = \frac{0.175}{(3.323 \times 10^{-7})s^2 + 0.093325}$$

Setting this denominator equal to zero, the poles can immediately be found for the system. For this system, the poles are the complex conjugate pair  $\pm 529.95j$ . These pole values indicate a marginally stable system, and the system is proven to be inherently stable. This solution does not account for the polar moment of inertia of the wing itself, but this would not affect the marginal stability of the system. Even though this experiment does not investigate the sweeping motion of the wing, this analysis indicates that future work using the sweeping motion would be stable with the system indicated in Figure 12.

## RESULTS FROM CFD

Using the experimental conditions outlined in Table 1, the computation of the ANSYS Fluent Solver produced a graph of the lift coefficient over flow time calculated through Equation 4 for a stationary airfoil:

$$C_L = \frac{\text{Lift}}{\frac{1}{2} \rho V^2 A} \quad \text{EQUATION 4}$$

The graph of lift coefficient produced by the FLUENT solver is shown in Figure 14.

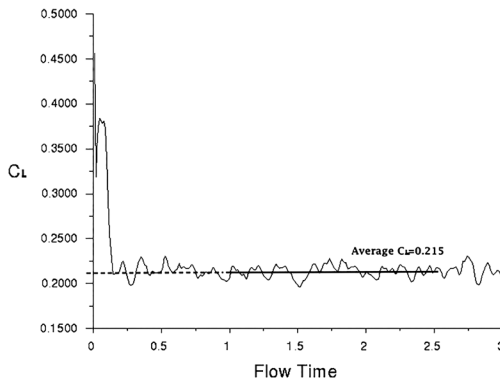
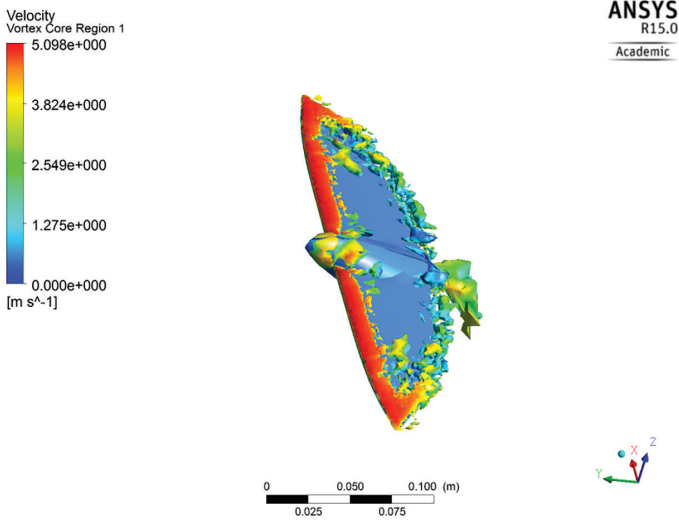


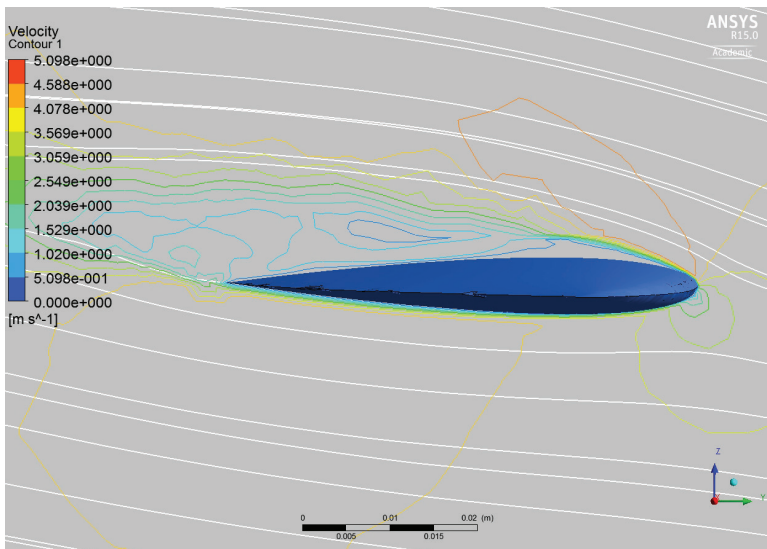
Fig. 14. Lift coefficient history with an average lift coefficient for a Stationary Wing Exercise

# VORTEX STRUCTURES

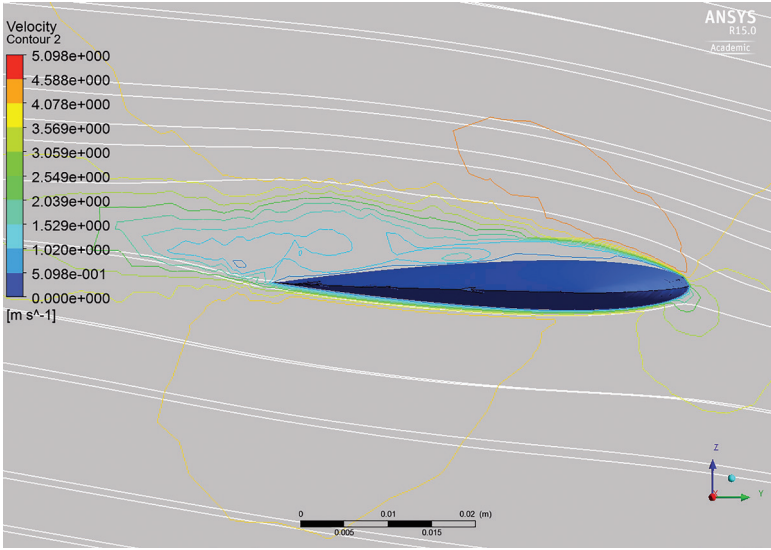
Apart from computing the lift coefficient for the stationary wing case, the ANSYS Fluent Solver was used to visualize the flow field (Figure 15). The rendering was done using ANSYS CFD Post.



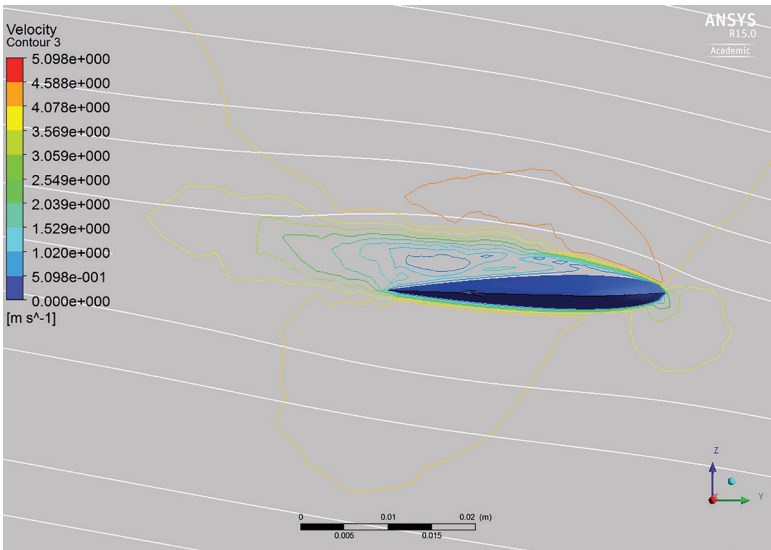
a



b



c



d

Fig. 15. (a) Vortex core region for velocity around the bird model, and (b) section view (velocity contour) through the velocity vortex at 25% span-wise, (c) 50% span-wise and (d) 75% span-wise with streamlines indicating the impact of leading edge vortices.

The average lift coefficient for the computational animation was about 0.215 and the lift coefficient for the current experiment (for the free flapping mechanism) was found to be no more than 0.347. The fact that the

average lift coefficient over stationary wings from the CFD simulation is smaller than that measured in the experiment using flapping wings is reasonable, considering that flapping motion can enhance lift generation with the formation of dynamic LEVs [11].

## DISCUSSION

From the results, it is evident that the lift coefficient for the dynamic wing was higher than that of the stationary one. This result makes sense because the dynamic airfoil has more control over the air around the wing and is able to also adjust to the air (in the case of a natural bird).

The CFD animation visualization in Figure 15(a) shows the presence of leading-edge vortices colored in red by the computational software. The presence of LEVs indicates that they play a major role in the aerodynamics of an avian flyer. If LEVs can be maneuvered, they can greatly impact flight characteristics. It is likely that a wing with a conventional up-and-down flapping motion, although better than a stationary wing in terms of how much lift it produces, is no better than a flapping airfoil with sweeping motions. This is because of destructive interference of vortices at the end of the downstroke and during the beginning of the upstroke [12] of the bird flapping cycle, which a morphing structure is able to avoid by swirling around (rather than destroying) that vortex region, thereby improving the lift coefficient.

The experiment also had its flaws in that the weight of the bird of about 110 g was quite large in order to allow more accurate reading of upward force on the spring scale, which had a graduation of as much as 10 g. The large weight of the bird robot assembly, coupled with the insufficient calibration scale, made it hard to take accurate readings of the upward force derived.

A suggested future study is a dynamic CFD and animation with a user-defined function in the CFD solver, as well as a robot morphing experiment with actuated wing sweep motions in addition to the flapping motion for complete mimicry of the natural bird.

The idea of modifying the aerodynamic profile of a lifting surface to enhance flight control and aircraft performance is not new. The Wright Brothers employed wing warping for seamless flight control in their first flying machine [13]. Conventional control surfaces present various limitations on the maneuverability and the capability of the air vehicle, and they set different constraints on its flight envelope and mission effectiveness.

## CONCLUSION

Similar to the studies referenced in the previous section, this work supports the hypothesis that lift generation is highly affected by the leading-edge vortices on the wings of an avian flyer. More research on the effect of flapping kinematics on the evolution of these leading-edge vortices and their effect on lift generation is to be performed in future work. This work raises the need to further parameterize and characterize how varying wing geometries of an aircraft help improve its lift characteristics at different experimental conditions. With a solid understanding of the performance of the aircraft under these different experimental conditions, it would be possible to create aircraft with wings that morph to improve the effectiveness of commercial aircraft during take-off and landing. In the future, by mimicking or even overhauling the stabilizing purpose of rudders and ailerons that are attached to the wing structures of today's aircrafts, this understanding would also create room for seamless aircraft wing structures that serve as a more generic solution to the instability problem faced by the Wright Brothers. This way, civilians can feel safer when their flights are taking off and landing.

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# Electrochemical Aptamer-Based Sensor for Measuring Astrocytic ATP Release

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## BIOGRAPHY

Brenda Gutierrez graduated *summa cum laude* with a B.S. in Biochemistry and Molecular Biology and a minor in psychology in May 2016. She was a Meyerhoff Scholars Program, National Institute on Drug Abuse (NIDA), Undergraduate Research Award (URA), and Donald Creighton Memorial scholar, as well as a member of Phi Beta Kappa. During her undergraduate career, she enjoyed tutoring general and organic chemistry as well as working in Dr. Ryan White's lab at UMBC. She participated in summer research internships at the University of Minnesota, the Broad Institute of MIT, and Harvard University. Brenda also had the privilege of being part of the Mayo Physicians of Tomorrow Program at the Mayo Clinic in summer 2015. She is now an MD/PhD student at the University of California, Irvine (UCI) where she hopes to conduct neuroscience research. She is also in the Program in Medical Education for the Latino Community (PRIME-LC) at UCI, which fosters future physician leaders in the Latino community. Brenda would like to thank the Meyerhoff Scholars Program, Dr. Freeman Hrabowski, Dr. Ryan White and his lab, Dr. Cynthia Wagner, Dr. Tiffany Gierasch, and Dr. James Fishbein for their support and guidance. She extends another big thanks to NIDA and her URA for helping fund her research, and Mrs. Arlene Creighton for the Donald Creighton Memorial Award.

## DEMYSTIFICATION

My paper stemmed from the work I did in Dr. Ryan White's lab for a little over two years. The goal of the project was to develop a biosensor that could determine the amount of ATP released by cells in the brain, called astrocytes, so we could learn more about the role of this release in the brain and in pathology. I first heard about Dr. White's research during a meeting with my advisor, Dr. James Fishbein, after sharing with him my interest in neuroscience. In order to receive additional funding for my research, I applied for the Undergraduate Research Award, which I learned about from a friend who had obtained it the previous year. As a URA scholar, I had the opportunity to hear about the interesting research being conducted on campus in different fields such as the arts, social sciences, engineering, biology, and chemistry. I was also able to present my research at URCAD towards the end of the year.

## ABSTRACT

The abnormal release of adenosine triphosphate (ATP) by astrocytes has been proposed as a potential astrocyte dysfunction in neurodegenerative diseases. However, the roles of astrocytic ATP release are not fully understood, in part because of the lack of analytical tools. Electrochemical aptamer-based (E-AB) sensors can be utilized for the quantification of ATP released by astrocytes, providing insight into the function of this release in the brain. E-AB sensors use aptamers, oligonucleotides that bind a specific target such as ATP, to measure target concentration. These aptamers undergo a conformational change upon target binding, resulting in an increase in current that is quantitatively related to ATP concentration. We have optimized a micro-cylinder ATP E-AB sensor that will be used to make bulk measurements of ATP released from astrocytes cultured in a three-dimensional (3-D) collagen hydrogel serving as an *in vivo* mimic. In order to make these measurements, we performed calibration titrations to determine the percent signal changes corresponding to different ATP concentrations at room temperature and 37°C. We found that the optimal frequencies used in square wave voltammetry for current measurements increased with increasing temperature. These new optimal frequencies will be used for measurements using cells cultured in a collagen hydrogel.

## INTRODUCTION

Astrocytes are a type of glial cell found in the brain and spinal cord that are five times more abundant than neurons, initially seen as the “brain glue” that hold neurons in place.<sup>1</sup> However, over the past several years, various unknown and surprising functions of astrocytes have been discovered.<sup>2</sup> Astrocytes have been found to be involved in processes including synapse formation and function, maintenance of brain homeostasis, storage and distribution of energy substrates, brain defense, and control of local blood flow.<sup>2,3</sup> Astrocytes even release gliotransmitters, chemicals proposed to modulate neuronal excitability and transmitter release, such as ATP.<sup>4</sup>

The roles of astrocytic ATP release are not fully understood, but astrocytic ATP has been found to mediate glial calcium waves<sup>5</sup> to allow for astrocytic intercellular communication, and possibly inhibit synaptic transmission.<sup>6</sup> Abnormal ATP release has also been identified as a potential source of astrocyte dysfunction in neurodegenerative diseases. One such hypothesis is that amyloid- $\beta$  plaques seen in Alzheimer’s disease cause an increase in the ATP released from astrocytes, thus increasing the amplitude and velocity of glial calcium waves.<sup>7</sup> Astrocytic ATP release has also been found to contribute to synapse elimination, which is vital for forming neural circuits and for proper brain function. Disruption of synapse elimination is likely involved in neurological diseases such as schizophrenia and autism.<sup>8</sup> In addition, ATP released by astrocytes was found to serve as a proliferative factor required for neural stem cell proliferation in the adult hippocampus. Neurogenesis in the hippocampus has been postulated to be important for learning, memory, pattern separation, aging, major depression disorder, and Alzheimer’s disease.<sup>9</sup> Due to the possible roles of abnormal astrocytic ATP release in pathology, measuring extracellular ATP concentrations has become increasingly important.

A commonly used method for measuring ATP is a luciferase bioluminescence assay that uses recombinant luciferase to catalyze the following reaction:



The intensity of the light emitted by this reaction is proportional to the ATP concentration. Therefore, a standard curve is created to correlate measured luminescence with moles of ATP.<sup>10</sup> This assay is sensitive and has a high affinity for ATP, but bioluminescence is required and it relies on the concentration of luciferase, oxygen, and luciferin,<sup>11</sup> reducing the operational convenience of this method of measuring ATP. This assay has been used for astrocytic ATP release measurements,<sup>8,9,12</sup> but in order to gain a better understanding of the role this release has in the brain and in pathol-

ogy, new methods are necessary. Such improved methods for measuring ATP are reagentless and allow for real-time measurements, as they are more applicable to *in vivo* experimentation. A promising new method for ATP measurements is ATP-specific electrochemical aptamer-based (E-AB) sensors.

E-AB sensors utilize covalently-linked aptamers, which are DNA or RNA oligonucleotides that bind a specific target, such as ATP. These aptamers have been modified to contain a thiol group at the 5' end that can form a bond with a gold electrode surface and a redox tag on the 3' end that can accept electrons from the electrode surface. For our experiment, the redox tag is methylene blue, and the binding of the target, or ATP, causes a conformational change in the aptamer that brings the methylene blue closer to the electrode surface, allowing for a more efficient transfer of electrons (Figure 1). This results in an increase in current that can then be used to determine ATP concentration.

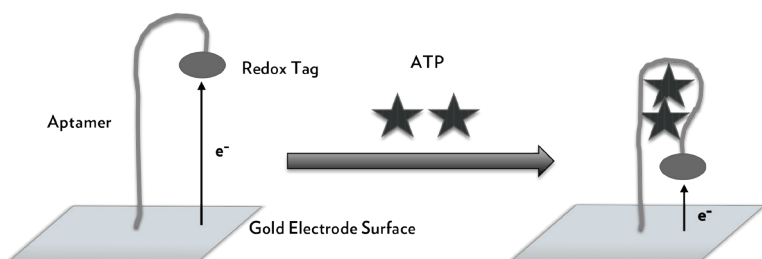


Fig. 1. A schematic demonstrating how electrochemical aptamer-based sensors result in an increase in measured current due to an ATP-dependent aptamer conformational change that brings the redox tag closer to the electrode surface.

E-AB sensors have a redox tag covalently bound to an aptamer immobilized on the electrode surface, making them reagentless. These sensors are also reusable because target binding and the reduction of the methylene blue redox tag are reversible processes.<sup>13</sup> The reagentless and reversible natures of E-AB sensors make them ideal for real-time measurements of target concentration. Measured changes in current occur due to the conformational change of the aptamer upon target binding, providing specificity to the sensor. The specificity of E-AB sensors allows them to be used in complex matrices such as blood, blood serum, saliva, foodstuffs, and cellular extracts.<sup>13</sup> E-AB sensors can also detect a wide range of targets such as proteins, small molecules, and inorganic ions due to the discovery of aptamers specific to these targets.<sup>14</sup> E-AB sensors are a promising biosensor platform that we sought to utilize to measure astrocytic ATP release *in vitro*, and ultimately *in vivo* using mice.<sup>14</sup>

The overall goal of this project was to create a microcylinder ATP E-AB sensor that could measure ATP released from astrocytes cultured in a collagen hydrogel matrix that better mimics *in vivo* conditions. ATP E-AB sensors optimized in the lab via electrodeposition were previously used to conduct ATP titrations in buffer at room temperature. These titrations allowed us to correlate measured changes in current with certain ATP concentrations at room temperature specifically. To use these sensors on astrocytes cultured in a collagen hydrogel, optimal parameters for current measurements at 37°C were determined, and titrations were conducted at 37°C (the temperature at which cells are incubated) in buffer and with the sensors embedded in a collagen hydrogel matrix.

## METHODS

### MICROELECTRODE FABRICATION

Microcylinder E-AB sensors were fabricated using handmade gold microelectrodes 50  $\mu\text{m}$  in diameter. A Teflon-coated gold wire was used to make these microcylinder electrodes. The Teflon was melted back at one end to expose the gold wire, which was then wrapped around the end of a tungsten rod (0.010 in. x 3 in.) and glued in place using conductive silver epoxy. The gold wire-tungsten rod assembly was then inserted into a soda lime glass capillary (1.65 mm outer diameter and 1.10 mm inner diameter) so that part of the Teflon-coated gold wire was sticking out of the capillary. Resin epoxy was then used to seal both ends of the capillary and the gold wire was exposed at the other end by melting back the Teflon.

### 2 MM E-AB SENSOR FABRICATION

Some E-AB sensors were fabricated using polycrystalline gold electrodes 2 mm in diameter. Before the electrode surfaces were modified, the electrodes were first mechanically cleaned by polishing in a circular motion on a microcloth using a 1  $\mu\text{m}$  monocrystalline diamond suspension and then in a 0.05  $\mu\text{m}$  alumina oxide slurry for one minute each. The electrodes were rinsed and sonicated with ultrapure water for five minutes after each polishing step. After the 2 mm electrodes were hand-polished, they were electrochemically cleaned through several voltammetric scans in dilute sodium hydroxide and sulfuric acid solutions.<sup>15</sup> The electrodes were then incubated in a 200 nM aptamer solution using Tris buffer (100 mM sodium chloride, 20 mM Trizma base, and 5 mM magnesium chloride) for approximately one hour at room temperature. Two different ATP aptamers were used, called the destabilized (5' HSC6-CTGGGGGAGTATTGCGGAG-GAAA-MB 3') and antisense 2 (5' HSC6-ACCTGGGGGAGTATTGCG-

GAGGAAGGTTTTTTTCTT-MB 3') aptamers. The sensors were rinsed and then incubated in a 30 mM mercaptohexanol solution for about one hour to form a self-assembled monolayer passivating the rest of the electrode surface.

## MICROCYLINDER E-AB SENSOR FABRICATION

The microcylinder electrodes were electrochemically cleaned via several voltammetric scans in dilute sodium hydroxide and sulfuric acid solutions as well. Gold nanoparticles were then electrodeposited onto the gold electrode surface to increase the signal-to-noise ratio of the microcylinder sensor, as oxygen reduction becomes a prominent issue for sensors of this size. Electrodeposition was conducted by immersing the electrodes in a stirred solution of 20 mM  $\text{HAuCl}_4 \cdot 3\text{H}_2\text{O}$  and 0.5 M HCl. A pulsed waveform from 0 to -0.4 V (vs. Ag/AgCl) with a frequency of 1 Hz for 60 seconds was applied to reduce gold nanoparticles onto the electrode surface,<sup>16</sup> and the electrode was then modified with the aptamer and mercaptohexanol as mentioned above.

## COLLAGEN POLYMERIZATION AROUND SENSORS

A 2 mg/mL collagen solution was prepared by first mixing (final volume of gel solution, mL/10) mL of 10X DMEM and 7.5%  $\text{NaHCO}_3$  solution, then adding (final volume of gel solution, mL – vol. of collagen, mL – vol. of 10X DMEM, mL – vol. of 7.5%  $\text{NaHCO}_3$ , mL) mL of water, and lastly (final volume of gel solution, mL x final collagen concentration, mg/mL / stock concentration, mg/mL) mL of rat tail collagen I. If the solution was not pink or basic after mixing, another volume of  $\text{NaHCO}_3$  was added because collagen does not polymerize well in acidic conditions. All of this was done on ice to prevent collagen polymerization. The sensors were immersed and incubated in the collagen solution for approximately 45 minutes at 37°C and 5%  $\text{CO}_2$ <sup>17</sup> until the collagen polymerized around the sensors.

## ELECTROCHEMICAL MEASUREMENTS

The sensors alone or sensors embedded in collagen were immersed in 3 mL of Tris buffer, and then desired amounts of ATP were added to the buffer. Current measurements were made approximately one to two minutes after ATP was mixed into the buffer, using square-wave voltammetry at different frequencies, a pulse amplitude of 25 mV, and a voltage increment of 1 mV. Sensors were rinsed with ultrapure water when transferring them from an ATP-buffer solution to buffer alone. The peak currents were measured and the percent signal changes were calculated using the equation:  $((\text{peak current measured with ATP} - \text{peak current measured with buffer only}) / \text{peak current measured with buffer only}) \times 100\%$ .

## RESULTS AND DISCUSSION

The goal of the project was to fabricate microcylinder ATP E-AB sensors capable of measuring ATP released from astrocytes cultured in a collagen hydrogel matrix in order to better mimic *in vivo* conditions. Before conducting these measurements, ATP titrations were conducted in Tris buffer at 37°C to correlate measured current changes with specific ATP concentrations at the temperature at which astrocytes are incubated. Current measurements at 37°C were first made using 2 mm electrodes. In this experiment, only the destabilized ATP aptamer was used along with square-wave voltammetry at 60 Hz. The sensor showed signal-off behavior, a decrease in current with increased ATP concentration (Figure 2), instead of the signal-on behavior, an increase in current with increased ATP concentration, normally seen at room temperature using the same parameters.

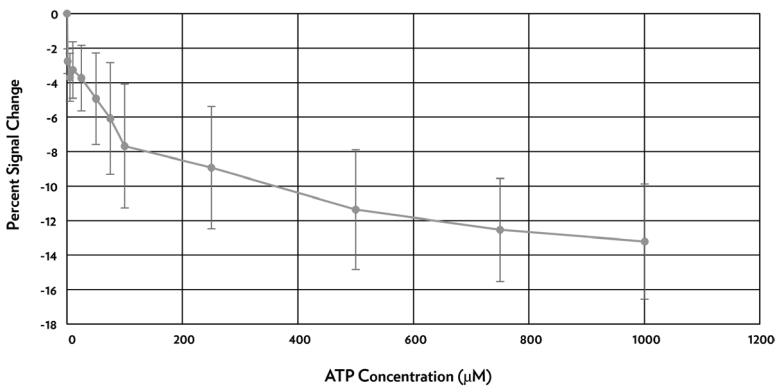
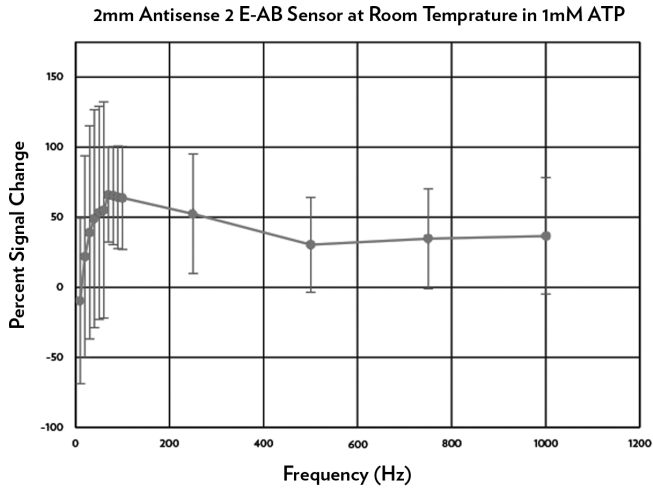
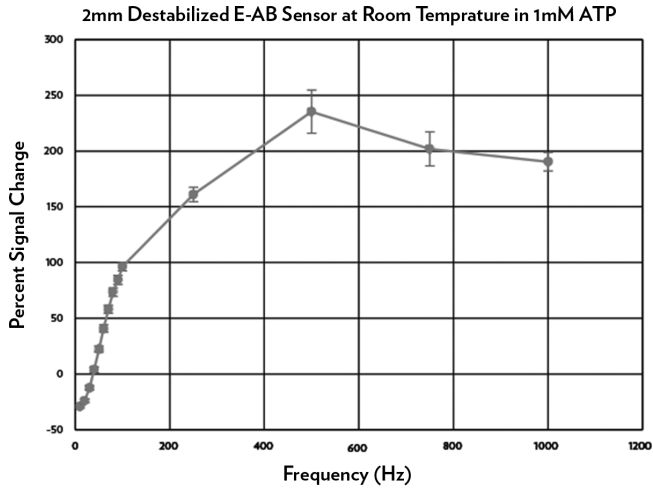


Fig. 2. Titrations conducted at 37°C and 60 Hz with the 2 mm destabilized E-AB sensors displayed signal-off behavior. (Error bars represent the standard deviation of 3 independently fabricated electrodes).

Signal-on and signal-off behavior have been found to be influenced by the frequency used in square-wave voltammetry.<sup>18</sup> Testing determined how the optimal frequency (frequency that gives the greatest percent signal change) of this destabilized ATP E-AB sensor changed with a change in temperature. The optimal frequency of the E-AB sensor using the destabilized aptamer was 500 Hz at room temperature and 750 Hz at 37°C (Figure 3), demonstrating that the optimal frequency had increased with an increase in temperature. In addition, the destabilized ATP E-AB sensor exhibited signal-off behavior at frequencies lower than 70 Hz, which explains the signal-off behavior observed at 60 Hz in Figure 2. To determine whether this increase in optimal frequency was specific to the destabilized aptamer or if it was seen in other aptamers as well, frequency sweeps of ATP E-AB sen-

sors using the antisense 2 aptamer were conducted. Antisense 2 E-AB sensors also demonstrated an increase in optimal frequency with an increase in temperature, increasing from 70 Hz at room temperature to 100 Hz at 37°C (Figure 3).





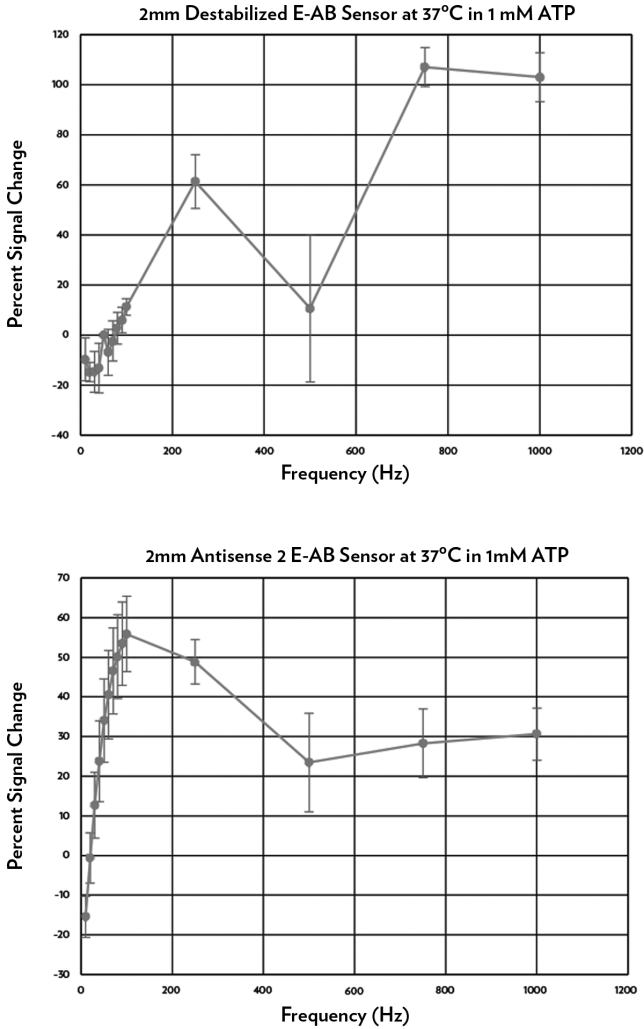
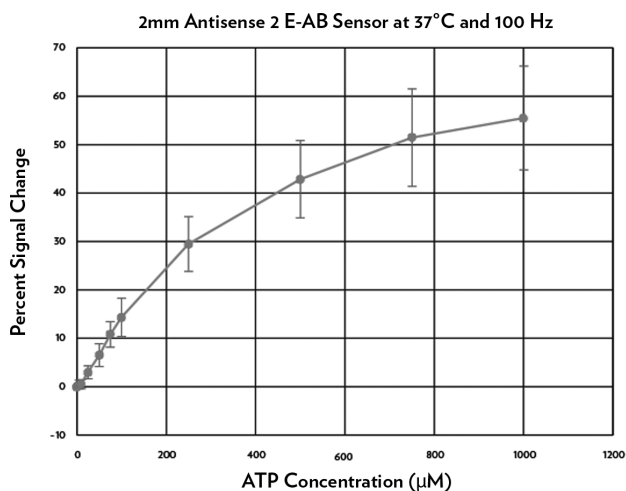
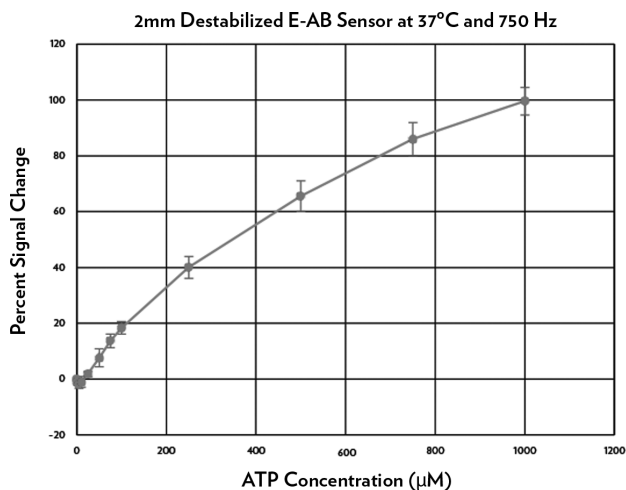


Fig. 3. Frequency sweeps at 1 mM ATP showed an increase in optimal frequency for both the destabilized and antisense 2 ATP E-AB sensors when the temperature was increased from room temperature to 37°C. (Error bars represent the standard deviation of 3 independently fabricated electrodes).

Using the measured optimal frequencies at 37°C, titrations were conducted at this temperature for both the destabilized and antisense 2 ATP E-AB sensors using the 2-mm electrodes. The 2 mm ATP E-AB sensors indeed displayed signal-on behavior (Figure 4). At 1 mM ATP and 37°C, the 2 mm destabilized E-AB sensor at optimal frequency of 750 Hz showed approximately 100% signal change (Figure 4), which is close to the percent signal change measured in Figure 2 of around 110%. For the antisense 2 E-AB sen-

sors at 1 mM ATP, 37°C, and 100 Hz, the 2 mm sensors showed a percent change of around 55% (Figure 4), the same as Figure 2. Once the optimal frequencies at 37°C were determined and the titrations at these frequencies displayed the expected signal-on behavior, the sensors were then fabricated using microcylinder electrodes which are smaller and more ideal for cellular measurements. The microcylinder destabilized sensor showed a percent signal change around 80%, while the microcylinder antisense 2 sensor showed about a 20% signal change at 1 mM ATP, 37°C, and their optimal frequencies (Figure 4).



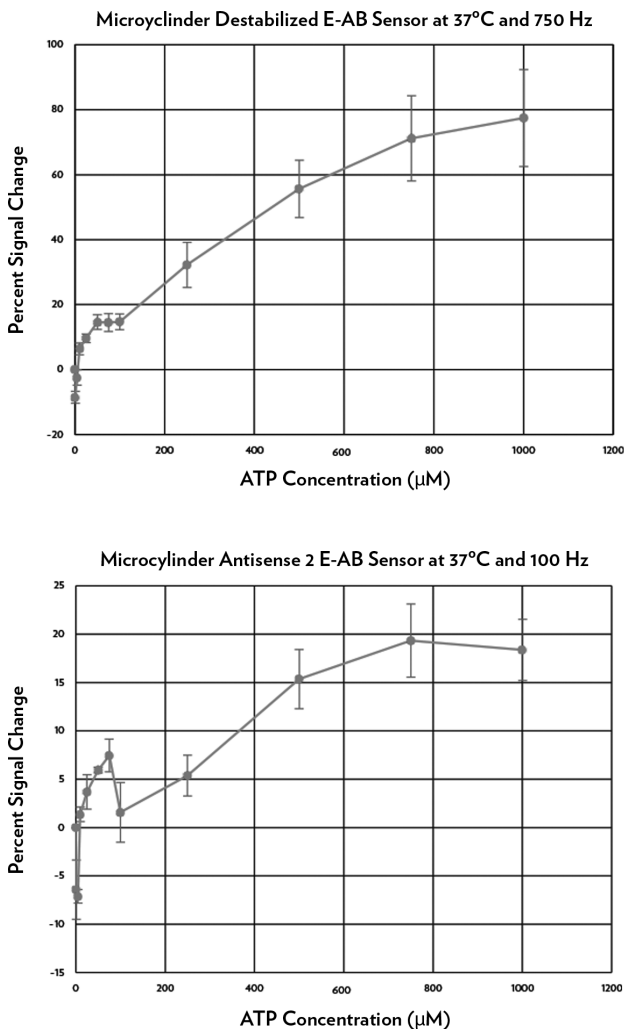


Fig. 4. Titrations of 2 mm and microcylinder destabilized or antisense 2 ATP E-AB sensors at 37°C and optimal frequencies. All of the titrations exhibit signal-on sensor behavior. (Error bars represent the standard deviation of 3 independently fabricated electrodes).

Analyzing Figure 5, which shows normalized current as a function of time, can address why the optimal frequency of a sensor increases when the temperature is raised. The current is normalized so that the area under each curve, or the amount of charge transferred, is the same. This normalization is necessary because the aptamer concentration is constant, and the amount of methylene blue tethered to the electrode surface via an aptamer should be as well. The current at a particular point in time is calculated using the equation  $i(t) = kQ^{-kt}$ , where  $i$  is current (C/s),  $k$  is the rate constant

( $s^{-1}$ ),  $Q$  is charge (C), and  $t$  is time (s). We hypothesized that an increase in temperature leads to more frequent collisions between methylene blue and the electrode surface (increase in  $k$ ), resulting in an increase in the current decay rate. This may explain why a greater frequency (70 Hz instead of 50 Hz) must be used in order to obtain the same increase in current upon target binding. In addition, if we look at 35 ms, or approximately 30 Hz, the sensor will be signal-on at room temperature and signal-off at 37°C.

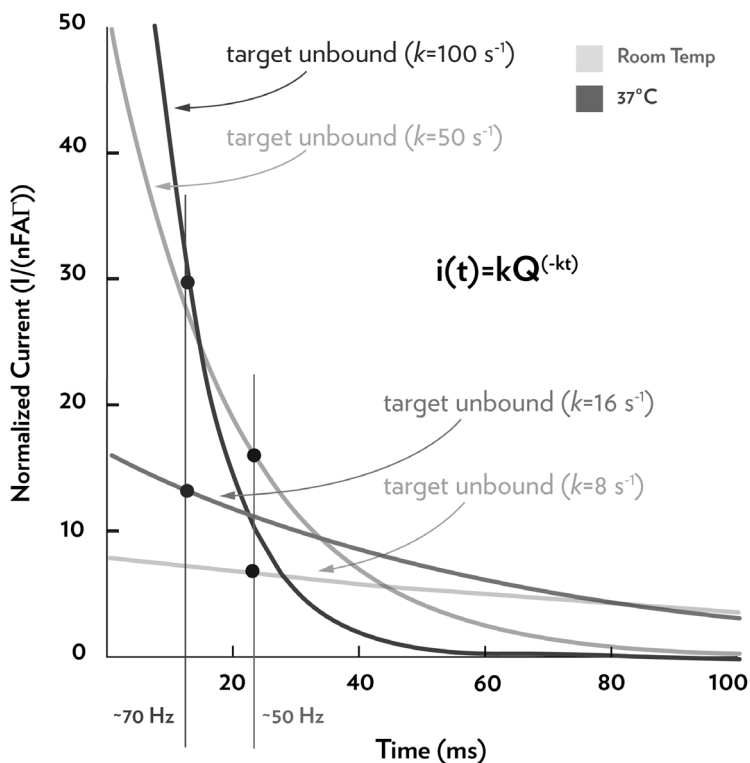


Fig. 5. A model of current decay at different temperatures and in bound or unbound aptamer states.  $i$  is current (C/s),  $n$  is the stoichiometric number of electrons involved in the electrode reaction,  $F$  is Faraday's constant (C/moles of electrons),  $A$  is the area of the electrode ( $cm^2$ ),  $\Gamma$  is surface coverage of electroactive species ( $mol/cm^2$ ),  $k$  is rate constant ( $s^{-1}$ ), and  $Q$  is charge (C). The line at 50 Hz and the line at 70 Hz represent frequencies at which the change in current is the same at the different temperatures.

After it was found that using the optimal frequencies for conducting titrations at 37°C was successful for the microcylinder sensors as well, we conducted titrations of microcylinder sensors embedded in a 2 mg/mL collagen hydrogel matrix. This step is necessary as the ATP measurements will be conducted on astrocytes cultured in a collagen hydrogel at 37°C. We

focused on the destabilized ATP sensor because it produced a greater percent signal change than the antisense 2 sensors. The titrations were conducted at 37°C and 750 Hz, and an increase in the percent signal change as the ATP concentration increased was observed (Figure 6). However, the error bars are large, and further repetitions of the experiment may need to be performed.

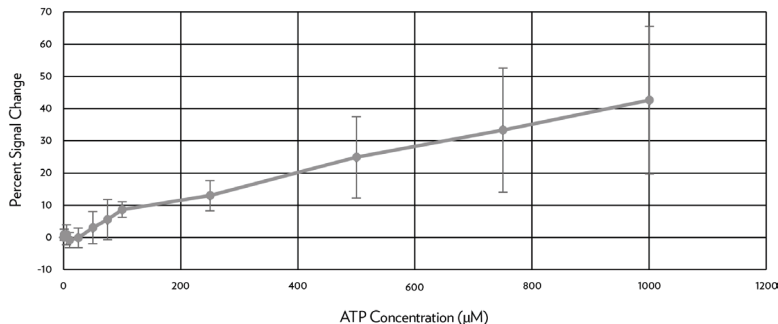


Fig. 6. Titration of a microcylinder destabilized E-AB sensor embedded in a 2 mg/mL collagen hydrogel at 37°C and 750 Hz. (Error bars represent the standard deviation of 3 independently fabricated electrodes).

ATP E-AB sensors are promising for real-time and *in vivo* measurements, as they are reagentless, reusable, and specific. However, these sensors have several limitations. There are a finite number of aptamers that fit on a confined electrode surface area modified with redox tags that accept up to one or two electrons. This limits the sensitivity and limit of detection of E-AB sensors.<sup>13</sup> This problem becomes more prominent with smaller electrodes, as the electrode surface area is reduced. Electrodeposition was found to improve the signal-to-noise ratio of smaller sensors<sup>16</sup> and was used on our microcylinder electrodes. The observed increase in signal-to-noise ratio may be due to the increase in electrode surface area upon the electrodeposition of gold nanoparticles onto the electrode surface. Another limitation of E-AB sensors comes from the structural and functional dependence of DNA on environmental factors such as pH, temperature, and ionic strength.<sup>13</sup> These factors are homeostatically regulated in the body, but have to be taken into consideration when conducting *in vitro* studies. When compared to the luciferin-luciferase method of measuring ATP, our ATP E-AB sensor is less sensitive.<sup>10</sup> However, the operational convenience and potential for *in vivo* measurements make further optimization of these sensors desirable. An exciting characteristic of the E-AB sensor is that the platform can be applied to the measurement of various targets as long as an aptamer specific to that target is available. Therefore, the possibilities and implications are vast.

## CONCLUSIONS

In these experiments, we determined the optimal frequency for the destabilized ATP E-AB sensor to be 750 Hz at 37°C and 500 Hz at room temperature, whereas the optimal frequency for the antisense 2 sensor was 100 Hz at 37°C and 70 Hz at room temperature. We postulated that this increase in frequency was due to the increase in the current decay rate resulting from more methylene blue collisions with the electrode surface because of an increased temperature. This hypothesis also helped explain why the sensors were signal-off at 60 Hz and signal-on at 750 Hz. Using the optimal frequency, we conducted ATP titrations of the microcylinder destabilized ATP E-AB sensors embedded in a collagen hydrogel matrix at 37°C. This will allow us to determine the concentration of ATP released by astrocytes cultured in a collagen hydrogel based on the measured percent signal changes.

## FUTURE DIRECTIONS

In the future, we would like to repeat the titrations of the sensors in collagen in order to obtain data with smaller error bars. Before doing this, we would like to conduct a current-time trace in order to determine how long it takes the ATP to diffuse through the collagen. This will give us an idea of how much time to wait after the addition of ATP before making any current measurements in order to more accurately determine ATP concentration. Once we have the titration curve, we can then measure changes in ATP concentration upon astrocytic stimulation by exposing astrocytes to  $\text{Ca}^{2+}$ ,  $\text{K}^+$ , or glutamate.<sup>12</sup> We can also determine whether the presence of these species affects measured percent signal changes. In the future, it would also be interesting to use a different hydrogel to better mimic *in vivo* conditions, as proposed by Placone *et al.* This hydrogel consists of collagen 1 for structural support, hyaluronic acid to mimic brain extracellular matrix, and matrigel to provide endothelial compatibility as astrocytes completely surround and interact with brain capillaries.<sup>19</sup>

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# Skeletal Muscle Atrophy Model

author

**Samantha Furman**

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## **BIOGRAPHY**

Samantha Furman is a senior Meyerhoff Scholars Program scholar and a MARC U\*STAR scholar pursuing a mathematics major and statistics minor at UMBC. After graduating in spring 2017, she will pursue a Ph.D. in the joint Computational Biology program at Carnegie Mellon University and University of Pittsburgh. During her time at UMBC, Samantha has been a Calculus II teaching assistant, mathematics tutor for the athletic department, and a grader for the mathematics department. She has also held the positions of Vice President of the Mathematics and Statistics Council of Majors, Vice President of Programming for the Delta Phi Epsilon International Social Sorority, and Vice President of Scholarship for the Panhellenic Association. Samantha would like to thank the Schneider Laboratory for their assistance, as well as her mentor Dr. Bradford Percy for his guidance and wisdom. She would also like to thank both the Meyerhoff Scholars Program and MARC U\*STAR Program for their help in guiding her towards the research field.

## DEMYSTIFICATION

I met Dr. Bradford Peercy during my first semester of college when I took his linear algebra course. In class, he would often discuss the applications of linear algebra to the research that his lab conducted. I took interest in his research and after participating in a summer research internship at the University of Chicago, I joined Dr. Peercy's lab at the start of my sophomore year. Dr. Peercy had previously laid a solid foundation to a project involving skeletal muscle atrophy, collaborating with Dr. Martin Schneider at the University of Maryland School of Medicine. Dr. Schneider works to investigate how a skeletal muscle degrades over time, in hopes of discovering how to prevent the degradation. Their work began the development of a project creating a model to simulate skeletal muscle atrophy. Part of this project was investigating various stimuli that either activate or decrease the degradation. I began working on this project with my then partner, Graham Antoszewski, who was a senior at the time, and we created a model using differential equations to simulate the atrophy process.

## ABSTRACT

Skeletal muscle atrophy occurs when there is a higher concentration of the transcription factor Forkhead box protein O1 (Foxo-1) inside the nucleus of a skeletal muscle cell than in the cytoplasm. Within a skeletal muscle cell, only dephosphorylated Foxo-1 can enter the nucleus, while only phosphorylated Foxo-1 can exit the nucleus. External stimuli such as insulin and leptomycin can activate a series of events in the cytoplasm, starting with the activation of protein kinase B (Akt) and ending with the phosphorylation of Foxo-1. Modeling the effects of these external stimuli can provide insight into how the skeletal muscle cell functions and how muscle degrades. The original model of this system was a time-dependent function with fixed parameters for the rates of phosphorylation and dephosphorylation as well as for insulin concentration. Our goal was to build on this study by shifting the fixed values of external stimuli to dynamic values and transform our time-dependent model into a dynamic model dependent on external stimuli concentration as well as time. We connected a previous model of insulin-like growth factor 1 (IGF-1) activation of Akt to our model of Akt phosphorylation of Foxo-1 in order to quantify the impact of IGF-1 on the nuclear-cytoplasmic ratio of Foxo-1. Differential equations, non-dimensional analysis, parameter optimization, and simulation conducted with MATLAB and other dynamical systems softwares were used in this study. We were able to create a functioning model that simulates the effects of IGF-1 on the nuclear-cytoplasmic ratio of Foxo-1. This research is a good

foundation for future studies that may model other external stimuli nuclear translocation systems based on similar mathematical analyses.

## INTRODUCTION

The goal of this project was to create a dynamic model to accurately predict the effects of external stimuli on skeletal muscle cells and determine which stimuli can potentially limit muscle degradation. Skeletal muscle atrophy is the deterioration of muscle cells, most commonly caused by aging or as a result of a medical ailment such as cancer, diabetes, or heart disease [1]. Often, patients who are immobile while ill or in recovery must later regain strength in atrophied muscles [2]. Modeling the effects of external stimuli on skeletal muscle cells will allow us to apply our findings at the cellular level to our understanding of degradation in the whole muscle.

Forkhead box (Fox) proteins are a class of transcription factors important in understanding atrophy. In skeletal muscle cells, the nuclear concentration of forkhead box protein O1 (Foxo-1) controls muscle-degrading proteins and determines the rate of muscle atrophy [3]. By investigating how external stimuli affect Foxo-1 concentration in the nucleus, we can better understand muscle degradation beyond the cellular level. Previously, we examined the effects of insulin-like growth factor 1 (IGF-1) on the phosphorylation of Foxo-1, and how IGF-1 affects the movement of Foxo-1 in and out of the nucleus, as shown in Figure 1. An increase in nuclear Foxo-1 concentration enhances transcription of muscle-specific RING finger protein (MuRF1) and muscle atrophy F-box (MAFbx)/atrogin-1 genes, which are linked to muscle degradation and wasting [2]. The ratio of nuclear to cytoplasmic Foxo-1 (N/C) levels is essential to muscle atrophy, as a higher concentration of nuclear Foxo-1 caused by a lower fraction of activated nuclear Akt pathways yields more muscle loss.

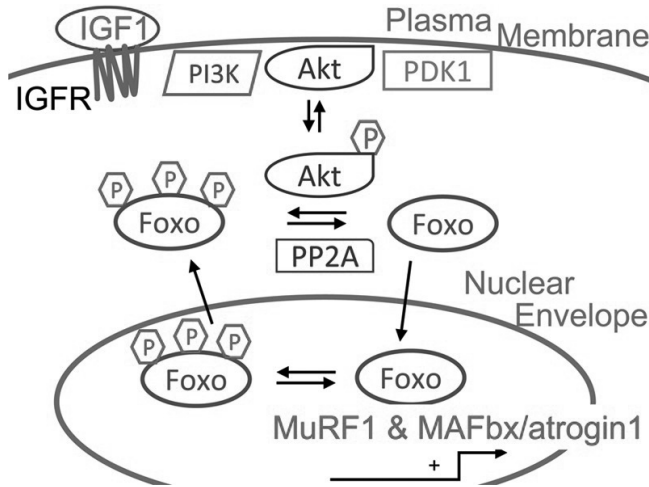


Fig. 1. A schematic of the IGF-1/P13K/PDK1/Akt activation channel pathway within the skeletal muscle cell. The presence of IGF-1 activates the IGF receptor (IGFR), which then triggers a signal cascade. IGFR activates phosphatidylinositol 3-kinase (P13K), which causes plasma membrane lipid phosphorylation and activation of phosphoinositide-dependent kinase 1 (PDK1). PDK1 phosphorylates and activates the Akt enzyme, and the activated Akt phosphorylates Foxo-1 in the cytoplasm. Through the nuclear import system, only dephosphorylated Foxo-1 can enter the nucleus, and through the nuclear export system, only phosphorylated Foxo-1 can exit the nucleus [3]. Nuclear Akt and protein phosphatase 2A (PP2A) action are not indicated in the diagram, but PP2A dephosphorylates Foxo-1 in the cytoplasm and also possibly in the nucleus.

As the activation of Akt begins the phosphorylation process of Foxo-1, our analysis relied on developing a model of the insulin-dependence of Akt. Understanding this pathway by writing Akt as a function of insulin incorporated insulin into the influx and efflux rates constants, ultimately leading to the nuclear-cytoplasmic ratio explicitly depending on insulin in the model.

## PREVIOUS WORK

We previously created a model to show the effects of external stimuli on skeletal muscle degradation. Figure 2 shows the governing processes for the varying concentrations of the phosphorylated and dephosphorylated Foxo-1 within the nucleus and cytoplasm. The four-state system of Figure 2(A) was reduced to the two-state system of Figure 2(B), which was used to produce the model.

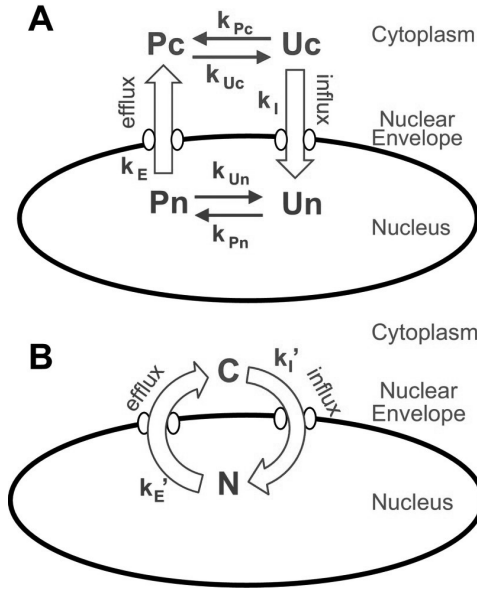


Fig. 2. Kinetic reaction schemes for Foxo-1 nuclear-cytoplasmic movements. A: A four-state diagram with the nuclear/cytoplasmic Foxo-1 phosphorylated ( $P_n/P_c$ ) and dephosphorylated ( $U_n/U_c$ ) states, the nuclear/cytoplasmic phosphorylation ( $k_p/k_p$ ) and dephosphorylation ( $k_u/k_u$ ) rate constants, and the nuclear influx ( $k_i$ ) and efflux ( $k_e$ ) rate constants of Foxo-1. B: A simplified two-state diagram with nuclear (N) and cytoplasmic (C) concentrations of Foxo-1, where the phosphorylated and dephosphorylated rate constants of the four-state diagram have been integrated into the nuclear influx ( $k'_i$ ) and efflux ( $k'_e$ ) rate constants [3].

Using the laws of mass action, we can describe the four-state model in Figure 2(A) as the Equation Set 1.

$$\frac{dU_c}{dt} = -k_{p_c} U_c + k_{u_c} P_c - k_i U_c$$

$$\frac{dP_c}{dt} = k_{p_c} U_c - k_{u_c} P_c + \frac{V_n}{V_c} k_e P_n$$

$$\frac{dU_n}{dt} = -k_{p_n} U_n + k_{u_n} P_n + \frac{V_c}{V_n} k_i U_c$$

$$\frac{dP_n}{dt} = k_{p_n} U_n - k_{u_n} P_n - k_e P_n$$

EQUATION SET 1

where  $k_{p_n}$  is the rate constant of nuclear phosphorylation,  $k_{u_n}$  is the rate constant of nuclear dephosphorylation,  $k_{p_c}$  is the rate constant of cytoplasmic phosphorylation,  $k_{u_c}$  is the rate constant of cytoplasmic dephosphorylation,  $k_i$  is the rate constant of Foxo-1 influx into the nucleus,  $k_e$  is the rate constant of efflux from the nucleus,  $V_c$  is the cytosolic volume, and  $V_n$  is the nuclear volume [3].

We assume the following:

$$C = U_c + P_c$$

$$N = U_n + P_n$$

where  $C$  is the concentration of Foxo-1 in the cytoplasm and  $N$  is the concentration of Foxo-1 in the nucleus. Assuming that the phosphorylation and dephosphorylation processes occur much faster than the influx and efflux, we can then consider the rapid equilibration situation. Accordingly, in the cytoplasm, and in the nucleus respectively,

$$k_p U_c = k_u P_c$$

$$k_p U_n = k_u P_n$$

With these relations, it is possible to produce the new efflux ( $k_E'$ ) and influx ( $k_I'$ ) rate constants shown in Figure 2(B). These new rate constants are the previous influx and efflux rate constants seen in Figure 2(A) scaled by the rate constant fractions as seen in Equation Set 2.

$$k_I' = \frac{k_{U_c}}{k_{U_c} + k_{P_c}} k_I$$

$$k_E' = \frac{k_{P_n}}{k_{P_n} + k_{U_n}} \widehat{k}_E$$

$$\widehat{k}_E = \varepsilon k_E, \quad \varepsilon = \frac{V_n}{V_c}$$

EQUATION SET 2

The changes in the states of the reduced model in Figure 2(B) are presented in Equation Set 3.

$$\frac{dC}{dt} = \varepsilon (k_E' N - k_I' C)$$

$$\frac{dN}{dt} = -k_E' N + k_I' C$$

EQUATION SET 3

Solving for the  $N$  and  $C$ , Equation 1 was developed in order to represent the nuclear-cytoplasmic ratio of Foxo-1 as a function of time.

$$\frac{N}{C} = \frac{k_I'}{k_E'} \left( \frac{k_I'}{k_E'} - \frac{N_0}{C_0} \right) e^{-k_E' t}$$

EQUATION 1

where  $\left(\frac{N}{C}\right)$  is the nuclear-cytoplasmic ratio of Foxo-1, and  $\left(\frac{N_0}{C_0}\right)$  is the starting value of this ratio for a given time range. From Equation 1, it is possible to determine the approximate influx and efflux rate constants from a given set of experimentally-determined data.

# FITTING THE LEPTOMYCIN MODEL

Before we produced our dynamic model, we used Equation 1 to analyze the effects of external stimuli on the observed influx and efflux rate constants. For this experiment, leptomyacin blocked all efflux when injected into the skeletal muscle cell. Our prediction was that  $k_E'$  should approach zero (as efflux was blocked) while  $k_I'$  should stay the same. Data was generated for a control period before injection of leptomyacin, and a period after injection of leptomyacin. To verify the change in influx and efflux rate constants, both the control and injected phase data were fitted with Equation 1 via MATLAB. Both fits are shown in Figure 3.

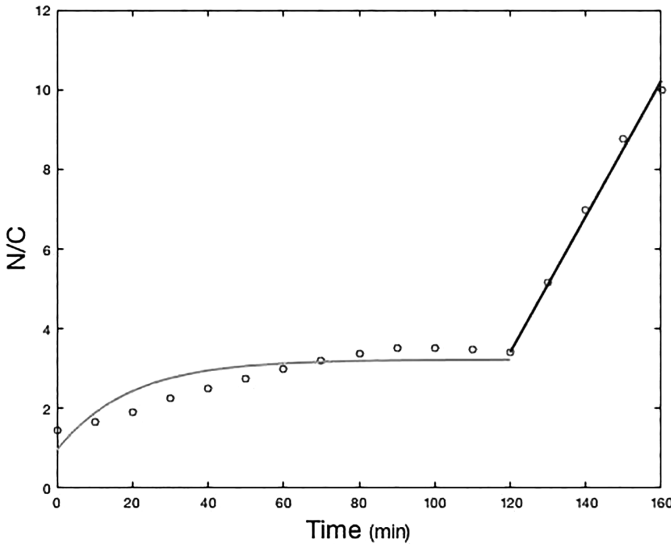


Fig. 3. The open dots are the experimental data points for the control and leptomyacin injected phases of the cell. The first curve from time zero to 100 minutes is the fitted control phase and the second curve from time 120 to 160 minutes is the fitted leptomyacin injected phase.

The efflux and influx rate constants ( $\text{min}^{-1}$ ) for both phases are shown in Table 1. Looking at the fitted values,  $k_E'$  does approach close to zero, but  $k_I'$  does not remain constant. The reason for the unexpected change in  $k_I'$  is currently unknown and future directions include further investigation into how this change came about.

TABLE 1

CONTROL	LEPTOMYCIN
$k_E' = 0.015$ $k_I' = 0.0611$	$k_E' = 10^{-10}$ $k_I' = 0.16$

# INTEGRATING INSULIN/IGF-1 INTO THE FOXO-1 MODEL

The glucose transporter (GLUT) model used by Quon *et al.* [4] incorporates insulin injection until Akt activation. Our Foxo-1 model considers Akt activation until influx and efflux of Foxo-1. The GLUT model in tandem with our model includes insulin injection until Foxo-1 flux. We consider a range of insulin values from  $10^{-13}$  M to  $10^{-3}$  M in small increments to obtain the data used in Figure 4.

We fitted the data points using a standard hill function, which results in Akt activation as a function of insulin (ins) as shown in Equation 2

$$Akt(\text{insulin}) = \frac{9.1681^{1.1189}}{i^{1.1189} + 4.258^{-11}} \quad \text{EQUATION 2}$$

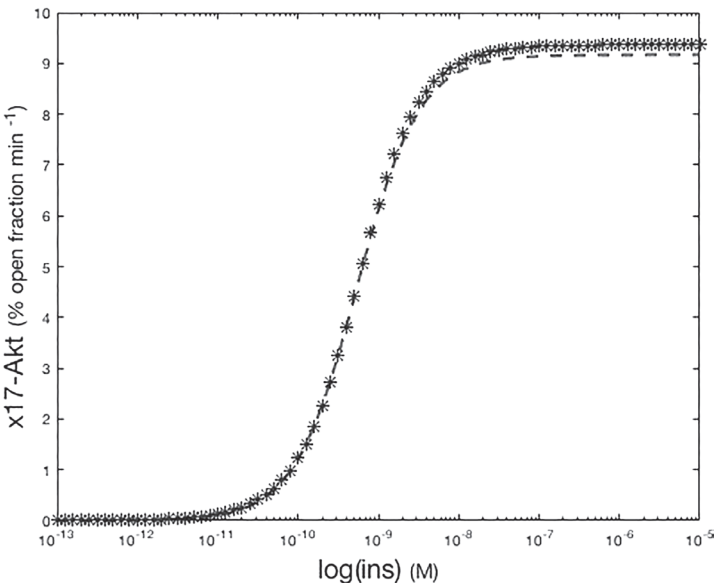


Fig. 4. In order to view the behavior appropriately, the semilog scale was used in creating this plot. The stars represent the data we received from looping through the GLUT model for a wide range of insulin values while the dashed line is the fitted Akt(ins) function.

In order to fully integrate insulin into the Foxo-1 model, we included insulin into the influx and efflux rate constants. In the cytoplasm, activated Akt will phosphorylate Foxo-1, and therefore the activated Akt is a part of  $k_{pe}$ . Details about the pathway phosphorylating Foxo-1 in the nucleus are unknown, except that this pathway behaves similarly to the phosphoryla-



tion of Akt in the cytoplasm [3]. Consequently, we can conclude that the phosphorylation rates are similar. In the nucleus, we assumed that  $k_p$  is an Akt-dependent rate constant as well, since it determines phosphorylation of Foxo-1. Therefore, we included the Akt(Ins) function into  $k_p$  as well. To account for the influence of the Akt function,  $\bar{k}_p$  and  $k_p$  were modified to  $\bar{k}_p$  and  $\bar{k}_p$ . With these substitutions, we produced Equation Set 4.

$$k_I' = \frac{k_{U_c}}{k_{U_c} + \bar{k}_p Akt(Ins)} k_I = \frac{1}{1 + \kappa Akt(Ins)} k_I \quad \kappa = \frac{\bar{k}_p}{k_{U_c}}$$

EQUATION SET 4

$$k_E' = \frac{\bar{k}_p Akt(Ins)}{\bar{k}_p Akt(Ins) + k_{U_n}} \hat{k}_E = \frac{\alpha Akt(Ins)}{\alpha Akt(Ins) + 1} \hat{k}_E \quad \alpha = \frac{\bar{k}_p}{k_{U_n}}$$

From the experimental data at the Schneider lab published by Wimmer et al [3], we know the values for  $k_I'$  and  $k_E'$  in the control and IGF-1 injected cells. With these values and the  $k_I'$  and  $k_E'$  functions of insulin, we have four equations with four unknowns, as shown in Table 2.

TABLE 2

CONTROL	IGF-1
$0.126 = \frac{1}{1 + \kappa Akt(Ins)} k_I$	$0.64 = \frac{1}{1 + \kappa Akt(Ins)} k_I$
$0.0132 = \frac{\alpha \kappa Akt(Ins)}{\alpha \kappa Akt(Ins) + 1} \hat{k}_E$	$0.137 = \frac{\alpha \kappa Akt(Ins)}{\alpha \kappa Akt(Ins) + 1} \hat{k}_E$

To solve this system of equations for the unknown values  $\kappa$ ,  $\alpha$ ,  $k_I$ , and  $k_E$ , we needed appropriate insulin values for the control and injected cells. We used the same values that the Schneider lab used:  $insulin_{low} = 10^{-10}$  M and  $insulin_{high} = 9.59 \times 10^{-8}$  M.  $insulin_{low}$  corresponds to the control cell while  $insulin_{high}$  corresponds to the injected cell. Using these values, we solved the system of equations in MATLAB and outputted the following values:  $\kappa = 3.062$ ,  $\alpha = 0.1536$ ,  $k_I = 0.6259$ ,  $k_E = 0.1529$ . We then used these values to plot the insulin vs.  $k_I'$  and  $k_E'$  as shown in Figures 5 and 6, respectively. Similar to the Akt function, these rate constants follow the standard hill function.

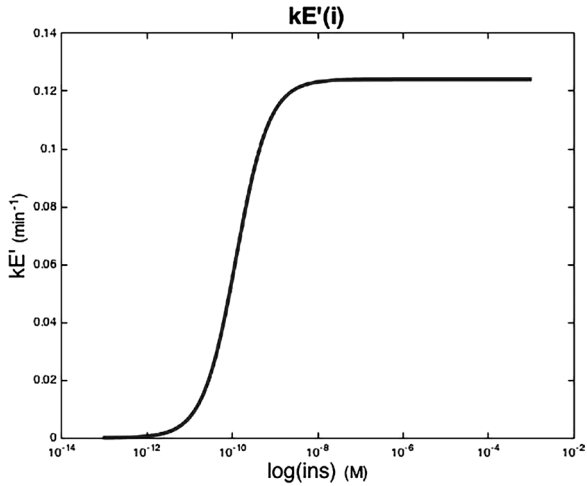


Fig. 5. To view the appropriate behavior of this rate constant, the semilog scale was used in creating this plot. As insulin concentration increased, phosphorylation in the nucleus increased and caused more Foxo-1 to exit the nucleus, resulting in an increase in efflux represented in the  $k_E'$  graph.

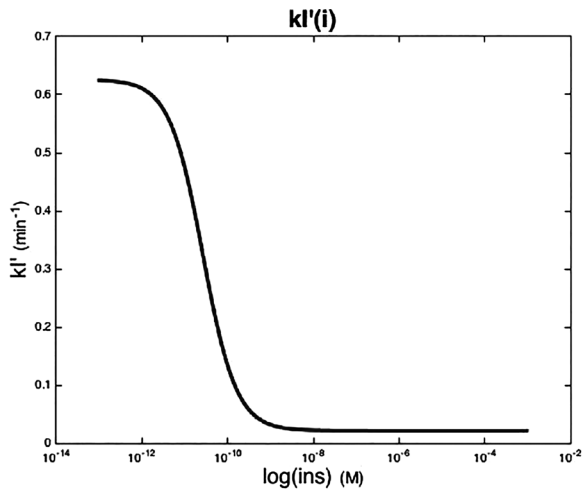


Fig. 6. To view appropriate behavior of this rate constant, the semilog scale was used in creating this plot. As insulin concentration increased, the phosphorylation in the cytoplasm increased, causing less Foxo-1 to enter the nucleus and a decrease in influx, represented in the graph.

The previously-known time course solution (Equation 1) for the nuclear-cytoplasmic ratio of Foxo-1 was modified to consider  $k_I'$  and  $k_E'$  as functions of insulin. By applying this insulin-dependence, the dynamic model of the nuclear-cytoplasmic ratio was produced.

The data that we wanted to fit this model to has a washout period where insulin concentration is low and is followed by a period where insulin is injected and becomes high. We began by using our original insulin values and adjusted them as necessary to fit the experimental data.

Experiments performed by the Schneider lab allowed the cells to sit in their own produced insulin, the  $\text{insulin}_{\text{medium}}$  phase. After the cells sat in their own medium, they were then washed out to the  $\text{insulin}_{\text{low}}$  phase, after which insulin was injected into the cell to incite the  $\text{insulin}_{\text{high}}$  phase. To incorporate the  $\text{insulin}_{\text{medium}}$  phase, we ran this dynamic model until it reached steady-state, which represented the self-produced insulin the cell would be in. Once the model reached steady-state, we then dropped it to the  $\text{insulin}_{\text{low}}$  phase for a period of time before insulin was injected into the cell to trigger the  $\text{insulin}_{\text{high}}$  phase.

Figure 7 shows the dynamic model fitted to the experimental data. The portion of the darkest curve before time zero represents the cell reaching its steady state, whereas our two-part model forces an initial start at time zero with the lab's experimental results of the ratio at this time. As expected, the  $\text{insulin}_{\text{low}}$  phase shows an increase in the nuclear-cytoplasmic ratio as the rate constant of influx of Foxo-1 into the nucleus is high (Figure 6), while the rate constant of efflux is low (Figure 5). Similarly, the  $\text{insulin}_{\text{high}}$  phase indicates a decrease in the nuclear-cytoplasmic ratio as the rate constant of efflux is high, while the rate constant of influx is low.

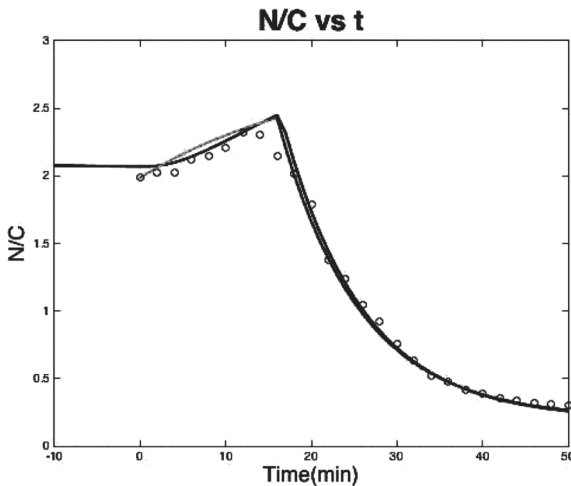


Fig. 7. The open dots represent the experimental data points. The darkest curve is the full dynamic representation from the GLUT model. The whole beginning phase before zero is not shown; the graph only shows when  $\left(\frac{N}{C}\right)$  comes to a steady state. The lighter line segment is  $\text{insulin}_{\text{low}} = 3.16 \times 10^{-11}$  M and the second line segment that overlaps the dynamic model is  $\text{insulin}_{\text{high}} = 9.59 \times 10^{-8}$  M.

We have shown that we can take the constant-parameter model and turn it into a dynamic model by connecting the GLUT and Foxo-1 models. Our results from fitting the experimental data mean that our assumption that the GLUT model can fit into this model is correct. This model is a prototype that can be altered to fit similar experiments using different external stimuli besides IGF-1.

## FUTURE DIRECTIONS

So far, we have been able to model the effects of external stimuli such as IGF-1 and leptomycin. These models are prototypes that can be used and altered in order to model the effects of various other external stimuli. We have learned that we should further investigate the dynamics of the influx when leptomycin is injected because our logical prediction was not correct. Such exploration could lead to new information about the skeletal muscle cell that we are not aware of yet. This research would expand the knowledge of how the skeletal muscle cell behaves and why it degrades.

## ACKNOWLEDGEMENTS

The Schneider Laboratory at University of Maryland School of Medicine assisted with this research. The experimental data came from the experiments conducted at the Schneider Laboratory by Dr. Martin Schneider and Sarah Russell, and a prior undergraduate researcher Graham Antoszewski also assisted this research. This investigation was sponsored by the NIH/NIGMS MARC U\*STAR T3408663 National Research Service Award to UMBC.

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# Charge Transfer from Single Semiconductor Nanocrystal to Single Molecules

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co-authors

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## BIOGRAPHY

James Loy dual-majored in physics and mathematics at UMBC. He graduated *summa cum laude* in May 2016, and began pursuing a Ph.D. degree in physics at Princeton University, focusing on quantum information. He enjoys teaching physics to students and loves working on his family's farm. James would like to thank his research mentor, Dr. Matthew Pelton, for his guidance and wisdom throughout his research experience. He would also like to thank Mr. Haixu Leng for the help and teachings offered during the research project. Finally, he would like to thank his family for supporting him throughout his undergraduate career, and Ms. Allison Osborne for motivation to work beyond his limits.

# DEMYSTIFICATION

I entered research in the Department of Physics on the recommendation of my first laboratory class teacher, Dr. Laszlo Takacs, because of my devotion to lab work. He directed me to Dr. Pelton, whose research was in nanophotonics. After our first meeting, I was intrigued by the types of research occurring in the lab, but lacked the background for contributing. Therefore, my first project in the lab was to produce a computer interface for a new microscopy unit being set up in the lab, which seemed like an excellent way to contribute my skills at the time while learning the background necessary to later pursue a research project. I learned of the Undergraduate Research Award (URA) program through the Honors College and decided to apply in 2014 with Dr. Pelton's approval. Being awarded the URA supported the development of the interface on a devoted computer system and construction of the microscopy unit. After completing the interface, allowing full control of and data-collection from the microscopy unit, I began one of the first projects to use the new instrument. This separate project was awarded a second URA, and led to a manuscript on which I was co-author. This was my favorite accomplishment of my undergraduate career, and I strongly encourage every student to perform a research project at UMBC.

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## ABSTRACT

A candidate material for next-generation photovoltaics is a lattice of nanometer-scale semiconductor crystals (quantum dots, or QDs).<sup>1</sup> To efficiently convert light into current, electrons must be photoexcited out of the QD at a fast rate to avoid being trapped in defects on the QD surface.<sup>2</sup> We created a model system to quantify the rate at which excited electrons are transferred out of the QD following photoexcitation. Our model used organic molecules adsorbed to the surface of the QDs to accept excited electrons that leave the crystal. The number of surface molecules, which can be as few as one, shortens the excited-state lifetime by offering electrons more pathways out of the excited state, increasing the excited-state decay rate. We examined QD structures individually to resolve integer numbers of surface molecules on the crystals, allowing us to determine the effect a single acceptor had on the rate. By measuring the excited-state decay rate (the inverse of the characteristic time that electrons remain in an excited state), we found a discrete change in the rate corresponding to the number of surface molecules.



# INTRODUCTION

A potential material for converting light to electrical energy includes lattices of semiconductor nanocrystals called quantum dots (QDs).<sup>1</sup> A key current issue for this type of renewable energy conversion is the cost of materials. QDs may be produced in bulk at low cost using colloidal chemistry techniques, and thus may offer a higher ratio of efficiency to cost-of-production than current silicon-based photocells.<sup>3</sup> Consisting of distinct core and shell materials, the QDs confine the electrons in three dimensions, which quantizes the energy allowed to electron states within the structure. Thus, the QDs only emit and absorb certain frequencies of light, depending on their physical size. A lattice formed by using QDs of varying sizes could potentially harvest energy from different regions of the solar spectrum for optimal efficiency.

Once excited, the electrons remain trapped in the structure and cannot escape to perform work unless they transfer to available states outside of the QD. Figure 1 demonstrates this process in a simple manner. An electron is excited to a higher energy in the structure, perhaps due to absorption of a photon. The electron can then either relax back to its original state, emitting a photon to conserve energy, or it can transfer out of the QD. Figure 1 shows an acceptor molecule on the QD surface, which accepts the electron and keeps it physically separated from the QD. This separation prevents the electron from returning to the QD after transfer. Since the acceptor molecule gives the electron a place to go, it facilitates the electron transfer process, increasing the rate at which it occurs.

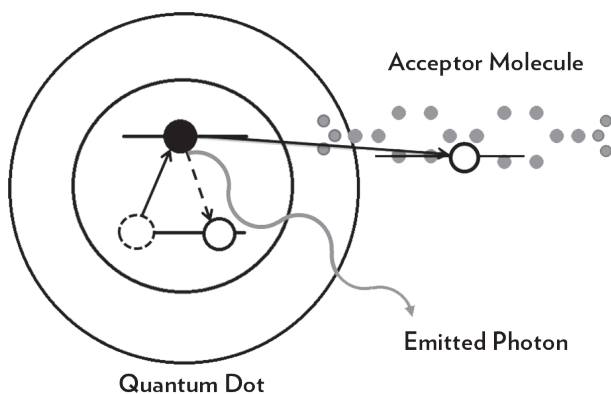


Fig. 1. The electron transfer process from a quantum dot. An electron (solid black circle), is excited from a lower energy state (dashed circle) in the QD. The electron has two paths: relax to its original state (dashed arrow) and emit a photon, or transfer out of the QD to a surface acceptor molecule (solid arrow). This molecule accepts the electron and physically separates it from the QD.

The transfer process competes with other pathways the electron may follow, which lowers the efficiency of the light-to-electrical-energy transfer. For example, crystal defects on the QD surface such as missing atoms, extra atoms, and impurities can create states that trap electrons, preventing them from exiting the QD.<sup>2</sup> It is ideal to increase the rate at which the transfer occurs so that it dominates these other processes. Any molecules that offer states which accept excited electrons facilitate electron transfer and thus increase the efficiency of the QDs for photovoltaics. In this project, we quantified the effect that individual acceptor molecules have on the transfer rate, using acceptor molecules as a model for future transfer sites. We produced a model system that allows investigation of the various features of the QD-acceptor molecule complexes.

This measurement has been performed previously using ensemble measurements, which involve exciting many QDs with a distribution of different acceptor molecule quantities all at once. In such measurements, the collected optical signal is analyzed using various assumptions about the QD emission distribution and the distribution of surface molecule quantity to obtain an average transfer rate per individual acceptor molecule.<sup>4</sup> Ensemble measurements are efficient due to the size of the structures, but suffer from complicated data analyses and the small differences between each QD complicate the signal obtained. In our research project, we observed individual QDs to resolve exact integer numbers of acceptor molecules. With this method, we were able to verify or refute the results of previous ensemble measurements directly.

## SAMPLES

As shown in Figure 2, we used cadmium selenide core, cadmium sulfide shell (CdSe/CdS) QDs supplied by collaborators at Northwestern University. The benefit of using these QDs lies in their documented use as model systems for charge transfer.<sup>5</sup> Furthermore, these QDs emit light in the visible spectrum, which helps in qualitatively monitoring the QD density when preparing samples. This property also enables our optical analysis, as our camera and Time-Correlated Single Photon Counting (TCSPC) equipment are sensitive to visible light.

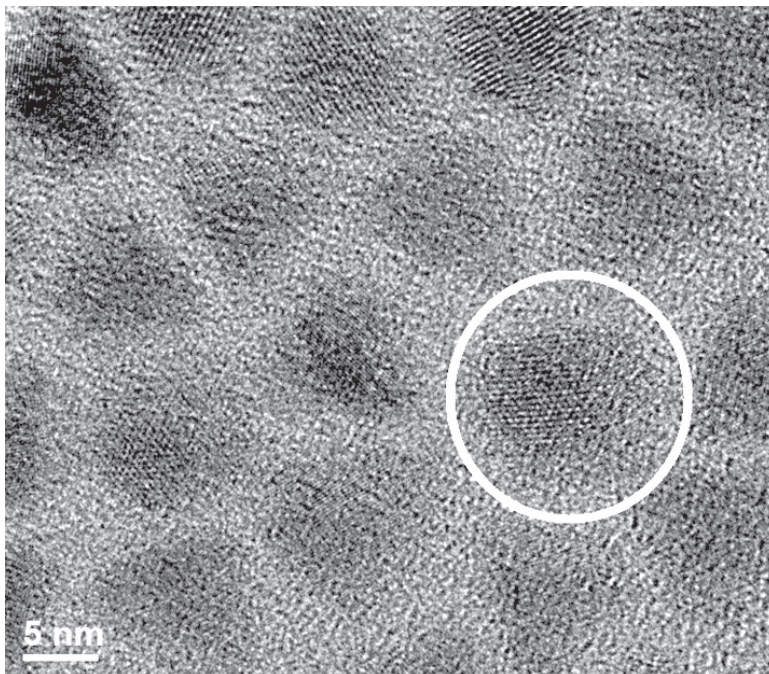


Fig. 2. A transmission electron micrograph image of our QDs. The white outline encloses a single QD. Due to their crystalline structure, the QD edges terminate along crystal planes, preventing them from being exactly spherical.

For our acceptors, we used an organic molecule called viologen, again due to its documented success with facilitating electron transfer. Using materials known to induce electron transfer will help us determine if our single particle analysis is reliable and a viable method of analysis.

Since the acceptor-molecule quantity is a variable we want to control, we produce the QD-viologen complexes in our lab. This involves suspending a dilute sample of QDs and viologen in chloroform. In chloroform, neither substance dissolves, so they are kept separate in the liquid. Physical contact between the QDs and molecules is facilitated by use of a sonicator that vibrates the sample for a variable period of time. When viologen encounters a QD, it adsorbs to the shell surface. The stochastic method results in a distribution of acceptor-molecule quantities; some QDs have none, some one, some two, etc. molecules adsorbed to their surface. We controlled the distribution by varying the mixing time and dilution of the substances, and found that a qualitatively optimal distribution is obtained after 30 seconds of adsorption time. Shorter times than this lead to too few QDs with any viologen adsorbed, while longer times lead to saturation of the QDs with viologen, which prevents them from emitting a detectable signal.

# INSTRUMENT

To analyze our complexes, we relied on an optical microscope built specifically to control and analyze nanoparticles individually. Figure 3 shows an overview of the system.

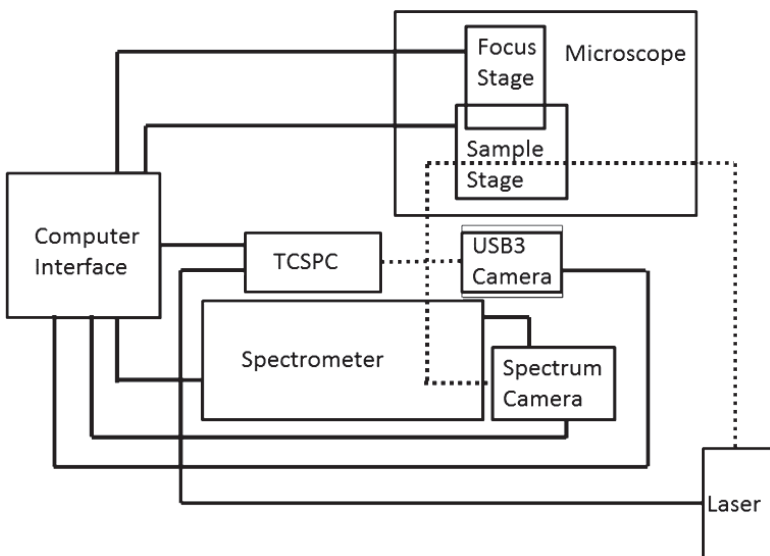


Fig. 3. Schematic showing instruments of the microscopy unit in their rough relative positions. Connections between instruments are depicted; solid lines depict data communication paths and dashed lines depict laser light propagation paths.

A dilute drop of the QD-viologen complex suspension (approximately 20  $\mu\text{L}$ ) was spread over a glass coverslip (Fisherfinest Premium Superslip) and allowed to dry. The QDs separated during this process, allowing us to then magnify and excite the structures individually. Pulsed laser light (diode laser PicoQuant PDL-800D) photoexcites the samples in 1 MHz pulses. We used a wavelength of 510 nm so that only electrons in the QD cores are excited, as the shell electrons absorb light of higher energy and thus cannot interfere with our signal. Pulses were focused through an objective lens (Nikon, Plan Apo 100X / N.A. = 1.40) to a minimally-focused point on the slide. Light emitted from the sample was reflected back through the lens and could then be intercepted by three different instruments for analysis. Note that this setup only collected light back-emitted from the sample and does not collect the stimulating laser pulse.

The microscopy unit was controlled by a specially-built computer interface that controlled the stages, spectrometer (Acton SpectraPro 500i), camera (Princeton Instruments Pixis 400), and the Time-Correlated

Single-Photon Counter (TCSPC) (PicoQuant model PicoHarp 300) instruments. The final device measures the arrival times of individual photons from the observed sample relative to the time of laser pulse emission, and collects the main data for this experiment.

## DATA COLLECTION

During data collection, QDs were located and centered on the laser focus. It was important that we isolated individual QDs rather than excite clusters of multiple QDs. To verify this, we used three parameters. First, abnormally bright samples, relative to surrounding QDs, were ignored, as the higher intensity was likely a combination of multiple QDs fluorescing. Second, we used a property of QDs called “fluorescence intermittency,” which appeared as an apparent blinking off and on during continuous excitation.<sup>6</sup> A cluster of QDs would contain overlapping QDs of different states, and the blinking would be less pronounced. This is because when some QDs blink off, others of the cluster will be in an “on” state, preventing the cluster from completely extinguishing. Therefore, a sample that blinked was more likely to be a single QD. Finally, we used spectral analysis of the QDs as sufficient proof of QD quantity. A single QD has a narrow spectral peak (roughly a 12-18 nm peak width at half the peak’s height). For a cluster of QDs, small inhomogeneities between the QDs shifts their peak wavelengths slightly, widening the observed peak (greater than 20 nm width).

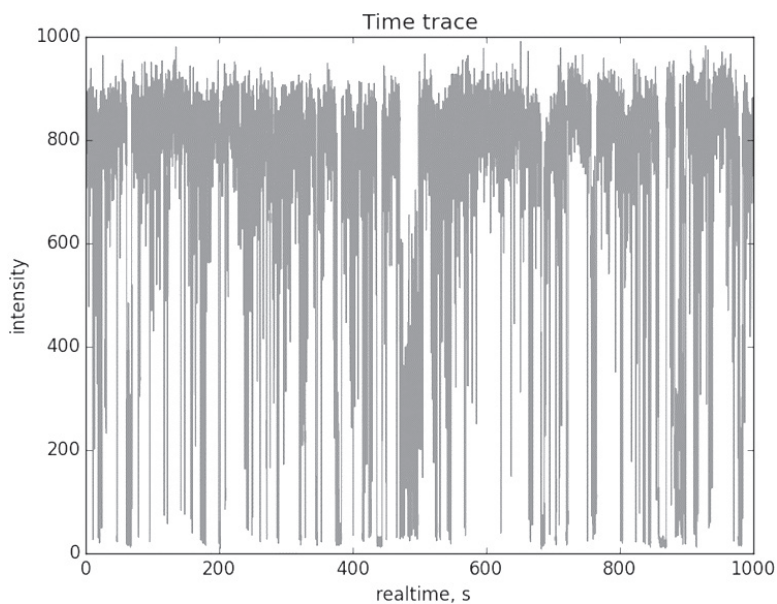
After verifying that a sample was an individual QD, we switched to data recording with the TCSPC. Samples were monitored for five to sixteen minutes, during which the intensity of the QD (in photon counts) was recorded against the time of arrival since the laser pulse.

## DATA ANALYSIS

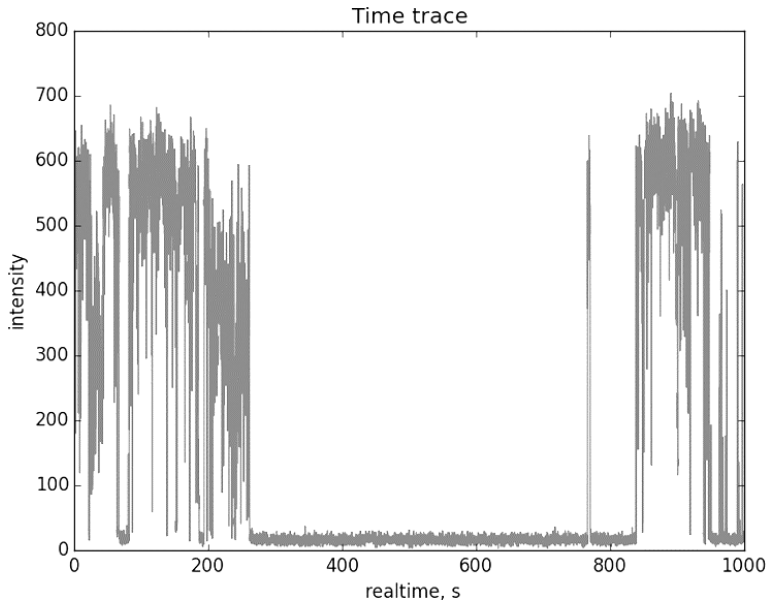
Our collected data could not be used directly without processing to address certain factors in our system. To process, we plotted the intensity of the QD over time for the experiment. Figure 4 shows various types of intensity plots. Figure 4(a) is an ideal data set, as the maximum intensity stays roughly constant over the data collection. The rapid change in intensity observed is due to the blinking phenomenon of the QDs themselves. Figure 4(b) shows a less ideal data set, where the blinking is more pronounced and eliminates the optical signal for significant periods of time. The loss of signal due to blinking is distinguished by how abrupt the change in intensity is. Another source of signal damage comes from instability in our microscope system. Figure 4(c) shows the effect that instability has on the intensity plot. The steady decrease in intensity over time is indicative of

drifting in our system, perhaps of the QD itself, the focus of the objective, or both. As the QDs are on the order of 10 nm in scale, the alignment of the sample must be very precise, and over a ten-minute interval the sample can drift out of focus. Temperature shifts and tension stored in the microscope from securing the system are likely to blame for much of the instability we observe. For some QDs, the drift in intensity is sinusoidal, perhaps corresponding to small variations in optimal focus due to sinusoidal interference like temperature shifts.

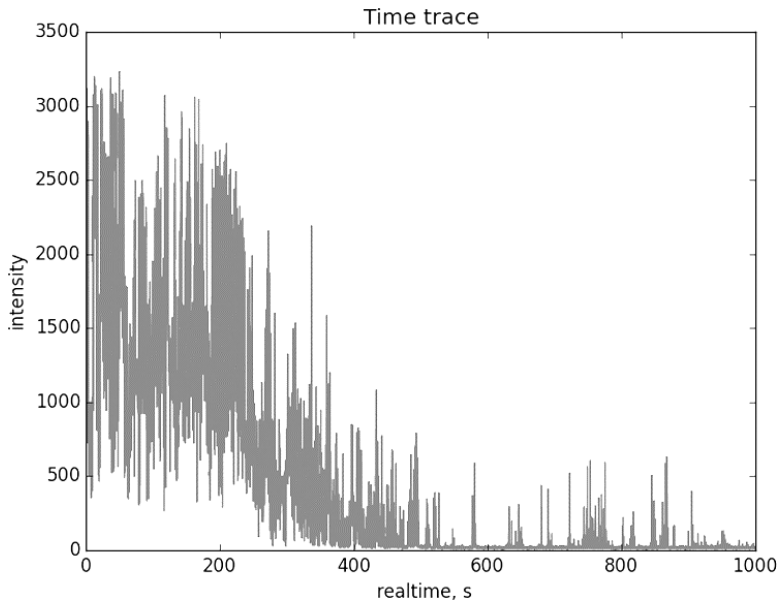
Since we collected an optical signal, the times during which the QD blinked off or drifted out of focus offered no valid data for analysis. To discern which states were usable, we used a variable threshold. The top and bottom half of the data (determined via the mean of the minimum and maximum of the data) were fitted separately to sinusoidal functions. The average between these two oscillating thresholds allowed us to track which states were “on” (above the averaged threshold), and were thus valid for our data.



a



**b**



**c**



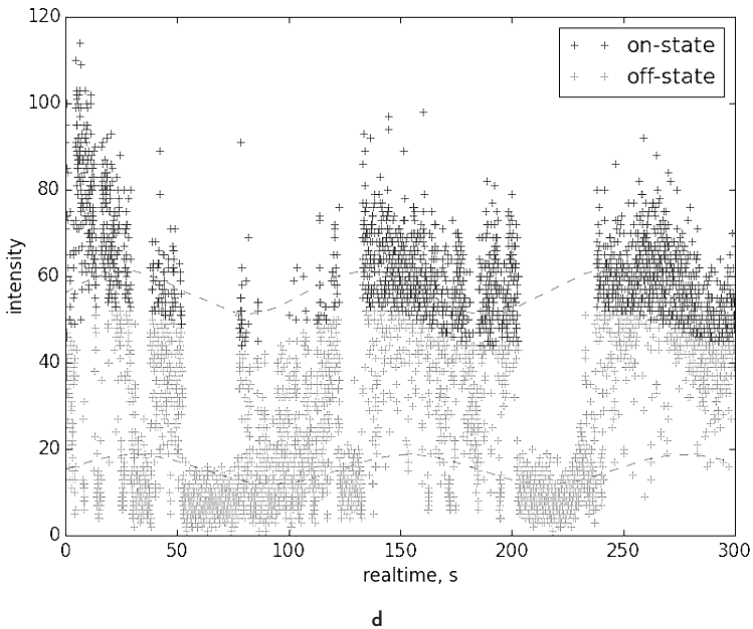


Fig. 4. Examples of the most common types of intensity plots. Each graph plots intensity of light (photon counts per second) against time in the experiment (seconds). (a) An ideal data set, with the maximum intensity roughly constant across the experiment, indicating a stable QD. (b) A data set featuring very pronounced blinking. The immediate loss of signal with the eventual return shows that the QD went into an “off” state for almost ten minutes of a 16-minute experiment. The signal’s return cannot be explained by drift. (c) A data set featuring drift, perhaps of the focus, the QD itself, or both. Characterized by a gradual loss of signal over the experimental run, this data set is essentially useless as we cannot compare maximum intensities of the QD at different times during the experiment. (d) A data set where blinking is dealt with via a fitting function. Above-mean points (dark gray) are fitted separately from below-mean points (light gray) to separate sinusoidal functions that fit the intensity over time. These fittings develop a threshold that decides which QDs are in the “on” state, and therefore offer valid data.

From the data corresponding to “on” states, we produced a lifetime plot. The data consisted of arrival times of individual photons relative to the most recent excitation of the sample via laser pulse. Over the course of the experiment (ranging from 5 to 16 minutes), we excited the same QD repeatedly, essentially resetting the initial time to zero after each excitation by a laser pulse. During the nanoseconds after the laser pulse, the QD decayed back to its ground state energy, emitting photons. Because the probability of relaxation is identical for every excitation, we expected an exponential decay curve to describe the number of QDs that remain in the excited state. If we defined a quantity  $Q(t)$  to be the ratio of QDs that remain excited after a time  $t$ , and we defined a natural rate of decay  $k$  for our QDs, then we expect the form:



$$Q(t) = e^{-kt}$$

However, of the remaining QDs that have not relaxed back to ground state, it is possible for the electrons to transfer to surface acceptor molecules. We expected another exponential rate of transfer, characterized by rate  $L$ . Then, the total equation governing  $Q(t)$  has the form

$$Q(t) = e^{-kt} e^{-Lt} = e^{-(k+L)t}$$

Therefore, we expected the natural decay rate and the rate of transfer to sum for a QD-viologen complex. From the “on” states for the QD, we plotted the arrival times of photons over the entire experiment, obtaining the exponential curve. Fitting the curve to an exponential function determined the rate of decay for that QD, as shown in Figure 5. The analysis process was performed for every QD collected in a single sample, for which we collected 30-60 QDs. Our QD quantity was limited by the time each data collection takes and the stability of our samples, which we found did not reliably exceed one day. Therefore, each set of 30-60 QDs refers to a single day of measurements.

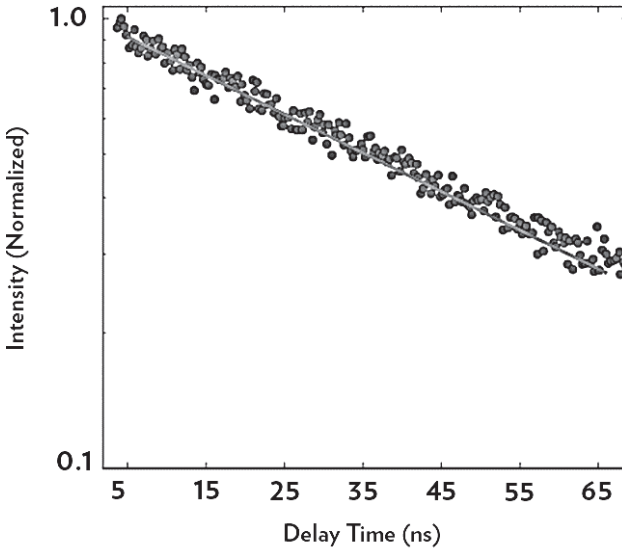


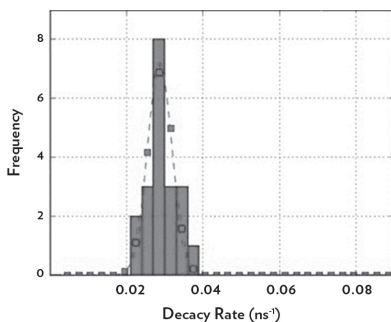
Fig. 5. Fitting an exponential to the photon delay, which signals the time the electrons of the QD were in the excited state. Plot is of normalized intensity (photon counts per second) against time since the most recent laser excitation (nanoseconds).

A histogram was produced, binning QDs with similar excitation decay rates together (bin size was  $0.003 \text{ ns}^{-1}$ ). The results in Figure 6 show the formations of peaks of QDs with similar rates rather than collections of QDs with randomly larger rates. Each peak corresponds to a different integer number of acceptor molecules on the QD surfaces. The first peaks, which agree with our results from analyzing bare QDs with no acceptor molecules, correspond to QDs with no viologen adsorbed, the next highest peak corresponds to one molecule of viologen adsorbed, and so on. The fact that the peak maxima are equally spaced in our data indicates that each additional molecule increases the transfer rate individually, as if it were the only molecule on the QD surface. Therefore, the acceptor molecules are not interacting on the QD surface, and the rates change linearly. This result is especially helpful, since it allows us to predict the transfer rate for any given number of acceptor molecules.

Note that our increased rates must be due to the acceptor molecules, as the spread of natural decay rates for bare QDs is too small to explain the larger rates we observe for samples with acceptor molecules. For our CdSe/CdS QD and viologen acceptor complexes, the rate change per molecule is  $L = (0.009 \pm 0.003) \text{ ns}^{-1}$ . Then our equation for  $Q(t)$  follows the form

$$Q(t) = e^{-(k+n \times L)t}$$

where  $n$  is the integer number of acceptor molecules on the QD.



a

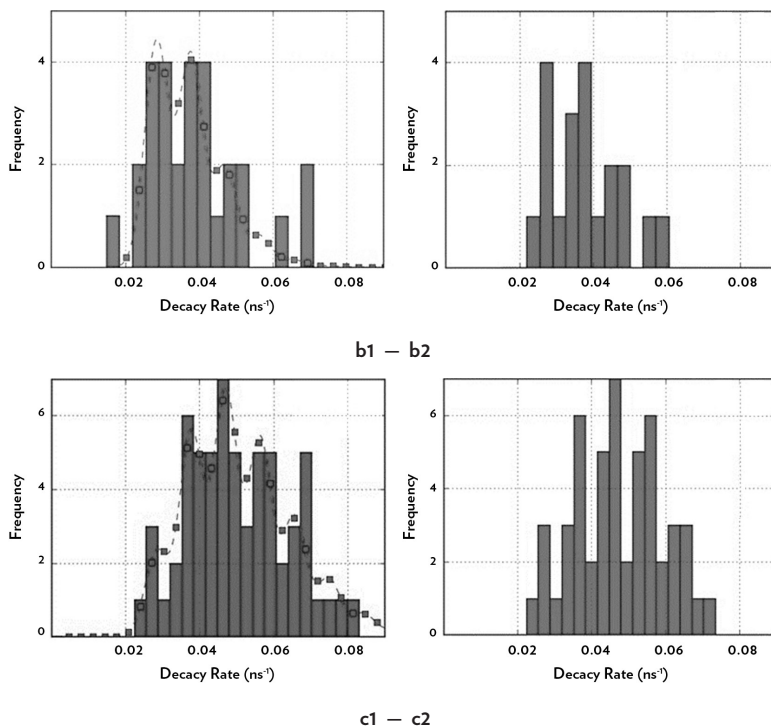


Fig. 6. Histograms plotting excitation decay rates against quantity of QDs showing a rate in that bin. Bin size is  $0.003 \text{ ns}^{-1}$ . (a) A control group of bare QDs, showing the spread of lifetime rates for QDs with no acceptor molecules on the surface. (b1) and (c1) Different samples of QD-acceptor molecule complexes, both showing an increase in the rates obtained. The increased rate of transfer appears quantized because of the equidistant peaks. The presence of peaks is explained by QDs of different integer quantities of acceptor molecules on the surface. (b2) and (c2) Theoretical plots produced based on measurements made of our QDs, showing predicted peaks in close agreement with our data peaks. Note that both samples support the existence of discrete peaks, and that the increased rates cannot be explained by the spread of rates from individual QDs.

## CONCLUSIONS

From our results, we concluded that acceptor molecules increase the charge transfer rate in a predictable, linear manner. The use of surface acceptor molecules may improve the efficiency of QD materials for use as photovoltaic materials. The predictable, linear improvement to the transfer rate improves the practicality of producing QD arrays.

We have verified that individual QD analysis is a valid method for quantifying the effects that acceptor molecules have on the charge trans-

fer rate. This is evidenced by the fact that we were able to resolve individual peaks that were reasonably attributed to different, integer quantities of acceptor molecules on the QD surface, and that the change in rate was clearly discernable from the typical distribution of rates exhibited by QDs of a single sample. Now that it has been verified, our model system can be used in further applications of the field. For instance, new acceptor molecules or combinations of acceptor molecules can be studied, as well as adjustments to the QD properties, such as the QDs shell thickness.

In this project, we relied on the spherical symmetry of the QDs to remove any spatial dependency on where the molecules adsorbed to the QD. A possible advancement can be made where we use asymmetrical particles to determine what spatial dependencies might exist for the charge transfer rate. For instance, semiconductor nanorods offer a break in symmetry along one axis, such that acceptor molecules adsorbed on the ends of the rods may lead to a transfer rate distinct from that of those adsorbed on the rod centers. Ensemble measurements would be incapable of resolving where on a collection of nanorods the acceptors were adsorbed, further justifying our development of individual nanoparticle analysis.

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# The Temple of Vesta in the Roman Forum

author

Abigail Worgul

## **BIOGRAPHY**

Abigail Worgul graduated from UMBC in December 2016 with a degree in ancient studies. Her interest in ancient studies began during her homeschool years when her father taught her Latin. After pursuing other interests during her first two years of college she found her way back to the study of the ancient world and its languages when she transferred into the Department of Ancient Studies at UMBC. Here, Abigail enjoyed working closely with the various faculty members, especially in independent language study. Through both this study and her Undergraduate Research Award (URA)—whose results became this paper—Abigail has become excited about the possibility of pursuing classics in graduate school. In 2017 Abigail will be in Germany learning its language to prepare her for accessing German classical scholarship in her graduate and post-graduate career.

## DEMYSTIFICATION

The gods and goddesses of classical mythology have always fascinated me. When I read the Percy Jackson & the Olympians series in high school I was introduced to and intrigued by a slightly less well-known goddess named Hestia—goddess of the hearth and home. It was either the mystery of her obscurity, or the aura of mystery that surrounds the all but mundane hearth and home that she represented, that followed me into my junior year of college when I chose to apply for an Undergraduate Research Award (URA). With no background in the Ancient Greek language at that time, I constructed a project focused on Hestia's Roman equivalent, Vesta. After tossing about various possible ideas for a project, I came to the question, "Since the majority of other temples from the mid-Republican period are rectangular in shape why is the temple of Vesta circular?" I wondered if the circularity of the temple reflected some unique aspect of the goddess Vesta. As one might expect of a year-long research project, this investigation yielded some results that I did not anticipate.

## BACKGROUND

Vesta was the Roman goddess of the state hearth.<sup>1</sup> This goddess was understood by the Romans to be embodied by the living flame housed in her temple, located in the Roman Forum.<sup>2</sup> Six virgin priestesses, called the Vestal Virgins, lived in a complex connected to this temple, tending the flame and performing various other religious rites.<sup>3</sup> The tending of the flame on this communal hearth was believed by the Romans to ensure not only the well-being of Rome, but also its success as an empire.<sup>4</sup> The Temple of Vesta as it appears today consists of several pillars surrounding a portion of the wall of the structure situated on part of its circular base, as seen in figure 1. These remains date to the end of the second century BCE.





Fig. 1. Temple of Vesta, the extant remains

# INTRODUCTION

The Temple of Vesta in the Roman Forum has long interested scholars because of the priestesses, the Vestal Virgins, who served in it. Their duty to constantly tend the fire of the state, the societal privileges that they enjoyed and most Roman women did not, and above all their vow of physical chastity, have sparked the imaginations of modern investigators. The uniqueness of Vesta's cult and priestesses, having little subsequent parallel, has caused her small circular-based temple to be studied independently from other structures in the Forum, with the exception of the Regia, whose connection with Vesta's Temple has long been noted. However, a trip to the Forum reveals that the location of Vesta's temple, roughly centered in the Forum and seated in close proximity to both the Regia and Juturna's small rectangular fountain, is far from being an isolated structure. This paper posits that the shape and location of Vesta's temple were equally important: the circular shape of her temple both mirrored the shape of the cosmos, and complemented the adjacent, rectangular Fountain of Juturna. Its location between the Regia and Fountain of Juturna displayed the tension between sovereignty and subjugation.

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## PREVIOUS SCHOLARSHIP

Various theories have been proposed by both ancient and modern scholars as to why Vesta's temple was circular. The shape could have been derived from Etruscan Iron Age huts,<sup>5</sup> it could have come from Greece—the hearths in Greece were circular and the other round temples in Rome were clearly linked to Greek models<sup>6</sup>—or, as the Roman poet Ovid suggested, the shape could have reflected the circularity associated with the elements of earth and fire.<sup>7</sup> As the temple of Vesta housed a communal hearth, I personally wondered if the temple was circular as a mark of the center of the community. By discovering the reason for the circularity, I hoped to contribute further insight into both the study of Vesta and her cult and into how they would have been understood in Roman society.

## METHODS

This study began with an examination of excavation reports of the sacred precinct of Vesta, as well as an investigation of other sources on the archaeology of Roman temples. The PHI Latin Text online database was used to search for references to Vesta and hearths, in addition to a review of numerous scholarly books and articles on Roman society, Roman religion, and sacred space. Then, the research became hands-on as I travelled to Rome

and investigated the temple and its surroundings. First, I examined the temple—its size and the remains of its frieze, pillars, and foundation. Next, the placement of Vesta’s temple in the Forum was measured by counting off paces to different monuments, roads, and forum entrances. Third, I visited two museums: one containing information on the Iron Age huts, and the other, containing images of pottery and other artifacts from the city of ancient Rome. Fourth, the temple’s location within the forum was studied from above and from outside the Forum. Finally, I went to another site housing an alleged temple to Vesta to carry out the same examinations.

## DISCUSSION ON CIRCULARITY

My study of the excavations of Vesta’s sacred precinct and other scholarship on temples did not yield any evidence supporting either the theory that the circularity had originated from the shape of Iron Age huts, or that it was related to the shapes of Greek hearths or temples. Although Russell T. Scott, in his *Excavations in the Area Sacra of Vesta*, admits that there were huts in the general vicinity where Vesta’s temple would eventually be built, he cannot trace the development of a single hut into a temple.<sup>8</sup> That the temple’s shape mimicked the circularity of Greek hearths is unlikely, first, because the excavations of the precinct demonstrate that the sacrificial platform in the area during the Early Republican period (late sixth century BCE) was in fact square, not circular.<sup>9</sup> Second, the theory of the shape’s origins as associated with Greek temples is doubtful in that the earliest round temple of Vesta probably dates to the end of the third century BCE.<sup>10</sup> Although the Greek round temples date to several centuries before this time,<sup>11</sup> and thus could have technically influenced the building of Vesta’s temple, the other examples of round temples that exist in the Republic, albeit few, are not built until approximately one-hundred years later, after the Macedonian Wars when Greek culture gained increased influence on Rome.<sup>12</sup> As Vesta’s temple, then, was circular before this influx, it is most likely that the shape is not tied to Greek examples.

Russell T. Scott’s excavation report did yield support for the statement by Ovid in his *Festival Days* that the shape of the temple was connected to earth and fire. That the earth was considered round, and not square, is echoed by multiple Roman authors. Ovid first states in his *Festival Days*, “The earth is similar to a sphere, leaning on no support.”<sup>13</sup> And Cicero, criticizing the belief of one philosophical school, demonstrates his belief in a round world by saying, “therefore nothing could be more un-learned than that which you are accustomed to claim: for you say that it is not certain that this world is round.”<sup>14</sup> Although Cicero makes these assertions approximately 200 years after Vesta’s temple was built at the end of the third cen-

ture BCE,<sup>15</sup> we know the assertions echo a belief of earlier times because of the use of the word *orbis*, meaning “circle” or “sphere.” The author Ennius, writing at the beginning of the second century BCE, had used *orbis* in his writings. Ennius states in a discussion of Italy’s early history, that, “in this way, Jupiter planted the religion of his cult throughout the circle (*orbem*) of lands.”<sup>16</sup> This use of *orbis* demonstrates that even if the ancient Romans could not scientifically prove that the world was round at that time, the earth was still most certainly associated with circularity. Moreover, the fact that Ennius did not need to explain his terminology in this sentence suggests that this use of the word had been familiar even earlier. Thus, at the time when Vesta’s temple was built, the earth was imagined, at least by the learned (excepting schools of thought like those which Cicero was criticizing), to be round. The circularity of the base of Vesta’s Temple can be seen in figure 2.



Fig. 2. The Temple of Vesta, the remains in the context of its circular plan.

The Greek historian Dionysius of Halicarnassus believed Vesta personified this round earth. The historian both exposes the ancient view of the structure of the world and states that Vesta personified it in his *Roman Antiquities* when he writes, “And they regard the fire as consecrated to Vesta because that goddess, being the earth, and occupying the central place in the universe, kindles the celestial fires from herself.”<sup>17</sup> Ovid reinforces this in his *Festival Days*, by stating that Vesta was believed to literally be the flame housed within her temple,<sup>18</sup> and that “[she] herself [was] earth.”<sup>19</sup>

Scott’s excavations of the mid-Republican era—the first period where there are confirmed traces of a temple—confirm this ancient association between Vesta and the round earth.<sup>20</sup> He notes that there was a shaft framed by posts that led down through the very foundations of the temple’s podium.<sup>21</sup> This shaft was extant throughout the temple’s history, and remained free of debris.<sup>22</sup> Scott himself links this shaft to Ovid’s statement referenced above that the earth “represented the goddess herself.”<sup>23</sup>

Since the goddess Vesta was considered by ancient authors to personify the earth and the available archaeological evidence shows that her temple reflects this association, I propose that the temple to Vesta was circular due to its imitation of the earth which the ancients, since at least the third century BCE, associated with centrality. As such, Vesta’s temple situated in the forum could be viewed as microcosm of the earth in the universe. Dionysius of Halicarnassus, as mentioned above, states that the earth was thought to “occupy the center of the universe.” If Vesta personified the earth, then naturally she would also be associated with centrality.

The results of my investigation of the temple as a possible centerpiece in the Roman Forum strengthens this association. I found that the temple was approximately two-hundred meters from one side of the Forum, and approximately three-hundred from the other side. Widthwise, it was about sixty meters from one end of the Forum and eighty-five from the other side. Although these measurements do not place the temple exactly in the center of the Forum, and a look at its map does not definitively reinforce this idea, the temple’s approximately central location along the *Sacra Via*—a prominent street in Rome leading through the heart of the Forum—features Vesta’s temple. This featuring, as it causes the temple to appear more central than its precise measurement would suggest, allows for the interpretation that the location of Vesta’s temple could be seen to replicate the position of the earth at the center of the cosmos within the Roman Forum.



## THE POLARITY OF THE TEMPLES OF VESTA AND JUTURNA

My examinations of the circularity of the temple in relation to its surroundings led me to investigate the temple's relationship to a rectangular fountain situated immediately to the south of Vesta's precinct. This fountain was dedicated to the nymph Juturna and was built on top of a natural spring. The proximity of the shrines can be seen in figure 3. After recognizing a potential link between the precincts founded in this proximity, I began to investigate them together using the essay by Jean-Pierre Vernant, "Hestia-Hermes: The Religious Expression of Space and Movement Among the Greeks" as a framework. Although Vernant's work has been criticized by many for relying more heavily on theory than historical data, I did not find his model of the concept of space in antiquity fallible because he supported his theory with archaeological and literary evidence. Furthermore, his historical-psychological approach elucidated aspects of ancient space which archaeology and textual study on their own could not accomplish. His model of the Hestia-Hermes relationship posits that Vesta's and Juturna's precincts could be both antithetical and complementary. They were antithetical because they respectively represented both the opposing elements of fire and water and the concepts of sovereignty and subjugation. They were complementary because fire and water used jointly were crucial for life in Rome, and because subjugated peoples were integral to Roman society.



Fig. 3. Right, the Temple of Vesta. Left, the rectangular Fountain of Juturna, in front of the three large pillars of another temple, that of the Dioscuri.

Vernant analyzes the relationship between the Greek gods Hestia—the Greek equivalent to Rome’s goddess Vesta—and Hermes. He describes the attributes of the two deities, and claims that they are both intimately related to the physical space of mankind. Hestia, the goddess of the hearth, is found solely in the hearth and home and her dominion does not extend outside this space. The Greeks thought of the hearth as the “centre of the domestic sphere. Sealed in the ground, the circular hearth denotes the navel which ties the house to the earth.”<sup>24</sup> Hermes, on the other hand, is the god of messengers, travelers, and thieves; his domain is never a fixed space. His place was at the door, at the gateways of towns, on state boundaries, and at crossroads.<sup>25</sup> Vernant claims, then, that space was understood by the Greeks as divided under the dominion of these two gods; although they controlled opposite spheres, they were understood together as masters of physical space.<sup>26</sup>

Hestia and Hermes are also found in larger, more general, designated sacred spaces which represents the polarity of their relationship. For example, Vernant states that in Athens, the seat of Hestia Koine—an altar to Hestia—was situated immediately beside an ever-fallow field dedicated to the god of hunger. This field was related to the god Hermes because the fallow field represented the space of the traveler.<sup>27</sup> Thus, these two sacred spaces, although representing opposing forces, were understood complementarily and placed side-by side. The space as an entire precinct then became representative of the tension that existed between centrality and wandering.<sup>28</sup>

The idea of polarity also characterized Vesta’s and Juturna’s precincts. For example, the opposing elements of fire and water, which together, symbolized life in Roman thought, reflect back on Vesta and Juturna. Vesta’s temple housed the most important fire in Rome and Juturna’s fountain surrounded Rome’s most important spring.

The fire in Vesta’s temple was the most prominent in Rome because it signified the Roman state. The archaeologist Coarelli states that when the Republic replaced the monarchy, the hearth of the former king, which at some point in Rome’s early history became associated with Vesta, was transformed into that which represented those of all other Roman households.<sup>29</sup> Vesta’s fire as a collective representation signified the entire Roman state, making it the most important fire in Rome.<sup>30</sup>

Similarly, Juturna’s spring and fountain, as seen in figures 4 and 5, were emblematic of water in Rome. The most obvious evidence we have for this is Juturna’s apparent status as the tutelary nymph of springs and rivers. In her first appearance in book 12 of his *Aeneid*, Vergil establishes her as such when Juno first comes to Juturna to galvanize her to help her brother, Tur-

nus: “Immediately, goddess to goddess, she speaks to Turnus’s sister who ruled over lakes and echoing rivers.”<sup>31</sup>

Historical evidence concerning the fountain itself likewise shows Juturna’s spring to be the most important in Rome.<sup>32</sup> The spring’s reputation for healing properties is evidence of this. Varro attests to this property of Juturna’s waters by saying “the nymph Juturna who heals: and thus many who are sick are accustomed to seek water from this place because of her name.”<sup>33</sup> Likewise, Frontinus, who was commissioned with the charge over Roman aqueducts, mentions Juturna’s fountain among two other fountains famous for their healing properties:

The memory of fountains with sanctity still remains and is cultivated: For they are believed to bring health to sick bodies— The fountains of the Camenai, of Apollo, and of Juturna, for example.<sup>34</sup>



Fig. 4. The Fountain of Juturna, as seen from the Palatine Hill.





Fig. 5. The Fountain of Juturna, looking into the fountain.

Although Frontinus names two fountains other than Juturna's in this discussion, Juturna's seems to be particularly distinctive in works of other authors. Statius, for example, in his *Forests*, attests to the unique quality of Juturna's water by suggesting that her spring alone would still provide pasture should the rest of the land become infertile, saying, "who would deny that there is pasture in the fountain of Juturna when all moisture is gone?"<sup>35</sup> Juturna's status as the titular deity of springs and the prominent space which her fountain held in the Roman Forum, have led scholars to identify Juturna's fountain as the most important in Rome.<sup>36</sup>

The prominent status of Juturna's fountain elevated it to the point that it became representative of Rome's water. In 328 CE, the headquarters for Rome's water and aqueduct administration was transferred to a building immediately to the east of her shrine.<sup>37</sup> This transfer can be securely linked with its placement next to Juturna's shrine by a statue of Aesculapius which decorated the building.<sup>38</sup> Although this event happened late in Rome's history, the fact that this transfer occurred suggests that the Romans' understanding of Juturna's fountain as representative of the water of the city was strong. Juturna's fountain, as seen in her mythological identity and in the history of her spring, was emblematic of water in Rome.

The classical scholar George Dumézil suggests that the elements of fire and water are oppositional. His discussion on fire and water is especially helpful because it both specifically discusses the Roman's concept of

the elements, and places them within the larger Indo-European context whence the earliest forms of Roman religion arose. He discusses the opposition between the two elements in his quotation and discussion of Servius, a Roman author who wrote a commentary on Vergil's *Aeneid*:

The word "futile" denotes a vessel with a wide mouth but a narrow base, which was used in the cult of Vesta, because the water fetched for this cult is not to be put on the ground, and because, if this happens, it is a matter for expiation: whence the invention of this vessel which cannot stand upright and which empties out if one sets it down.<sup>39</sup>

As Dumézil notes, "It is clear that the Romans, who are not metaphysicians, simply cling to the idea that water and fire, in our earthly experience and practice, do not go together, that they are enemies, and that the first is dangerous to the second."<sup>40</sup>

However, fire and water used jointly were integral to life in Roman society. This is first evident in Roman religion. In his *Festival Days*, Ovid discusses a sacred rite carried out for agricultural abundance, fruitfulness, and the celebration of the founding of Rome.<sup>41</sup> In the ritual it was necessary for water and fire to be used together:

Say this four times, and wash your hands with living dew. . . and soon move your vigorous limbs with swift foot over the burning piles of crackling straw. The custom is told: the origin of the custom remains for me to tell. . . Is it because all things are from two opposing contrary elements, fire and water? And our forefathers joined these elements, thinking it right to touch their bodies with fires and sprinkled water?<sup>42</sup>

The fact that these two elements were used in a sacred ritual celebrating Rome's founding and performed for fruitfulness intimately connects them with the source of life in the religious sphere.

Fire and water were likewise used together in Roman marriage ceremonies to symbolize the new life of married couples. Varro states, "The conditions for procreation are two: fire and water. Thus these are used in the threshold in weddings, because there is union here."<sup>43</sup> Festus, a fourth century CE Roman author discussing religion, states, "Water and fire are both denied to condemned men and accepted by brides. The reason is probably because these two substances contain the very stuff of human life."<sup>44</sup>

In Cicero's *De Domo Sua*, we see this juxtaposition signifying the source of life in the legal sphere. Cicero, after being condemned to exile for putting citizens to death without a trial, discusses the interdiction—the prohibition from fire and water—in a speech in his own defense: “But what judgement did the skilled and clever scribe give? ‘By means of both guards and orders that Marcus Tullius be interdicted from water and fire.’ A cruel and wicked judgment, that ought not to be borne by even the most wicked citizen without a trial.”<sup>45</sup> Since exile—the leaving behind of one's home and country, the center of one's life—is equated with prohibition from fire and water, we can see that fire and water were recognized in the legal sphere to be the elements most crucial to the sustenance of life.

The combination of fire and water was believed to be necessary for life in Roman society as these elements encompassed the three key societal spheres of religion, domestic affairs, and state. The juxtaposition of Vesta's temple, representing individual households and the entire Roman state, with Juturna's fountain, Rome's most prominent spring, suggests that together, these shrines embodied the opposing powers of fire and water, symbolizing life in Roman society.

## THE POLARITY OF SOVEREIGNTY AND SUBJUGATION

The second polarity between the precinct of Vesta and the fountain of Juturna is that between sovereignty and subjugation. Vesta's temple acted as a public display of Roman sovereignty because of its historical relationship to the Regia, a complex immediately to the north that was once the palace of Rome's ancient kings. The proximity of the precincts of Vesta and the Regia can be seen in figure 6. The layout of the earliest archaeological phases of the Regia is unclear, but scholars believe that the king's royal complex encompassed not only the Regia itself, but the area where Vesta's cult and temple would later develop.<sup>46</sup> The entire area was leveled, with pre-existing huts demolished in the seventh century BCE, and the first Regia was built at the end of the seventh century.<sup>47</sup> At that time, no structure existed for Vesta's cult, but there may have been some votive deposits there by the mid-sixth century.<sup>48</sup> Scholars believe that this complex was an imitation of Etruscan royal domestic structures of the seventh century BCE.<sup>49</sup> These structures included rooms surrounding a courtyard and a rectangular pit for sacrifice. The Regia would have been the royal palace,<sup>50</sup> but it has not been defined where the courtyard and sacrificial pit would have been during that century, although traces of a sacrificial pit dating to the mid-sixth century have been found in the precinct of Vesta.<sup>51</sup> As there

is no evidence for the royal hearth *per se* during this era, perhaps this sacrificial pit in the precinct of Vesta was the sixth century religious equivalent of the hearth that would be surrounded by Vesta's temple in the third century BCE.



Fig. 6. Left, Temple of Vesta. Top Right, Regia.

During the third century BCE, by means of various wars and treaties, Rome extended its sovereignty by gaining control of all Italy.<sup>57</sup> A major part of this expansion lay in Rome's conquest of unincorporated Latium, the territory in which Rome was located. Although Rome originated from the same Latial culture as the other Latin tribes, the city of Rome itself grew more powerful than other Latin towns, and in the sixth century BCE, even claimed authority over them.<sup>58</sup> By the end of the fourth century BCE, after various Latin revolts, the territory of the Latins was taken and settled by Romans.<sup>59</sup>

Despite the fact that Rome and the rest of Latium were inimical to one another, strong cultural similarities caused the original bond between them to continue to be recognized. The most evident of these is their linguistic connection: the language that the Romans spoke was called Latin. Other ties persisted as well, as seen in Livy's account of Rome's war with Latium at the beginning of the fourth century BCE. Livy records that the Romans still felt uncomfortable fighting with a people so similar to them, and that the Romans and Latins could hardly tell each other apart in dress and manner.<sup>60</sup>

Juturna's fountain and cult were intimately connected to these Latin peoples before they were associated with Rome. Servius praises Juturna's waters, which, at first glance, the modern reader would be inclined to identify as Juturna's fountain in the Roman Forum. However, he mentions that the waters in question are near the Numicius River, which lay outside of the city of Rome, in Latin territory.<sup>61</sup> The fact that Servius chose to praise the Numicius instead of the fountain in the Forum indicates the heightened importance of the Numicius fountain, demonstrating a time-honored legitimacy and respect bestowed upon the Numicius fountain. This leads scholars to believe that the cult of Juturna actually originated in the Latin town of Lavinium and was imported into Rome.<sup>62</sup>

Vergil, in his *Aeneid*, echoes this bond between Juturna and the Latin peoples. He makes her the sister of Turnus,<sup>63</sup> a mighty man of a tribe neighboring the Latin kingdom, who was betrothed to Lavinia, the daughter of the king of Latium.<sup>64</sup> Although Turnus, and consequently Juturna, were not technically Latins in Vergil's epic, they were very closely associated with them in that Turnus was the chief warrior of the Latin army in opposition to Aeneas.<sup>65</sup> Juturna's renowned fountain in the Latin town of Lavinium and Vergil's close association of her with the Latins in the *Aeneid* reflect the ancient bond between Juturna and the Latins.

At the beginning of the Republic, before her rectangular fountain was built in the Roman Forum, the area surrounding Juturna's spring was developed for urban and religious use.<sup>66</sup> From that time on, Juturna's spring was the most important in Rome.<sup>67</sup> It is, however, unclear when this spring became associated with Juturna.<sup>68</sup> If it was associated with her since the beginning of the Republic, this association would correspond to the time before the Latin revolts when Rome was dominant over Latium. If it was not attributed to her until after the fountain was built on top of the spring in the mid-second century, one-hundred and fifty years after the Latins had been subdued, then it would correspond to the time when Rome had defeated Macedon and finally subdued Carthage. If the association occurred at a date after the Latin revolt, it would suggest that the Romans understood the importance of the correlation between their dominion

over the Latin people and their expansion beyond Italy: without control over the Latin people, Rome could never have broken out into, and thus achieved dominion over, the Mediterranean.

The juxtaposition of Vesta's Temple with Juturna's fountain reveals a polarity between sovereign power and a people subjugated by that power. However, the historical bond between Rome and the Latins, whom Juturna represented, and her prominent role in Vergil's *Aeneid* nuanced subjugator-subjugated dichotomy, which the shrines display, suggests that Rome's attitude toward the people whom it subjugated was not entirely one of cultural obliteration. Rather, the very fact that Juturna's fountain was granted such a prominent space in the forum reveals how Rome acknowledged its connection to the Latin peoples, recognizing that without them, Rome could not have become an empire.

## CONCLUSION

The study of the shape of Vesta's temple, led me to three major conclusions. First, as the shape and location of her temple mimicked those which the Romans associated with the universe, Vesta's temple could be viewed as a microcosm of the earth. Second, the circularity of her temple is part of a larger juxtaposition—that with Juturna's fountain—which represented the foundational elements of Roman life. Third, the location of Vesta's temple between the Regia and Juturna's fountain reveals an ever-present tension within Roman society between the state's sovereign and subjugating power, and Rome's acknowledgement of a bond to the culture of its origins.

Connecting Vesta's temple and Juturna's fountain appears to be new in the scholarship of ancient Rome. Although Rome has been an object of study and a travel destination for hundreds of years, I have found no other discussion highlighting the juxtaposition between these two precincts or discussing the two axes of polarity between them. Viewing the polarity between the two temples through the opposing elements of fire and water is a new interpretation, and the dichotomy between sovereignty versus subjugation is one which I developed with the aid of my mentors.

This project has contributed to the field of classics by proposing a new way in which to interpret the southeast area of the Roman Forum containing the Temple of Vesta, the Fountain of Juturna, and the Regia. Suggesting that Vesta's temple became a display of the sovereign power inherited from the Regia after the road separated the two shrines is a new addition to the discussion concerning the Temple of Vesta and the Regia. The discussion of the polarity and complementarity between Vesta and Juturna's precincts presented here is also novel.



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# Changing the Nature of Education in the Valleys of Bolivia: Teaching Vivir Bien

author

Melina Latona

## **BIOGRAPHY**

Melina A. Latona graduated from UMBC in the spring of 2016 with a double major in anthropology and global studies and a minor in spanish. She was a member of the Humanities Scholars Program all four years and studied abroad in Bolivia in fall 2014. During these courses of study, she developed a passion for studying the ways culture influences community well-being and drives social change. Melina would like to thank professor and mentor Dr. Bambi Chapin for her continuous support in this project, for challenging her to become a stronger writer, and for inspiring a passion for anthropology. Melina would also like to thank Dr. Felipe Filomeno for mentoring her first undergraduate research experience and for giving her the tools and the opportunities to explore her interest in research.

# DEMYSTIFICATION

In the context of Bolivia's social and political efforts to dismantle the lasting colonial infrastructure in their country, I explore the work of culture in one small school and how ideas of living well, *vivir bien*, are embodied in their approach to teaching and learning. In this article, I describe the case of La Comunidad Verde, my pseudonym for an educational community and school, which was founded in a collective effort as an alternative to the public and private school models. This research was completed during my studies abroad in Bolivia, where I studied themes of multiculturalism, globalization and social change. I lived in a small town where this school was located, attending the school for the last two weeks of their semester as I conducted my research. The research in this article was originally conducted and written-up in Spanish and was then translated and developed into this article after my return to UMBC. I also published and presented research with the Global Studies Department in the first issue of the Global Baltimore Report and at UMBC's annual Undergraduate Research and Creative Achievement Day in 2015, making this my second piece of undergraduate research to be published at UMBC.

## INTRODUCTION

In the fall of 2014 I spent three months studying multiculturalism, globalization, and social change with the School for International Training (SIT) in various regions of Bolivia<sup>1</sup>. During my studies, I had the incredible opportunity and privilege to learn from scholars and professionals in various fields about Bolivia's history, the impact of colonialism, indigenous movements, and current political and social issues. I met with individuals and groups representing diverse positions on the political spectrum including policy makers in the presidential office, representatives of the World Bank, and petroleum companies with an agenda of economic development and specific, economy-oriented ideas of progress. I also talked with individuals in grassroots organizations and social and environmental activists, who have radical ideas to shift away from the dominant paradigm of global exploitation and neoliberalism to approaches that are more just to humans and the Earth, and more sustainable for all life. In these diverse encounters, I sensed a common and powerful desire for people to better their country and their communities. Although the call for social and political change was present among each of these groups, I observed that their words and actions were rooted in very different ideals of development and well-being. As my study abroad program focused on these themes, one question continued to arise in conversations: How do people in Bolivia think about and

practice *vivir bien*? That is, what does it mean “to live well,” what does it look like, and how is it promoted?

I will explore this question by drawing upon my findings and observations from research I conducted in a small town in the province of Santa Cruz, located in the fertile valleys that border the amazon rainforest in the northeastern region of the country. To maintain participants’ confidentiality, I will call this town El Valle. I spent three weeks living among and learning from a group of people with a similar vision of what it means to live well, who have come together to create a unique educational space that I will call La Comunidad Verde. In this case study I describe an educational community that is built on values of collectivity, creativity, and sustainability; that is intentionally and effectively challenging the model of popular pedagogy that has been implemented through colonial means since the beginning of the 20th century.

The aim of my research was to determine how this school shapes the future generation in El Valle and how this institution reflects the core values and addresses the emergent needs of the community at large. I will demonstrate that this educational community is challenging the neoliberal paradigm that is present in the Eurocentric education system by reconstructing education in a way that promotes their own ideas of well-being, and addresses their needs at the local level; practicing and teaching values of environmental and cultural sustainability, cooperation, coexistence, and reciprocity. I observed this alternative paradigm embodied in the way the school was created, in the physical learning environment, and in the types of classes and daily activities that were incorporated into the curriculum.

Before I present my research methods and observations from this educational community, it is important to describe the country’s current political and social landscape by explaining the key paradigm shifts that have moved Bolivia’s development goals away from standards of neo-colonial and imperial infrastructure, and into a space where alternative paradigms have emerged. A key part of these political shifts includes an education reform that encourages new ways of thinking about education and its potential for making social change. These recent shifts have opened spaces for new voices of autonomy and resistance, such as those who have advocated for and participated in the foundation of this school that is the site of my research, and those who have given rise to the growth of decolonization movements of which this school sees itself a part.

## THE SOCIAL AND POLITICAL LANDSCAPE

In Bolivia and throughout the world, the paradigm of neoliberal economic development dominates national and global politics: the race for

land and resources, and the implementation of social infrastructure. In Latin America, this paradigm has been introduced and promoted through colonial means since the 18th century, and explicitly demands the assimilation of neoliberal development policies. Over the past decade, a shifting political landscape in Bolivia turned towards more inclusive, multicultural approaches to social reforms, voicing autonomy as a means of strength in the face of western, neocolonial, neoliberal standards of development. The current president, Evo Morales, rewrote the constitution in 2009 to reflect and address the needs of Bolivia's diverse population, in what he calls the decolonization agenda. Many of his policies are aimed at dismantling the institutions that have been established by European and North American corporate interests, such as strengthening the autonomy of Bolivia's 36 distinct indigenous groups by recognizing Bolivia as a plurinational state for the first time in history.

## COMPETING PARADIGMS OF DEVELOPMENT: NEOLIBERALISM AND LOCAL RESISTANCE

In a critical discussion of development interventions in the postcolonial world, anthropologist Arturo Escobar asserts that western-driven interventions have proven to be destructive in the "third-world" (Escobar 1995). According to R. Tathagatan, new regulations for social infrastructure bring a range of struggles to local communities, as well as social subordination based on imperialism, class, and race (2008, 37). Despite romanticized visions of positive growth, modernization, and development, these approaches and solutions are based on Western ideas and standards of what it means to live well. While this neoliberal and Western worldview often underlies national and international political motives for development projects in Bolivia, local resistance is growing.

There has been a long standing and deeply rooted paradigm of sustainability and cultural preservation in Bolivia, held mostly by the collective 36 indigenous groups, but also in urban centers where subcultures emerge and call for social change. Since the 1970s, the national popular movement and the indigenous movement have held the strongest voices of opposition to neoliberal policies (Tathagatan 2008, 37). Native groups voice much of the resistance to the neoliberal development paradigm, as they have historically been displaced from their homelands, enslaved, and exploited for labor by colonizers and hegemonic systems. Although these movements represent different populations, they are united by similar visions of living well: they fight for human rights, environmental and cultural sustainability, multiculturalism, and community solidarity.

Renowned scholars and activists in Bolivia such as Jim Schultz, founder and director of The Democracy Center, and Rafael Puente Calvo, acclaimed author, educator, ex-vice minister and historian, have observed a persistent and long lasting clash of worldviews between the industrial mentality and the sustainable mentality, the manipulated world and the natural world, those oriented toward profit and those oriented toward harmony. In my research at the school in El Valle, the latter of these worldviews is visible and exemplifies the strength of this alternative paradigm.

## DECOLONIZING BOLIVIA

The landslide victory of Evo Morales in the 2006 elections marked the beginning of a decolonization era. A branch of the government was dedicated to decolonization efforts to revert the years of colonial infrastructure and to reform public services and economic sectors to promote national growth. Felix Cardenas Aguilar, Bolivian Vice Minister of Decolonization, writes that decolonization movements seek to identify and deconstruct the existing colonial structures that shape Bolivian society: dependence on foreign industries and investment, schools which teach a certain image of progress and a certain idea of backwardness, religious institutions which have been used to consolidate colonial objectives, and the legal system modeled after the Spanish colonial empire (Cardenas Aguilar 2013). The National Congress of Education (2006), quoted by Lopes Cardozo, explains decolonizing education in Bolivia as “putting an end to ethnic borders that influence opportunities in the area of education, work, politics and economic security, where no one is privileged on the basis of race, ethnicity and or language” (Lopes Cardozo 2011, 4). The Congress also avoids favoring “conceptualizations of the Western world as if they are universal,” while “valuing the knowledge, skills and technologies of the indigenous civilizations, both of the Amazonian and Andean regions” (Lopes Cardozo 2011, 4). In both descriptions, there is an explicit message that to achieve equity of opportunity, for the well-being of all people, there must be a more diversified set of options, of institutions that value and include indigenous knowledge and skills. The path towards this equity, this collective wellbeing, begins with education: *What knowledge is being passed onto future generations? What does this imply about the way we are to live and the way we are to define living well?*

## TOWARDS CULTURALLY RELEVANT EDUCATION

A new education reform law passed by the decolonization administration in 2009 replaced the former neoliberal education reform of 1994. This law, entitled Avelino Sinani Elizardo Perez (ASEP), is built on four pillars: 1) decolonization, 2) intra- and inter- culturalism together with plurilingualism, 3) productive education, and 4) communitarian education (Lopes Cardozo

2011, 4). With the new reform, there has been a greater focus on the notion of education as a means toward social change, the development of the country, and the betterment of its people. As a Bolivian minister states, “society will not change if we do not change education” (Lopes Cardozo 2013, 2).

In an essay, Mieke T.A. Lopes Cardozo (2013) writes about this aim of social change through education and what this means for schools, for teaching and learning, and what this change would produce in Bolivia. She argues that “education policies represent not only the state’s vision on how its population can be best ‘developed,’ it also defines what type of citizen is envisaged, or how Bolivia aims to deal with its diverse population and social inequalities” (Lopes Cardozo 2013, 3). Homogenization of the school system contributes to the inequality of opportunities: more access for middle and upper classes while creating greater challenges for children from rural and indigenous families to attain education. Indigenous families often reject public schools as they feel it does not teach their children anything useful or helpful to their lives, and only draws them away from *el campo*, and into the city life. Cardenas Aguilar (2013) writes that schools teach children that wearing a *poncho* or a *pollera* is regression, that it is backwards; and that wearing a shirt and tie or a dress is progress. Intervention of Western institutions may put the next generation of Bolivians on a fast track out of poverty, while pressuring them to leave their families, their communities, their language, and their traditions behind.

The new educational reform is aimed at providing culturally relevant and accessible education to various and distinct groups in Bolivia. While public schools are accessible to most children, they are often lacking in quality teachers and relevant curricula. For students that do graduate from secondary school, they may need to take an extra year of classes to meet international standards for university (Ozisk 2015). Private schools on the other hand are believed to provide a higher quality of education, but they are unaffordable for many families. In the rural regions of Bolivia, private schools are practically non-existent, leaving very few schooling options for those children. Alternative schools offer accessible education that can address the educational needs of underserved students and make the changes that people want to see in their communities.

At the core of these efforts, according to Delany-Barmann (2010, 181), is an implicit critique of hegemonic practices and voices, in addition to the promotion of spaces for subaltern practices and voices to be heard where they may become a base for change. With the education reform, communities can create spaces for more culturally relevant pedagogy, more self-sustainable and reflective of their specific values and desires for educational outcomes. It is in this context, where neocolonial models of education are being rejected, that the school in El Valle grew.



## METHODS

I used participant observation and interviewing as ethnographic methods to investigate these questions. During my research, I lived with a family who helped pioneer this educational community, allowing me to form important connections with other parents, teachers, and students. I conducted formal interviews with the school director and with my host parents, as they not only helped found the school but were also teachers there at that time. I also conducted several informal interviews with two parents who were waiting for their children after school in the main plaza, a former music teacher whom I met in the café, and with two teachers whom I met in the school. Through discussions with adults, I aimed to get a variety of perspectives on the school's social and educational goals, and how their ideas of what it means to live well are incorporated into these goals.

My findings are largely based on these conversations and participant observation within the school, La Comunidad Verde. I attended the school during the last two weeks of their semester, participated in classroom and schoolyard activities, went on a class trip to the local museum with the first/second grade, and observed the rhythm of daily interactions alongside students and teachers. Another significant part of my participation at the school, and a significant contribution to my research, was a series of guided lessons and activities surrounding themes of climate change and the interconnectedness of humans and nature, presented in a bilingual children's book called *Que Pasó con Chita?*

*Que Pasó con Chita?* was written by an SIT alumna in 2011 as part of an initiative called Kids Books Bolivia. These books come with a manual of corresponding lesson plans, a sort of creative curricula, which was provided to me by my study abroad program director before my visit to El Valle. I presented the book and my lesson plans to the school director at La Comunidad Verde on the first day of my visit, and was given permission to work with the children in 1st and 2nd grade. By incorporating this story and selected activities, I hoped to facilitate conversations about the relationship between humans and nature. The outcomes of these lessons, which I detail later, not only revealed a level of awareness and responsibility which I found to be remarkable among students of that age, but also reflected a particular worldview and vision of living well.

## LA COMUNIDAD VERDE

After I arrived at the home of my kind and generous host family in El Valle, I quickly assimilated to the laid-back way of life, *la tranquilidad*, and the inescapable beauty of the green valley. I admired the town's commitment to

organic agriculture and small, local businesses, and wondered how it could be that just two hours from the city of Santa Cruz, the most “modern” and “westernized” city in Bolivia, this town could be left relatively untouched, left to its own self-sustaining devices. In this small town, there were only about two markets where one could buy food, and only a handful of cafes and restaurants. I became familiar with many faces, and I began to notice that all of these faces seemed to know each other as well. I soon learned that out of all the adults I encountered daily, about half of them were somehow connected to this school community, as parents or former teachers or guest workshop leaders: they were all part of La Comunidad Verde.

Three elements structurally and ideologically distinguish La Comunidad from other schools in Bolivia. The way this school was founded, the way it was constructed, and the way it approaches learning characterize this school and speak to its efforts to promote a particular way of living that is valued by the local community.

## THE FOUNDATION

The couple I stayed with, Lucas and Magdalena, were two of the parents involved in the founding of the school in 2012. They are parents of nine children: the oldest seven were off studying, living, or traveling in different parts of the world at the time of my study. The youngest two children were raised in El Valle and had attended the school from its conception. It was explained to me that a group of four families, all of them parents of young children, decided that the education in El Valle, and Bolivia in general, was not addressing issues that their children would face as they grew up in this world. These parents felt that critiquing the school system was not enough; they had to do something, create something. They had a vision of what kind of learning they wanted for their children, and of the world in which they wanted their children to be raised. Reflecting core values of sustainability, coexistence, and “organic learning,” the foundation for this primary school was created. I will show how this vision of what it means to live well is present in all aspects of the school.

La Comunidad is young, but growing and adapting each year as students advance and as other similar movements emerge in Bolivia. At the time of my visit, the school was getting ready to move to a location on the periphery of the town, where they will have more room to expand. The school uses a system of combined grade levels, placing students ages two to five in kindergarten; ages six to eight in first/second grade; ages nine to 11 in third/fourth grade; and ages 12-15 in fifth grade. There were 24 students enrolled at the time of my visit, the largest group being the first/second grade with eight students. There were only six students over the age of 11, so the fifth grade at this school was like a combined sixth, seventh and eighth grade class in the

United States' public school system. The scheduling of the school day followed in the custom of other Bolivian schools, which consisted of two sessions per day: from 8:00am to 12:00pm and from 2:30pm to 5:00pm, allowing for a family lunch and a *siesta* (nap time). However, as I will address in the following sections, the activities that fill these learning sessions were intentionally quite different from those of traditional public or private schools.

Parents' voluntary involvement was critical to the school's physical existence as well as its administration. The school was not affiliated with any board of education, and was not dependent on government funding. Although the founders did apply for and did receive an initial sum of grant money for the construction of the school, nearly all the books, materials, and even the school playground, were acquired by donations or were provided by cooperative efforts to supply and provide for the school. As the parents were highly involved in administrative decisions, they often volunteered to teach classes based on their own areas of expertise, knowledge, and passions. This means that, contrary to the popular pedagogy model, the teachers were not required to have degrees or certificates in teaching; the only requirements were to have extensive knowledge on the subject and a devotion to passing on that knowledge. The curriculum, flexible to fit the needs and demands of each group of students from year to year, and teaching assignments were planned during parent meetings,

At the end of each semester, parents and the appointed school director met in the schoolyard to discuss the learning outcomes over the past months and to discuss learning goals and means of improvement for the following semester. These meetings were free-form, democratic, and allowed for much flexibility in the dynamic of conversation. At this time, parents could make suggestions for new subject material, new workshops, or project ideas. When discussing the implementation of a new class, the group considers the benefits of their children learning about the subject, the possibilities for who would teach the class, which grade level would gain the most from this class, and methods of teaching the material. In most cases, if the topic was feasible and there was a positive or beneficial outcome to learning, it would be approved and incorporated in the schedule for the following semester. As students age up, new topics and courses were added to meet their learning capacities, and to teach skills and knowledge that will aid them in adult life.

For this group of parents and teachers, the public school curriculum lacks elements of learning that they view as fundamental to their children's and the community's well-being. These elements include the notion that everyone is always learning (including the adult teachers), that creativity and cooperation (as opposed to standardized independent work) is a more natural and healthy environment for children, and that diverse and criti-

cal approaches to thinking and learning are essential for sustaining culture and preserving life. Allowing schools to form based on community needs and values not only creates space for culturally relevant learning, but also provides a sense of security and well-being for the adult members as they become more directly involved in their children's learning process. As the community takes control over their children's education, they simultaneously challenge the state and federal systems which implement a standard, Eurocentric curriculum. The community's values of environmental sustainability and creativity are especially reflected in the physical and social spaces of the schoolyard.

## THE GREENSCAPE

The school was found nestled between a hardware store and a restaurant on the main road that enters the town. The classrooms were modest in size and structure, the walls were painted with lively yellow and orangey pink, and the doors were painted forest green. Classrooms, workshop stations, and the small library occupied one-third of the property, leaving enough open space for children to play games like soccer and tag. Continuing through a small doorway in the schoolyard, there was a wooden jungle gym, a tire swing, a composting pile, a chicken coop, and the beginnings of a small garden. By observing the physical layout, I sensed that the community promoted play and outdoor activity for children as being central to living well.

The typical school day began and ended with outdoor free time. It seemed the children spent equal amounts of time in the classroom settings as they did in workshops and playtime. During free time and breaks between classes, students played in the schoolyard doing a variety of physical activities. There were hula hoops and juggling toys, a slack line, soccer balls, painted tires on the ground, and a tire swing in the tree, as well as an elaborate jungle gym with monkey bars, a climbing wall, and swings. I learned that one of the fathers had built the jungle gym by hand, utilizing recycled material from his home and from surrounding towns, as a gift to the school when it first opened.

The first/second grade group had two morning classes from 8-9:00am and 9-10:15am, followed by a mid-morning snack, and free time or workshop (depending on the week) until 12:30pm. The mid-morning snack is provided by students; each brought fruit or homemade baked goods to share with the others. No processed foods or preservatives are allowed during snack time as the school aims to maintain a waste-free environment. Once the fruit is cut and presented on the communal serving plate on a table, the children gathered around and sang a song of thanks, acknowledging all the hands that helped to grow and provide these fruits. The song gave thanks to those who planted the seeds, to the sun and rain for letting

fruits grow, and for those who harvested the fruits and brought them to the market for us to buy and eat. After the snack, two classmates were responsible for cleaning up. The director reminded everyone that everything can go into the compost pile, since it is organic matter. One of the students looked to me and repeated excitedly “we can compost all of this!”

This daily practice is one of many ways that this school environment promoted an ideal of living well that includes sustainable practices and appreciation for nature. Conscious snacking and composting instill a sense of responsibility for protecting the natural world that feeds us. These practices of mindfulness, responsibility, and awareness of human relations to the natural world will be highlighted in the following section as I describe the outcomes of my guided activities with the students.

## THE CONCEPT OF TEACHING AND LEARNING

The type of classes and workshops I observed speak to the general learning goals of parents in this community and their teaching styles. Classes included a variety of subjects, including the basic mathematics up through geometry, reading and writing, English, German, social studies, natural or environmental science, architecture, musical therapy, martial arts, ceramics, and comparative cosmology. Without a standardized curriculum, teachers were allowed great flexibility in regards to teaching styles, lesson plans and activities. Depending on the subject, classes may often bear more resemblance to a Socratic seminar than to the elementary school classrooms in which I was raised.

One parent and teacher (and my host mother during this visit), Magdalena, taught sacred geometry and architecture to fifth grade students. She used a computer program to teach them about shapes and symmetry and utilizing space, and about the art of Feng Shui. Magdalena is herself a successful architect, and taught her class based on her own approaches to design and construction. She liked to teach the architecture class because it involved using a set of skills that are applicable to many different fields, and prepared them for professional work. Teaching students at this age enabled them to design and construct virtual homes, possibly introducing them to passions and talents that they might not otherwise explore.

From what I observed, the methods of learning were very hands-on and creativity-based, in the sense that children created, talked about, and actively practiced and interacted with the subjects that they were learning. Workshops were designed to be fun, yet informative and practical for use outside of the classroom. Popular workshops included biological soap and shampoo making, crafts with recycled materials, juggling and hula hooping, gardening, and composting. These children, starting at age five, were taught to replace store bought shampoos and soaps with a natural,

clean, and economical alternative. They were taught to tend to plants and to stir compost. They were encouraged to be creative and reduce waste by turning trash into something functional. Teachers took an approach that allowed children to be motivated by curiosity and to embrace creative inspiration. There also seemed to be an overarching sentiment that children were learning better and were remembering more when the activities were guided in a context that welcomed creativity and broad applications. As one teacher explained to me, students willingly engaged in activities, and shared what they have learned or made, when they felt that what they are learning is relevant and important to them.

Another aspect of my involvement at the school, and a significant source of my findings, came from the readings and activities surrounding the children's book, *Que Pasó con Chita?* The story tells of a young girl who is worried about her favorite sheep named Chita, who was looking frail and sick. The girl learns that this is because the sheep no longer have enough to eat and drink. Mother Earth is not well and is running a fever, unable to provide for all the animals. The story ends with the question, *¿cómo podemos curar a la tierra? How can we cure the earth?* I chose to work with the story about Chita because of its themes connecting environmental awareness and stewardship to problems of global warming. The school director liked the idea and approved my proposal to guide these activities and discussions, as the themes corresponded well with the philosophy and learning goals of the school.

I had considered that it was not a good idea for me to introduce material that was put together by American students if it would not be in line with the school's approaches to learning. However, this approval indicated that the director and I shared the idea that talking about issues of climate change, sustainability, and environmental stewardship with children is valuable. In the following reflections of my time guiding lessons and activities with the first/second grade students, I demonstrate that not only did the director accept my lesson plans, but the children did as well. The way the students internalized and understood themes, issues, and concepts brought up in these activities shows that students value learning about and talking about the environment; they do not deny the harms that humans have done to the Earth.

## GUIDED LESSONS: HUMANS, NATURE AND CLIMATE CHANGE

### DAY 1

We began with a warm up exercise (from the manual) in which the children lined up and, following the leader, acted out the scenarios I was describing.

The scenes transitioned from a nice sunny day, to big heavy raindrops, to freezing cold temperatures and lots of wind, to drought-like heat. These vignettes represented living in a world where climate change is growing more extreme. Next, we gathered in the classroom and read the story *Que Pasó con Chita?* We later talked about some of the human activities that cause harm or damage to the natural world. I sent them home with a sheet of homework, a crossword puzzle with some vocabulary, and the negative effects of climate change in respective regions of Bolivia.

The students already seemed to know a lot about what was happening in the world in terms of destruction to the natural world, and how this is a result of a certain way of life. After we read the story together, they shared their knowledge and their sentiments about how deforestation is *muy muy mal* (really, really bad), and how people who pollute are just lazy; *a ellos no les importa nada* (to them, nothing matters: they are careless).

## DAY 2

I met with the same students again. We reviewed what we had learned the day before, and upon reviewing the homework, we discovered some new vocabulary terms: inundación (flooding), sequía (drought), incendios (fires). I then read the class some excerpts from the “Letter from the Chief Seattle,” which highlighted warnings of the dangers of living in disharmony with nature and with one another. Later, I gave the students colored paper and crayons, and asked them to draw their ideal home, the house and the land surrounding, whether it be imaginary or real, of the present or of the future. I collected the drawings, made photocopies for my own record keeping, and returned the originals to the students at the end of my stay.

When I read excerpts from the letter, the students listened attentively to the words he shared. They asked questions, and gave feedback: *Who is the chief of Seattle? I think he was really smart.* Later, when I asked students to draw their ideal homes or their favorite places, all images included at least one tree, grass, flowers, and clear skies. No person drew a driveway, or roads, or even a car (cars are not very common in El Valle, anyways). Their drawings illustrated a healthy and lush environment, resembling their homes in the fertile greenness of El Valle. This demonstrated that it was important to them to live somewhere with natural environments, where animal and plant life can flourish alongside man-made environments.

## DAY 3

I joined the students of first and second grade on their field trip to a local museum. Afterwards, we continued discussing the importance of taking care of the earth and its inhabitants, and what would happen if we don't. I asked them to draw some examples of what destructive events could do

to the earth. What could change? What will the future look like if we do not care for the environment? The children drew a variety of things that alter or cause harm to the natural world, or alternatively, they drew something they hope to never lose because of climate change and human activity on earth.

#### DAY 4

I had the opportunity to meet with students in third and fourth grade, however since it was during their play-time and participation was optional, many decided they would rather play soccer or practice guitar. One ten-year-old boy seemed interested, and when I went to sit under a tree he followed and sat down next to me. We read the book together and I told him about the activities that the first/second grade had done with me. He asked if he could draw too. I provided him with paper and colored pencils, and he shared with me why he believes it is important to learn about the natural environment around us, and why we should live our lives among other beings and habitats. My brief talk with this one enthusiastic student went as follows:

**Me:** *Para que es necesario aprender a cuidar a la tierra?*

*(Why is it necessary to learn to care for the earth?)*

**Boy:** Porque si no, cosas malas van a pasar, y el mundo será un caos. Todo se va secando y no habría un hogar sana.

*(Because if we do not, bad things will happen, and the world would be chaos. Everything would run dry and there would not be a healthy home)*

**Me:** *Qué pasará si cortemos todos los árboles en el bosque?*

*(What would happen if we cut down all of the trees in the forest?)*

**Boy:** Los árboles son la causa de todo el oxígeno, si cortamos todos los árboles, no podríamos respirar. Los animales no tendrían comida ni un hogar. Todos morirían.

*(Trees are the cause of all of the oxygen. If we cut them all, we would not be able to breathe. Animals would not have food or a home. Everyone would die.)*

**Me:** *Cómo es tu relación con las plantas y los animales?*

*(How is your relationship with plants and animals?)*

**Boy:** Bien. Sabes cual prefiero, la naturaleza o la tecnología? Prefiero la naturaleza, porque a veces la tecnología falla, pero la naturaleza nunca falla.

*(Good. You know which I prefer, nature or technology? I prefer nature, because sometimes technology fails, but nature never fails.)*

**Me:** *Que haces en tu casa o aquí en la escuela para reducir el desperdicio?*

*(What do you do at home or here at school to reduce waste?)*



**Boy:** Tenemos un compost aquí en la escuela. En mi casa tengo uno también, y lo usamos esa materia en el huerto. Tenemos un huerto grande!  
(We have a compost here at school. At my house I have one too, and we use that material in the garden. We have a huge garden!)

When I asked this student if he could ever imagine living in a place without forests, rivers or big gardens, he responded: *No, no puedo. Quiero vivir aquí por todo mi vida* (No, I can't. I want to live here for all of my life).

The fact that the school director was on board with these activities and the fact that first and second grade students were engaged and knowledgeable and responded passionately reflects a certain type of awareness of our responsibility to be stewards of the earth and to take responsibility for our impact on other beings. The first and second graders liked to draw and to play, which may be expected of all children at this age. They were also very curious and creative, very aware of their own achievements. They were proud of the work that they do, the art they made, and their achievements on the playground. Very rarely did students get into arguments, and impressively, I did not observe any hateful comments or negative comments among students. On the contrary, I would frequently hear them praise one another and admire each other's work. Themes of learning do not resemble those that I grew up with in the U.S. public school system, but rather are centered on creativity and curious pursuits of knowledge, application of knowledge to real world issues and concerns, and a recognition of unique talents that removes much of the competition among students.

La Comunidad seeks to provide an education based on a deeper understanding of one's self, of one's relationship with other people and with the changing world around us. It fosters an environment of sharing knowledge rather than a place of giving and receiving knowledge. It teaches and practices sustainability from the environmental layout to the rituals of snack time. It provides space for creation, for exploration, and for a more multifaceted education, one that approaches learning as an ongoing process in which individuals are simultaneously teachers and learners.

## COLLECTIVE RESISTANCE: PRODUCING CHANGE AT THE LOCAL LEVEL

I would like to return to the notion of education having potential for social change. Global theorist Michael Mann (2013) says that social change is born from ideological power: a power that arises in response to crisis, where communities seek alternative possibilities when current needs are being underserved or unaddressed. In Bolivia and all over the world, groups of people are responding to the injustices that are inflicted by global

systems of wealth and knowledge. To break this pattern and to interrupt the transmission of ethnocentrism and global homogenization, alternatives emerge in small spaces, in the fringes and in the margins, among people with a similar vision of what it means to live well.

Institutions that reproduce culturally relevant knowledge within communities serve as an active force of resistance to the Eurocentric model of education and western ideology presented within it. The new education reform in Bolivia has created many opportunities, but also faces many challenges in achieving its goals of truly decolonizing education. If the Bolivian government views teachers as the “soldiers of transformation” to translate goals into an educational reality, then there are many factors getting in the way of that envisioned reality: “there is still a long way to go to bridge the gap between ideological intentions and a complex educational reality” (Lopes Cardozo 2011, 1). However, when the parents and community members are themselves the teachers, and are playing an active role in their students’ learning inside and outside the school, then pedagogy takes on a new definition.

As a school that was founded on cooperation and inspired by the need for a more sustainable and equitable future, La Comunidad Verde makes room for new approaches to learning, offering an alternative to the pre-existing standards for education in Bolivia. This group exemplifies the importance of questioning the utility and effectiveness of dominant paradigms present in society and asking ourselves *what does it mean to us to live well?* Furthermore, it demonstrates the potential for positive social change through culturally relevant education. Solutions that are rooted in community culture, based on local realities and resources, and that recognize the need to be responsible stewards of the earth, may be the seeds for change in creating a more sustainable and equitable world around us.

## NOTES

<sup>1</sup>During the first six weeks of my studies abroad with SIT, I attended classes at La Universidad San Simon in Cochabamba, where a variety of guest speakers lead our classes on themes of the country’s history, indigenous movements, political shifts<sup>1</sup>, and current social issues<sup>2</sup>. Speakers included authors Rafael Puente and Jim Shultz, and social activist and leader of the great Water War, Oscar Olivera. The program included many excursions, allowing us to visit nearly every part of the country. I visited the high-altitude political capital of La Paz, the even higher-altitude mining city of Potosí, and the historic capital of Sucre, and the tropical city of Santa Cruz. The program also included two rural homestays: one was in the mountainous village of Tocoli on the shore of Lake Titicaca, where I got a taste of subsistence farming; the other was in the hot and humid missionary town of Santa Rita, where I learned to weave cotton. These combined experiences allowed me to get a greater sense of Bolivia’s geographic and cultural diversity, and most importantly, they showed me the many ways in which people construct the meaning of living well.

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# An Unlikely Refuge: Jewish Refugees from Nazi Europe in Shanghai, 1933-1945

author

Jennifer Wachtel

## **BIOGRAPHY**

Jennifer Wachtel graduated from UMBC in May 2015 with a Bachelor of the Arts in History and minors in German, judaic studies, and art history. She developed an interest in studying the Holocaust during her undergraduate career. By Jennifer's senior year her studies focused on emergent fields of Holocaust research, including the Jewish refugees who survived the Holocaust by escaping to Shanghai. With the support of her colleagues and advisors in the Honors College and Humanities Scholars Program, Jennifer presented a poster and delivered an oral presentation at two separate Undergraduate Research and Creative Achievement Days (URCADs). While conducting her research, she also interned in archives and museums and worked in UMBC's Special Collections. With her combined research and work experience, Jennifer entered the History and Library Science (HiLS) dual master's degree program at the University of Maryland, College Park in fall 2015. She looks forward to a career in archives where she will share her love of historical research. Jennifer would especially like to thank Dr. Meredith Oyen, her history advisor, for her guidance through two URCADs and especially the honors thesis research process.

## DEMYSTIFICATION

Between 1933 and 1941, when most Western nations closed their doors to European refugees, over twenty thousand German, Austrian, and Polish Jews survived the Holocaust by escaping to Japanese-occupied Shanghai, China. In 1943, the Japanese authorities in Shanghai confined these Jewish refugees from the Nazi regime to the Restricted Sector for Stateless Refugees, or Shanghai Jewish Ghetto. Aware of my keen interest in Holocaust Studies, my advisor, Dr. Meredith Oyen, encouraged me to produce an honors capstone for the history department on this subject. I received a 2014-2015 Undergraduate Research Award (URA) that allowed me to fund the travel necessary to conduct oral interviews, consult archival repositories, and marshal evidence in both German and English. Over the course of this research, I discovered that the story of the Jewish refugees who escaped Nazi Germany extended far beyond the ghetto itself. The Jewish refugees' experience pointed to a much larger narrative of victimhood and agency not yet fully addressed in secondary source scholarship.

## VICTIMHOOD AND AGENCY OF SHANGHAI'S JEWISH REFUGEES FROM THE NAZI REGIME: AN INTRODUCTION

Born in Berlin in 1934 and now living in New Jersey, Peter Engler feared the sound of breaking glass well into his twenties. Engler was only four years old on the night of *Kristallnacht*, November 8 and 9, 1938, when Germans attacked and destroyed Jewish homes, businesses, and synagogues. Like thousands of other Jews, the Englers desperately sought a means of escape. In 1939, Engler and his parents fled Germany after *Kristallnacht* bound for an unlikely refuge: Shanghai.<sup>1</sup> Stripped of their German citizenship, Jews like the Englers sought a refuge they could enter without visa documents. Historian David Kranzler, recognized as a founder of the field of scholarship pertaining to Jewish Holocaust refugees to Shanghai, claimed in 1976 that 18,000 Jews fled to Shanghai between 1938 and 1941.<sup>2</sup> In 2013, scholar Gao Bei raised that estimate claiming that between 1933 and 1941, nearly 20,000 Jewish refugees, including the Englers, fled to Shanghai from Germany, Austria, and Eastern Europe as most Western nations barred their entry.<sup>3</sup>

For the Jewish refugees, Shanghai's allure lay in its status as an open port city. Nineteenth-century treaties ceding land to foreign powers and guaranteeing Europeans and Americans entry for a fee made Shanghai attractive to these refugees as a last resort.<sup>4</sup> Even though the Nazi regime

stripped the Jews of their rights, Jews could enter the city legally. The Japanese military, however, captured part of Shanghai in 1937 and represented a menacing presence in the refugees' lives. Gao notes that the city of Shanghai included several discrete administrative districts: the Chinese-controlled area of the city under Chiang Kai-Shek, the International Settlement represented by Western powers, Hongkou to the east of the International Settlement under the Japanese, and the French Concession governed by the French consul.<sup>5</sup> When the refugees arrived in Shanghai in 1938 and 1939, many of them lived and worked in the International Settlement. After the Japanese attack on Pearl Harbor in 1941, the Jewish refugees lived in fear of both Japanese warmongering and U.S. retribution on Japanese-occupied Shanghai. Jews intermingled with the international society of Shanghai until 1943, establishing businesses or subsisting with low-wage employment. In 1943, the Japanese tightened their restrictions on the Jewish refugees and relocated them to a one square mile section of the Hongkou district in Shanghai. The Jewish refugees found themselves at the mercy of the Japanese authorities and dependent on external aid. Those without funds lived in decrepit dormitories called *Heime* in a district surrounded by Japanese guards.<sup>6</sup> After liberation by the U.S. military in 1945, the refugees attempted to either return to Europe or resettle elsewhere.

In the last five to ten years, as popular interest and scholarly publications on the Jewish Holocaust refugees in China increased, the stories of these refugees contributed crucial missing elements to the history of the Holocaust. Additionally, the surge of memoirs published from the early 1990s to the present provide crucial insights into the ways Jewish refugees in Shanghai remembered their experiences long after the war. Both scholarly works and personal memoirs present a dichotomy of Jewish life either as victims of the Nazis and the Japanese military who depended on charity to survive, or as the fortunate ones who successfully created new lives for themselves in Japanese-occupied Shanghai. Jewish refugees in this way straddled the roles of the victim and the survivor, illustrated by the refugees' compelling stories. By securing passage to Shanghai, dissociating themselves from their countries of origin, establishing new businesses, and reforming their Jewish community, these Jewish refugees exhibited considerable control over their own destinies despite living under the increasingly strict control of the Japanese authorities in Shanghai.

This study examines how Jewish refugees, fortunate to escape the Holocaust, established livelihoods under Japanese rule. The first three sections detail Jewish dependence on charitable aid, Japanese control of Jewish life in Shanghai, and Jewish demonstration of agency throughout their time in Shanghai. For the Jewish refugees, aid societies represented one of their first contacts with their new refuge. The refugees' fear of the

Japanese provides a stark contrast to their relationship with aid societies. In this environment of oppression and dependence, the Jewish refugees continued to express their European Jewish culture. After the war, as the last section details, Jewish refugees once again exercised agency in uprooting their lives out of Shanghai and relocating elsewhere.

The refugees were neither solely victims nor solely agents, but rather products of their European upbringing. The refugees upheld traditions despite Japanese controls and restrictions on their livelihoods. Although the Jewish refugees created a familiar environment for themselves in Shanghai, these Jews depended upon relief organizations and remained the targets and pawns of the major powers of World War II. The Jewish Holocaust refugees in Shanghai occupied a middle ground of both victimhood and agency, which they created out of their status as Europeans in China under Japanese rule.

## JEWISH REFUGEES' DEPENDENCE ON DOMESTIC AND FOREIGN AID

While in Shanghai, Jewish refugees depended on support from both established Jewish communities in Shanghai and foreign aid organizations. When Jewish refugees from the Nazi Germany and Austria arrived in Shanghai in 1939 following *Kristallnacht* and the *Anschluss*, they found that they were not the only Jewish community or even the only refugee community. Two Jewish communities already existed in Shanghai: Sephardic Baghdadi Jews, who established their community by the 1850s, and Ashkenazi refugees from Bolshevik Russia.<sup>7</sup> In contrast to these well-established groups who had already migrated to Shanghai, the refugees from the Nazis had limited resources at the time of their arrival.<sup>8</sup> For the Jewish refugees already dealing with complex national identities, encountering these preexisting Jewish communities further defined their refugee status and led them to carve out a niche in Shanghai. The Jewish refugees from Nazi Europe were desperate and started new lives with limited personal possessions. After their voyage to the other side of the world, the Jewish refugees grappled with not only their shifting national identities but also their redefined social status in Shanghai.

The Baghdadi Jews, members of the Sephardim, migrated between 1820 and the First World War to India, China, the Malayan Peninsula, and Japan. Of the Sephardim, the Sassoons remained the single most influential Jewish family in the Far East until the rise of Communist China in 1949.<sup>9</sup> The Sassoon family and other prominent Sephardim became some of Shanghai's most prominent landowners between 1820 and 1918.<sup>10</sup>



Although most Sephardim did not share the immense wealth and status of the Sassoon family, the community as a whole funded beds for Jews in the Shanghai General Hospital and the Country Hospital and, in 1934, established the B'nai Brith Polyclinic, which became the Shanghai Jewish Hospital in 1942.<sup>11</sup> The other Jewish community, the Russian Jews, numbered between 6,000 and 8,000 refugees by the 1930s. Although some arrived after the Russo-Japanese War (1904-1905), the majority fled Russia after the October Revolution of 1917. Since the accumulated wealth of the Russian Jewish population never matched that of the Baghdadi community, they hardly participated in relief efforts for refugees after 1938.<sup>12</sup>

The Sephardi Jewish community's charity towards Jewish refugees figures prominently in the narrative of the migrants' experience of Shanghai. Although Peter Engler never interacted with the Sassoons, he spoke of them with immense respect and awe, describing them as "extraordinarily wealthy" and especially recalling the name Sassoon.<sup>13</sup> Sir Victor Sassoon opened sections of the Embankment Building to refugees in 1939. Although it lacked proper sanitation facilities, the Embankment Building served as a refugee shelter and receiving center for hundreds of incoming refugees at once.<sup>14</sup> Vivian Jeanette Kaplan produced a work of creative nonfiction recording her mother's impressions of Shanghai. She claims, "Names like Sassoon and Kadoorie are spoken with awe. Through philanthropic efforts, they have set up relief organizations to aid the newcomers ... They have established the charity homes where hundreds of people are cared for and fed. Without the generosity of these people, many of us would have starved to death by now."<sup>15</sup> According to memoirs like that of Vivian Jeanette Kaplan and Ernest Heppner, the Sephardi community initially responded generously, "They welcomed the refugees, fed and housed them, and assisted them in finding employment or setting up small businesses. Funds were established, and everything possible was done to alleviate their suffering and restore their dignity. The board of the Sephardic Synagogue granted permission to use the synagogue as a reception center, and mattresses were placed in the sanctuary."<sup>16</sup> With the support of wealthy families like the Sassoons, destitute Jewish refugees arriving in the months after *Kristallnacht* were able to survive in an unfamiliar environment.

By August 1939, Japanese authorities believed that Shanghai could not sustain the influx of refugees from both Europe and the Second Sino-Japanese War. With immigration at its peak for the eight months after December 1938, as many as three or four German, Italian, and Japanese ocean liners per month carried hundreds of Jewish refugees from Europe to Shanghai. In addition to Jewish arrivals from Europe, the Second Sino-Japanese War culminating in the Battle of Shanghai had made refugees of 10 to 15,000 Japanese residents and tens of thousands of Chinese.

Approximately 40,000 Chinese refugees returned to the city of Shanghai per month. The existing Jewish communities of Sephardim and Ashkenazim, despite their efforts to repair and restore war-damaged buildings, were unprepared to sustain this sudden flood of migrants. As more Jewish refugees from Europe made their way to Shanghai by ocean liner in 1939, they competed with fellow Jews as well as the Japanese military and civilians for coveted resources such as housing.<sup>17</sup> According to historian David Kranzler, by 1939, “Care could no longer be administered on an individual basis, and concern had to give way to sheer subsistence on a mass scale ... many ... had to make do with the hastily set up refugee camps.”<sup>18</sup> Ernest Heppner recalled that Jewish residents of Shanghai guided him directly from his ocean liner to the Embankment Building. After traveling first class, Heppner noted the sharp contrast between his luxurious voyage to Shanghai and the survival-based charitable soup kitchens in the Embankment Building.<sup>19</sup> In 1941, both the preexisting Jewish community and Japanese authorities claimed that the city could no longer sustain the destitute, dependent refugees of Nazi Europe. The refugees then turned to the American Jewish Joint Distribution Committee (JDC), a humanitarian relief organization.

The JDC provided much-needed relief at this critical moment, but their representatives found the existing aid situation in Shanghai disorganized. In May and December 1941, Laura Margolis and then Manny Siegel arrived in Shanghai as representatives of the JDC, respectively. In her remarks at the 1944 annual meeting of the National Refugee Service, Laura Margolis commented on the situation of the Jewish community she found upon arrival, “You must remember that Shanghai was totally unprepared to receive the invading horde. Shanghai was economically unprepared to absorb them ... there was never a real community plan for them, or any plans made to receive them ... This is why the Joint Distribution Committee sent me to Shanghai ...”<sup>20</sup> Margolis’ remarks indicate disorganized charitable contributions from the preexisting Jewish community in Shanghai. Margolis also specifically referred to the “complete apathy of all local Jewry to the refugee problem.”<sup>21</sup> Maisie Meyer offers a plausible explanation for Margolis’ assessment, “[Margolis] arrived in Shanghai as late as May 1941, by which time the Sephardim had dissipated their resources and stamina. Many were British subjects, and therefore were regarded by the Japanese as enemy aliens. Understandably, their own deteriorating circumstances, [sic] made the plight of the European refugees a low priority.”<sup>22</sup> Margolis and Siegel arrived after the Baghdadi Jews had exhausted their available charitable resources, forcing the refugees to turn to a new source of humanitarian aid.

As the Jewish refugees' living conditions deteriorated over the course of the war, the number of Jewish refugees requesting aid from the JDC climbed. By the end of World War II, the majority of the Jewish refugees from Nazi Europe depended upon this aid for their very survival. Under Margolis and Siegel's guidance, the JDC organized a "system of emergency relief with the equipment needed to run steam kitchens capable of feeding 10,000 people per day."<sup>23</sup> Laura Margolis, in her own words, created "order out of chaos," after the JDC had sent funds to local committees in Shanghai for two years.<sup>24</sup> Although the JDC started sending Polish refugees to Palestine, Australia, New Zealand, Canada, and Burma before the Japanese attack on Pearl Harbor, their main function was to support the community of Jewish refugees living in Shanghai. In Margolis' view, "An undernourished, stateless, unprotected group of humans faced starvation."<sup>25</sup> After December 8, 1941, the JDC representatives struggled to procure funds since, as enemy nationals, their assets were frozen. They stopped all relief for four thousand of the eight thousand refugees receiving one bowl of stew per day, but continued providing for "children, the aged, the sick, and those whose malnutrition was so serious that they were on 'special diets.'"<sup>26</sup> Despite its struggles throughout the war to procure sufficient funds, the JDC remained in Shanghai as a humanitarian relief organization.

Serving as a humanitarian relief organization, the JDC established food kitchens, schools, hospitals, and an emigration office. Siegel reported to the JDC that he and Margolis acted as community organizers despite lack of funding. He claimed, "During this time [December 1941-1942], in addition to providing food, clothing, medicine and other care, we were able to organize committees, arrange for the borrowing of money, and complete plans in preparation for the day we knew would come – the day we would be imprisoned."<sup>27</sup> By the JDC's own accounts, the JDC's kitchens kept Jewish refugees alive for the duration of World War II. In 1944, after her 1943 arrest and deportation as an enemy alien, Margolis reported on the progress of the JDC. She noted that she and her staff had procured two unused steam boilers from a British realty company after meeting resistance from the employees. After scaling back their efforts in 1941, the JDC was able to serve five thousand refugees per day by March 1944 by utilizing the soup kitchen established around these two boilers.<sup>28</sup>

Jewish residents and other aid workers in Shanghai fondly recalled their interactions with JDC representatives and the impact of Siegel and Margolis on the refugee community. Ernest Heppner's mother called her "the American lady." After Heppner's mother met Margolis, she described Margolis as an extraordinary and admirable woman who was sensitive to the plight of the Jewish refugees. His mother decided to work for the JDC

and regretted that Margolis had not arrived earlier.<sup>29</sup> U.S. Army Chaplain Alvin I. Fine wrote to Moses Leavitt, a leader of the JDC, “During this period, it has been my privilege to work closely with Manny Siegel ... No verbal report could give you the slightest indication of what one goes through in the course of a day’s work in Hongkew [Hongkou] on behalf of the people there ... I assure you that in the Army men have been decorated for doing less than Manny has done and is doing here in Shanghai.”<sup>30</sup> This high praise indicates the residents’ and aid workers’ appreciation for Margolis and Siegel’s leadership of the JDC’s operations in Shanghai.

Aid and charity marked the Jewish refugees’ lives in Shanghai, since they primarily arrived destitute. As victims of the Nazis, these refugees left behind the only homes they had ever known and depleted most of their financial resources in order to escape. They had leveraged personal and business connections in order to secure passage on voyages lasting between 23 to 72 days.<sup>31</sup> Aid societies, however, could not entirely shield refugees from hardship. By the year the JDC arrived, the Japanese authorities in Shanghai were increasingly restricting the refugees’ lives.

## JEWISH REFUGEES UNDER JAPANESE CONTROL

The members of the Shanghai Jewish Ghetto community experienced unique challenges as stateless refugees. The Jewish refugees found sanctuary in Shanghai in the midst of the Second Sino-Japanese War, when the Japanese controlled part of the city. Arriving with limited knowledge of Shanghai or China itself, the Jewish refugees found themselves in the hands of the future allies of Nazi Germany. On December 7, 1941, as their forces attacked Pearl Harbor, the Japanese established total military control of Shanghai. The Japanese placed no formal restrictions on Jewish refugees until 1943, when Japanese authorities relegated stateless Jews to a one square mile area within Shanghai’s Hongkou district. The establishment of the Restricted Sector for Stateless Refugees, known colloquially as the Shanghai Jewish Ghetto, and the subsequent imposition of stringent restrictions on Jewish life within that sector, defined Jewish refugees’ experience in Shanghai for the remainder of World War II.

The Japanese military imposed proclamations restricting the stateless Jewish residents of Shanghai’s lives once they realized the Jews served no financial benefit to their empire. Initially, Japanese authorities harbored misconstrued expectations that the Jewish refugees from Europe would fund their colonial interests.<sup>32</sup> Misunderstanding the economic role of Jews in both Europe and the United States, Japanese leaders planned to

use Jewish capital to fund their imperial ambitions in China.<sup>33</sup> By 1941, the Japanese authorities determined that the new refugees served no strategic or financial purposes for their empire and their restrictions on Jewish life in Shanghai intensified. George Funt, born in China to wealthy Russian Jews, stated, “And then [after Pearl Harbor] they started with their edicts, one after another — proclamations they were called ... each one took away a liberty. Each one made the pressure tighter. So, in the beginning, you thought, ‘Oh, I can live with this proclamation...’ Eventually, the proclamations deprived you of everything.”<sup>34</sup> As a Russian Jew born in China, Funt would not have been subject to the same proclamations as the refugees; his statements indicate the keen awareness the existing Jewish community felt for Japanese restrictions on Jewish life. Although residents expected the war to reach Shanghai, they did not anticipate the subsequent series of Japanese restrictions on their daily lives.<sup>35</sup> Where previously they intermixed with the already international culture of the port city, these unexpected restrictions limited their activities.

The most life-altering proclamation came on February 18, 1943, raising simmering fears and tensions in the Jewish community about the Japanese alliance with the Germans. The proclamation, published in local newspapers, restricted stateless refugees to the Hongkou district of Shanghai. All stateless refugees from Europe already living in Shanghai, implicitly meaning the European Jews, received a deadline of May 18, 1943 to move into the Restricted Sector.<sup>36</sup> With their restriction to the ghetto, the Jewish refugees experienced full exclusion from Shanghai proper rather than their previous relative freedom to live in the International Settlement. Once inside the ghetto, the Jewish refugees experienced further restrictions such as the institution of the *baojia* (or *Pao Chia*) system in the Restricted Area. The Japanese military organized households “into units called *jia*, which in turn consisted of a larger unit, the *bao*.”<sup>37</sup> Japanese authorities required the *Pao Chia* to keep detailed census records, report anti-Japanese actions, criminal activity, or civil disturbances or risk collective punishment to their respective units.<sup>38</sup> Japanese proclamations restricting Jewish life dramatically altered the reality of the Jewish refugee experience in Shanghai.

Rumors circulated that the Japanese leadership would cooperate with the Germans and murder the Jews. Dr. Peter Engler stated, “... we had heard that the Germans tried to persuade the Japanese authorities to do away with us. And apparently one of Hitler’s concentration camp administrators was seen driving around the city of Shanghai with one of the Japanese officers ... the Nazis suggested to the Japanese that they put us all on a rusty old boat and towed [sic] out into the ocean.”<sup>39</sup> Although Engler never truly believed such rumors while he lived in the ghetto, these sto-

ries circulated among the Jewish population as soon as the Japanese and the Germans formalized their alliance. Kranzler cites a report that recalls this particular rumor. The report claims that Japanese Vice Consul Shibata informed the Jewish community's representatives of Japanese plans to either "confine them to the Hongkew [sic] area" or send them "to one of the islands at the mouth of the Yangtze near Shanghai" because of the Japanese alliance with Germany.<sup>40</sup> Jewish refugees in Shanghai witnessed other instances of antisemitic collusion between the Germans and Japanese. The Japanese Bureau of Information and the German Embassy in Tokyo, for example, jointly subsidized and sponsored antisemitic books, pamphlets, brochures, and widely-attended exhibitions in Osaka and Tokyo, further stoking Jewish fear of the Japanese.<sup>41</sup> Jewish fear of the Japanese expanded beyond the Japanese connection to the Germans. Memoirs written after the fact by both adult refugees and former child refugees suggest the Japanese themselves inspired terror and loathing. Jewish refugees described the ghetto as a veritable prison where they existed at the mercy of the Japanese. Kanoh Ghoya, one of the two Japanese officials responsible for issuing passes to exit the ghetto, called himself "King of the Jews" and delighted in intimidating Jewish applicants for exit pass. Ghoya's intimidation tactics for exit visas represented another significant element of Japanese restrictions, since the Jewish refugees needed those passes in order to leave the Restricted Area. The refugees primarily interacted with Ghoya and Subinspector Okura, an even more sadistic officer; meanwhile, the rest of the Japanese authorities remained aloof.<sup>42</sup> The Jewish refugees initially feared Ghoya but soon developed an intense hatred towards him over the course of the war. In September 1945, Jewish cartoonist Friedrich Melchior wrote a satirical introduction to a series of comics depicting Kanoh Ghoya's typical behavior towards the Jewish refugees, "Sir, you called yourself 'King of the Jews' assuming your position unshakable. Yet, we knew better. And in spite of your beating us and your humiliating men and women we knew you pretty well, you little brute ....you were a ridiculous clown ... a maniac, a nightmare but a ridiculous fool as well."<sup>43</sup> Melchior's statements indicate that by the end of the war, these adults agreed with memorist Ursula Bacon's opinion of Ghoya as a "ridiculous" authority figure.

Like the memoirs of their elders, memoirs written in adulthood by former child refugees share the adults' sense of foreboding surrounding Kanoh Ghoya. Sigmund Tobias, now an eminent scholar of educational psychology, left Germany in 1938 and spent nine years in Shanghai, starting at age six. Although his memoir follows the narrative arc of a coming-of-age story as he finds his calling at the Shanghai yeshiva and presents only one perspective, he provides valuable insights into Kanoh Ghoya's menacing presence.<sup>44</sup> Sigmund Tobias recalled rumors of the power-mad

Ghoya comparing himself to Napoleon, casting women out on the street, and kicking and slapping refugees who came to his office for passes.<sup>45</sup> While Tobias admittedly never experienced these situations firsthand, his recollections reflect the general attitude of fear and foreboding Ghoya generated amongst the Jewish refugee population. Ursula Bacon, who was approximately eleven years old when she first interacted with Ghoya, found him “ridiculous” in retrospect. In her memoir, she referred to him as “the mighty Goya-san” who “hissed” at her in Japanese and had “beads of spittle settling at the corners of his mouth.”<sup>46</sup> She recalls that he insulted her, “You are a dirty girl. You make dirty love to dirty men. You are very dirty.”<sup>47</sup> Bacon found this encounter astonishing, but she remarked that while waiting in line to meet with Ghoya, she heard the stories of “raw fear some of the men expressed at the prospect of having to face our crazy camp commander.”<sup>48</sup>

The refugees’ impression of the ghetto was of that of a prison rather than a haven. Although Jewish refugees, like Heppner, recall the ghetto as surrounded by barbed wire, Susan Stamberg, who produced an *All Things Considered* special report based on years of research, remarked, “Unlike the Nazi ghettos, there were no walls around the Hong Ku [Hongkou] area, no barbed wire, but signs and guards were everywhere, and passage was limited.”<sup>49</sup> The Englers and the rest of the Jewish refugee community spent the two years after 1943 living in the ghetto section of Hongkou, located north of the International Settlement. Exit was only possible with a special pass specifying the time and purpose for refugees’ departure. Inside the ghetto, the Japanese controlled aspects of daily life by establishing authority over Jewish institutions and newspapers. The Japanese created Jewish organizations to carry out official directives. As scholar Irene Eber points out, establishing these organizations allowed the Japanese to maintain control over “proxy organizations” that oversaw funding for shelters needed for “destitute [Jewish] refugees.”<sup>50</sup> This proxy control meant that the Japanese military expanded the *Pao Chia* system from Shanghai proper to the Hongkou district. Peter Engler recalls that his father either volunteered or was assigned a role within the *Pao Chia*.<sup>51</sup> The Japanese military used the *Pao Chia* system to police the refugees’ daily lives.

Jewish refugees describe a victimization process living under Japanese rule in Shanghai. These refugees, first victimized by the Nazi regime, experienced a second victimization at the hands of the Japanese authorities. While the Japanese military’s oppression never amounted to anything near that of Nazi Germany’s concentration camps, one of the Jewish refugees’ main concerns was their vulnerability once Japan formalized its alliance with Nazi Germany. Japanese authorities, realizing the refugees offered no financial or strategic incentives, took advantage of the refugees by impos-



ing increasingly stringent restrictions. Confinement to the Restricted Sector for Stateless Refugees epitomizes Jewish victimhood at this time. Compounding this frightening situation, Jewish refugees' destitution led them not only to live at the mercy of the Japanese, but also to depend on both foreign and domestic aid from fellow Jewish people.

## JEWISH REFUGEES' CULTURE IN SHANGHAI

In an environment of dependence on humanitarian aid and control by hostile authorities, the Jewish refugees found avenues of recreating certain elements of familiar European culture. Despite the antisemitic atmosphere supported by the Japanese and the Germans, as late as 1941 Jewish organizations continued to demonstrate their connection to their European roots. Jewish refugees produced periodicals and event calendars, “[that] bear witness to the centrality of central European culture in Shanghai’s fledgling musical, artistic, and literary life.”<sup>52</sup> These refugees drew from familiar aspects of German and Austrian culture and repurposed them in Shanghai. In the International Settlement prior to the establishment of the Restricted Sector, the more fortunate refugees held piano concerts, opened bakeries, and dined in luxurious cafes. Even within the confines of the restrictive Japanese pass system, the Jewish refugees managed to maintain their Jewish traditions and their familiar occupations. For example, in November 1941 Berlin-born concert pianist Miriam Magasi performed Austrian composer Hugo Wolf’s *Lieder*.<sup>53</sup> The Jewish refugees established similar cultural programs amid heightening Japanese control over Shanghai and despite the mounting tensions that would lead to the establishment of the Restricted Sector for Stateless Refugees.<sup>54</sup>

The Lindenstrauss family’s story is one example of maintaining connections to European culture despite hardship. Prior to the opening of the ghetto, the Lindenstrauss (later shortened to Linden) family established businesses in Shanghai. Fritz Lindenstrauss, born in Prezlau, Germany, moved to Wayside Road in Shanghai along with his wife Ruth and his son Kurt in 1939. There, Ruth Lindenstrauss, a seamstress, operated the Ladies Secondhand Store. She printed her advertisements in both English and German, catering to customers in the International Settlement.<sup>55</sup> Fritz Lindenstrauss, whose *Pao Chia* records upon arrival in Shanghai noted that he was a “boarding housekeeper,” opened a boardinghouse at 335 and 337 Wayside Road, thereby continuing his earlier profession.<sup>56</sup> He reported in October 1942 that he earned \$3,663 from fourteen tenants. These tenants lived in his boardinghouse for durations of one and one-



half to five months.<sup>57</sup> Kurt Lindenstrauss, born in 1936, earned high marks at Freysinger's Jewish Elementary School in Shanghai. He received the marks during the term ending on December 22, 1943, including the time during which the Lindenstrauss family relocated to the Hongkou district.<sup>58</sup> The Lindenstrauss family's records indicate financial stability and continuation of their trade, suggesting an element of familiarity even on the other side of the world. In this way, the Lindenstrauss family maintained their European Jewish identity in exile.

In 1943, a minority of ghetto residents managed financial independence. Historian David Kranzler notes that "the owners of a bakery reputed to be among the wealthiest families in the ghetto. Others made money selling commodities of value in the ghetto such as caffeine, or dealt in the profitable black market."<sup>59</sup> They also obtained passes to exit the ghetto and patronize Café Louis, owned and operated by the Eisfelder family of refugees who had left Germany in 1938. The café had opened its doors in February 1939 in the International Settlement and served German chocolates, beer, and pastries throughout the war.<sup>60</sup> Business continued even after the establishment of the ghetto because of a half-Jewish employee who retained German citizenship and therefore was not confined to the Restricted Sector for Stateless Refugees.<sup>61</sup> These Jewish entrepreneurs, while living inside a ghetto, exercised their limited rights in order to not just survive, but also to reinforce their own cultural traditions.

Peter Engler and his family were able to maintain their standard of living even after the establishment of the ghetto by procuring exit passes. Engler's mother, Else, continued her trade as a milliner, unlike other Jewish professionals who tried their hand at any trade available based on economic circumstance. She obtained a pink Designated Area Pass indicating her source of income that allowed her to leave the confines of the ghetto in order to conduct her business.<sup>62</sup> His father, a chemist, prepared gold alloy for dentists. While still living in the French Concession, they had enrolled young Peter in the Shanghai Jewish School where he "quickly became a colonialist brat with an amah [Chinese nanny] who referred to me [Peter] as Master Peter, and a private rickshaw coolie [native laborer, see note] who brought me to and from school daily."<sup>63</sup> Peter Engler continued attending the Jewish school, located just outside the borders of the ghetto. In order to attend the school Engler had to obtain a special badge, "To get these badges, there were two badges ... I think a blue badge and a red badge. One was good for three weeks and another was good for three months ... [Ghoya] was very nice to kids ... Every three months we ... renewed ... No problem."<sup>64</sup> Although the Englers lived in exile, they managed to maintain their previous professions even in the ghetto and continue sending their son to a Jewish school.

Peter Engler pointed out in his interview that the fact that his parents were wealthy enough to hire a coolie for him made him “one of the most fortunate.”<sup>65</sup> He believed that although it was typical for Jewish families to remain together like his own throughout their Shanghai experience, his experience differed in that he continued to live a life of relative affluence throughout his time as a refugee, since the Engler family managed secure their own financial independence almost immediately. The fact that Peter Engler referred to himself as a “colonialist” indicated that he acknowledged his own wealth and foreignness in Shanghai. His assessment of himself as a colonialist brat based on his economic status is tongue-in-cheek, but suggests one way Jewish refugees dissociated culturally from the place where they found refuge.<sup>66</sup> Engler’s comments indicate that some European Jewish refugees also brought colonialist views of European superiority with them. In this way, they re-created a version of their European experience in Asia under restrictive circumstances.

Like the Lindenstraus and Engler families, Heinz Praschkauer, a German who arrived in Shanghai after *Kristallnacht* as a young boy, also maintained his previous interests and established his own source of income. At first, Praschkauer worked as a tailor alongside Wilhelm Fuerchtgott on Broadway East, then with a tailor identified only as Kaplan on East Seward Road. After 1940, when his parents arrived, he opened his own tailor shop. In 1944, after moving to the ghetto, he received an invitation to enter an advanced tailoring course offered by the Guild of Craftsmen in Shanghai. Based on his examination results, he entered the Guild.<sup>67</sup> His records at the United States Holocaust Memorial Museum include a vocabulary book for the study of English from spring 1938. Between December 1941 and December 1942, Praschkauer recorded viewing twenty-four individual films including *Dr. Jekyll and Mr. Hyde* and *The Cat and the Canary* and listed their prominent American actors. He included reviews such as “*Gut*” (good) or “*Fabelhaft*” (marvelous) and noted whether the films were in color.<sup>68</sup> He continued collecting playbills for films in Shanghai, including the German-language *Tom Sawyer’s Abenteuer* (Adventure) in 1939 and *Marx Brothers Go West*, produced by Metro Goldwyn Meyer with English and Chinese advertisements, in 1942.<sup>69</sup> According to Howard Horst Levin, another Jewish refugee in Shanghai during the Nazi regime, “[There were] 5 or 6 American movie theatres in the International Settlement and the French Concession. They were under the control of Metro Goldwyn Meyer and had a fancy suite of offices.”<sup>70</sup> This meant that young Praschkauer was able to continue practicing the English language, even while living as a refugee. Praschkauer, similar to the Lindenstraus and Engler families, demonstrates how Jewish refugees applied their skills and knowledge to create new lives for themselves as refugees.

For other Jewish refugees, however, living situations worsened as the war progressed. Crucially, those refugees who managed financial independence after 1943 lived outside of *Heime*. Those refugees dependent on the JDC lived in *Heime*, or shelters often converted from former barracks or factories and outfitted with bunk beds. The number of refugees requesting assistance from the JDC rose from 6,000 by the end of 1943, the first year they lived in the ghetto, to 7,300 by April 1944 and 11,000 by June 1945.<sup>71</sup> As living situations for the Jews living in *Heime* worsened, the refugees became increasingly dependent on foreign aid from the JDC. An American Jewish soldier by the name of Stan wrote a letter to his father describing difficult living conditions in the Shanghai Ghetto by 1945, despite aid from the JDC:

My friend ["a swell Jewish boy of about 18"] ... lives in a room five yards long and four yards wide. He lives with his father, mother, brother, another family of four people and a third family of three. All in one little stinking room ... The hospital was crowded as a hell, full of every disease possible. I next went to the school where ...[t] he children had not given up hope... the school had no money for buying vaccines ... I went to see the committee in charge of the relief and I begged him [sic] to tell me why the people aren't better taken care of. He told me that he gets only \$100,000 for his relief work from the JDC and he does his best."<sup>72</sup>

Since the JDC relied upon donations, sometimes limited during wartime, their representatives utilized what limited funding was available to mitigate the circumstances Stan described. The contrast of the Jews living in the *Heime* to other experiences highlights the dual role of the Jewish refugee. Both realities existed for the Jewish refugees, as they occupied a middle ground between destitute victim of the Nazis and Japanese and active agent in practicing their own cultures.

In establishing themselves in a distant land far from their familiar homes, the Jewish refugees of the Nazi regime living in Shanghai exercised considerable agency. Without losing sight of their European roots, the refugees established businesses and sent their children to Jewish schools. Significantly, they maintained their European Jewish culture even under the pressure of Japanese control and financial dependence. At the conclusion of World War II, the Jewish refugees from Nazi persecution living in Shanghai found themselves at a crossroads. Just as they exercised control over their own futures by securing passage to Shanghai, choosing to leave Shanghai came as a matter of course.

## CONCLUSION: CLOSING OF THE GHETTO AND DEPARTURE FROM CHINA

In July 1945, towards the end of the war, Americans bombed Shanghai, by then a strategic Japanese stronghold. Ernest Heppner recalled that B-17s, B-24s, and B-29s flew low over Shanghai and the Hongkou ghetto area in May 1945 and they grew more frequent by July. On July 15, bombs landed on the wharves only a few blocks from the ghetto itself.<sup>73</sup> Two days later, Americans bombed Shanghai proper, leaving thousands of Chinese and 31 refugees dead, 190 refugees wounded, and 703 refugees homeless. The Japanese radio transmitter on Dongshan Road near Hongkou may have been the Americans' target.<sup>74</sup> Within weeks, the Allies issued their ultimatum of total surrender to Japan and dropped the atomic bombs on Hiroshima and Nagasaki. After the Japanese surrendered, Engler recalled, "In the night from August 14th to 15th, the Japanese vanished ... One day on the 14th you would run into them every time you were on the streets, and they just disappeared."<sup>75</sup> The Jewish refugees in Shanghai found themselves free to move about the city and leave Shanghai altogether.

The Jewish refugees from the Nazi regime never intended to set up permanent residence in Shanghai. An October 1946 survey conducted by the JDC indicated that "40 percent of Shanghai Jewish refugees wanted to go to the United States, 21 percent to Palestine, which was still closed to them [in 1946 and 1947], 26 percent to Austria and Germany, and the rest to Australia and Latin American countries."<sup>76</sup> Unlike the White Russian and Baghdadi Jews in Shanghai, the Jewish refugees of the Nazi regime envisioned no future in Shanghai. Likewise, news of the slaughter of their families in Europe made many unwilling to return to their erstwhile homelands.<sup>77</sup> Unfortunately, the refugees faced laws such as the United States' Displaced Persons Act in 1946, which prioritized displaced persons in Austria, Germany, and Italy who had entered those countries between September of 1939 and December 1945 and now wanted to enter the United States.<sup>78</sup> By 1947, news of Communist Mao Zedong's territorial gains added urgency to the refugees' desire to leave.<sup>79</sup> After 1948, the new State of Israel dispatched an emissary to Shanghai, inviting refugees to the new nation. Over 9,700 refugees left for Israel in the six years following the end of World War II.<sup>80</sup> Of the remaining Jewish population, the majority sailed to San Francisco with the aid of the JDC.<sup>81</sup> The number of former Jewish refugees remaining in Shanghai dwindled until the last former refugee died in 1982.<sup>82</sup> The Shanghai Jewish Refugee Museum, established in 2007 on the site of the Ohel Moishe Synagogue in the former ghetto, recognizes the refugees' experience fleeing Europe and living in Shanghai. Although

most of the physical landmarks in the refugee community did not survive the Cultural Revolution in China, the story of the Jewish refugees lives on through oral histories of Jewish refugees such as Peter Engler.

The fact that the desperate Jewish refugees from Nazi Germany actively chose to relocate to Shanghai, despite having limited to no knowledge of the city, suggests that the refugees sought any possible escape. Although they left in desperation and became dependent upon charitable aid, the Jewish refugees not only survived, but established businesses and ensured their children received a Jewish education. Because of Japanese restrictions on Jewish activities in and around the ghetto, the Jewish refugees certainly experienced victimization. Nonetheless, while the Japanese controlled their daily lives, the Jewish refugees eventually determined their own future.

## ENDNOTES

1. Dr. Peter Engler, interview by author, Berkeley Heights, NJ, August 13, 2014.
2. David Kranzler, *Japanese, Nazis & Jews: The Jewish Refugee Community of Shanghai, 1938-1945* (New York: Yeshiva University Press, Sifria Distributors, 1976), 19-21.
3. Gao Bei, *Shanghai Sanctuary: Chinese and Japanese Policy toward European Jewish Refugees during World War II* (New York: Oxford University Press, 2013), 3. See also Deborah Dwork and Robert Jan van Pelt, *Flight from the Reich: Refugee Jews, 1933-1946* (New York: W.W. Norton & Company, 2009), 140, which cites Kranzler's lower estimate of seventeen thousand.
4. Imperial China granted concessions beginning with the 1842 Treaty of Nanjing with Great Britain. Such treaties obligated China to open treaty ports and cede land to foreign powers including the France, the United States, and Great Britain. Great Britain and the United States merged their concessions.
5. Gao Bei, *Shanghai Sanctuary*, 5.
6. Kranzler, *Japanese, Nazis & Jews*, 92. "Heim" in German is "home" (similar to Heimat as "homeland"), and *Heime* is its plural form.
7. Kranzler, *Japanese, Nazis & Jews*, 47. The term Ashkenazi (plural Ashkenazim) refers to a Jewish person from Eastern Europe or collectively describes Jews from Eastern Europe. Sephardim (adjective Sephardic) refers to Jews from the Iberian Peninsula and the Mediterranean. A related term is Mizrahi, referring to Jews descending from communities in the Middle East.
8. Kranzler, *Japanese, Nazis & Jews*, 45, 57.
9. *Ibid.*, 46. The Sephardim consisted of between 600 and 700 people in Shanghai. Ashkenazim working for the major magnate families occupied lower-level positions within the establishment of the more powerful Jews. Most of the Sephardim lived in the International Settlement.
10. Marcia Reynders Ristaino, *Port of Last Resort: The Diaspora Communities of Shanghai* (Stanford: Stanford University Press, 2001), 21-22.
11. *Ibid.*, 55.
12. Irene Eber, *Wartime Shanghai and the Jewish Refugees from Central Europe: Survival, Co-Existence, and Identity in a Multi-Ethnic City*, vol. 1 of *New Perspectives on Modern Jewish History*, ed. Cornelia Wilhelm (Boston: Hubert & Co. GmbH Co. KG, 2012), 21-23.
13. Dr. Peter Engler, interview by author, Berkeley Heights, NJ, August 13, 2014.
14. Kranzler, *Japanese, Nazis & Jews*, 93. While Kranzler claims Sassoon donated the entire building, Heppner's memoir states that Sassoon only opened two floors to refugees.

15. Vivian Jeanette Kaplan, *Ten Green Bottles: The True Story of One Family's Journey from War-Torn Austria to the Ghettos of Shanghai* (New York: St. Martin's Press, 2004), 136.
16. Heppner, *Shanghai Refuge*, 42.
17. *Ibid.*, 107.
18. Kranzler, *Japanese, Nazis, & Jews*, 90.
19. Ernest Heppner, *Shanghai Refuge: A Memoir of the World War II Jewish Ghetto* (Lincoln, NE: University of Nebraska Press, 1933).
20. Laura Margolis, "Remarks by Laura Margolis at Annual Meeting of Members and Directors of NRS," January 15, 1944, American Jewish Joint Distribution Committee, The Jewish Federations of North America, [http://archives.jdc.org/assets/documents/shanghai\\_remarks-by-laura-margolis.pdf](http://archives.jdc.org/assets/documents/shanghai_remarks-by-laura-margolis.pdf) (accessed April 17, 2015), 3. The National Refugee Service was established in 1939 in New York as a successor agency to the National Coordinating Committee with the goal of helping refugees fleeing Nazi persecution.
21. Quoted in Maisie Meyer, "Their Brother's Keeper?: An Assessment of the Assistance the Sephardi Jewish Community of Shanghai Provided the Victims of Nazi Oppression" (paper presented at the scholarly symposium Jewish Diasporas in China: Comparative and Historical Perspectives: Conference on Jews in China, Cambridge, MA, August 16-18, 1992).
22. *Ibid.*
23. "Refuge in Shanghai (1938-1953)," American Jewish Joint Distribution Committee, The Jewish Federations of North America <http://archives.jdc.org/educators/topic-guides/refuge-in-shanghai.html> (accessed April 17, 2015).
24. Laura Margolis, "Race Against Time in Shanghai," *Survey Graphic: Magazine of Social Interpretation* 33, no. 3 (March 1944): 169, [http://archives.jdc.org/assets/documents/shanghai\\_race-against-time-in-shanghai.pdf](http://archives.jdc.org/assets/documents/shanghai_race-against-time-in-shanghai.pdf) (accessed April 26, 2015).
25. *Ibid.*
26. *Ibid.*, 171.
27. "JDC Representative in Shanghai Tells How 15,000 Refugees Survived Japanese Ghetto," in JDC Press Release, January 24, 1946, American Jewish Joint Distribution Committee Archives, Jewish Federation of North America [http://archives.jdc.org/assets/documents/shanghai\\_jdc-representative-in-shanghai-tells.pdf](http://archives.jdc.org/assets/documents/shanghai_jdc-representative-in-shanghai-tells.pdf) (accessed April 17, 2015).
28. Margolis, "Race Against Time in Shanghai," 171.
29. Ernest Heppner, *Shanghai Refuge*, 93.
30. Letter from Chaplain Alvin I. Fine to Moses Leavitt, November 7, 1945, American Jewish Joint Distribution Committee Archives, Jewish Federation of North America [http://archives.jdc.org/assets/documents/shanghai\\_letter-of-chaplain-alvin-i-fine.pdf](http://archives.jdc.org/assets/documents/shanghai_letter-of-chaplain-alvin-i-fine.pdf) (accessed April 17, 2015).
31. Marcia Reynders Ristaino, *Port of Last Resort: The Diaspora Communities of Shanghai* (Stanford, CA: Stanford University Press, 2001), 101.
32. Marvin Tokayer and Mary Swartz, *The Fugu Plan: The Untold Story of the Japanese and the Jews During World War II* (New York: Paddington Press, 1979), 9.
33. Pamela Rotner Sakamoto, *Japanese Diplomats and Jewish Refugees: A World War II Dilemma* (Westport, CT: Praeger, 1998), 56, 63n52.
34. "Jews of Shanghai," All Things Considered, National Public Radio (Washington, DC: WAMU): September 18, 1990, 16, Susan Stamberg Collections, University of Maryland Libraries, College Park, MD.
35. *Ibid.*
36. "Proclamation of Restricted Zone in Shanghai for Refugees," from the USHMM special exhibition Flight and Rescue, accessed May 7, 2015 [http://www.ushmm.org/wlc/en/media\\_da.php?ModuleId=10005589&MediaId=5282](http://www.ushmm.org/wlc/en/media_da.php?ModuleId=10005589&MediaId=5282). The United States Holocaust Memorial Museum provides a scan of the proclamation and its surrounding commentary as seen on display in its special exhibit, but does not include the title of the newspaper in which it was printed. The announcement never mentions Jews by name but it implied

- the newly stateless refugees from Nazi Germany, not an earlier group of White Russian refugees.
37. Ristaino, *Port of Last Resort*, 187.
  38. Ibid. By late 1942, suggestions circulated that this system should expand as far as Hongkou.
  39. Dr. Peter Engler, interview by author, Berkeley Heights, NJ, August 13, 2014.
  40. Laura Margolis, "Report of the Activities in Shanghai, China, from December 8, 1941 to September 1943," quoted in Kranzler, *Japanese, Nazis & Jews*, 478. Margolis' account is secondhand. According to Gao Bei, Margolis later claimed the person who informed her about this meeting was untrustworthy. Gao Bei, *Shanghai Sanctuary*, 124.
  41. Kranzler, *Japanese, Nazis & Jews*, 485-486.
  42. Ristaino, *Port of Last Resort*, 200. The Subinspector's first name is not listed.
  43. United States Holocaust Memorial Museum, Collection 2006.398.1, "Hans Praschkauer Collection," "Documents Regarding Life in Shanghai." There is no record explaining the change of Heinz Praschkauer's name to Hans.
  44. Sigmund Tobias, *Strange Haven: A Jewish Childhood in Wartime Shanghai* (Champaign: University of Illinois Press, 1999), 43, 54. Tobias finds his place in society by defying his parents' fears; instead of following their wishes to attend the Kadoorie school (established by Sephardim), he left in order to join a strictly Orthodox yeshiva. A yeshiva is an institution of Jewish learning in which students study the Torah, the Talmud, and other Jewish philosophies and laws.
  45. Tobias, *Strange Haven*, 54-55.
  46. Ursula Bacon, *Shanghai Diary: A Young Girl's Journey from Hitler's Hate to War-Torn China* (Milwaukie: M Press, 2004), 171.
  47. Ibid.
  48. Ibid.
  49. Susan Stamberg, "Jews of Shanghai," All Things Considered, National Public Radio (Washington, DC: WAMU): September 18, 1990, 16, Susan Stamberg Collections, University of Maryland Libraries, College Park, MD. Scholarly sources including David Kranzler corroborated the statement that the ghetto was not surrounded by barbed wire.
  50. Eber, *Wartime Shanghai*, 179.
  51. Heppner, *Shanghai Refugee*, 114; Dr. Peter Engler, interview by author, Berkeley Heights, NJ, August 13, 2014.
  52. Susanne Wiedemann, "Views from 'the End of the World': Reorientations in the Shanghai Exile Community," *Amsterdamer Beiträge zur neueren Germanistik* (October 1, 2010): 306.
  53. Ibid.
  54. Ibid.
  55. United States Holocaust Memorial Museum, Record Group 10.172, "Linden Family Papers, 1939-1995," "Small Collections," "Shanghai Documents, 1939-1947," and "Ladies Secondhand-Store."
  56. Ibid., "Pao Chia Census Form" and "Report about Satisfaction of Tenants."
  57. Ibid., "Report about Satisfaction of Tenants."
  58. Ibid., "Freysinger's Jewish Elementary and Middle School Report for term ending Dec 22 1943."
  59. Kranzler, *Japanese, Nazis & Jews*, 545.
  60. Horst 'Peter' Eisfelder, *Chinese Exile: My Years in Shanghai and Nanking*. (USA: Avotaynu Foundation, 2004), 39.
  61. Kranzler, *Japanese, Nazis & Jews*, 546.
  62. "Application for Prolongation of Special Regular Pass," July 28, 1945, personal collection of the author.
  63. Peter Engler, Letter to David Brooks, n.d. Collection of the author. In his email to me on 18 August 2014, Dr. Engler stated that he wrote this letter "for some reason." The term "coolie" refers to a native indentured servant in the 19th and 20th centuries in India or South China and has connotations of both a racial slur and a legal term.
  64. Dr. Peter Engler, interview by author, Berkeley Heights, NJ, August 13, 2014.
  65. Ibid.
  66. Ibid.
  67. United States Holocaust Memorial Museum, Collection 2006.398.1, "Hans



Praschkauer Collection,” “Documents Regarding Life in Shanghai.”

68. United States Holocaust Memorial Museum, Collection 2006.398.1, “Hans Praschkauer Collection,” “Pre-War and Wartime Scrapbooks and Copybooks.”
69. United States Holocaust Memorial Museum, Collection 2006.398.1, “Hans Praschkauer Collection,” “Playbills from Shanghai.”
70. Howard (Horst) Levin, interview by Irene Eber, Jerusalem, 14 October 1988, transcript, Folder 22.5, 11, Susan Stamberg Collection, Special Collections, University of Maryland Libraries, College Park, MD.
71. David Kranzler, *Japanese, Nazis & Jews*, 560.
72. Letter by an American soldier in Shanghai to his family back home, October 31, 1945, American Jewish Joint Distribution Committee Archives, Jewish Federation of North America [http://archives.jdc.org/assets/documents/shanghai\\_letter-by-american-soldier-in-shanghai.pdf](http://archives.jdc.org/assets/documents/shanghai_letter-by-american-soldier-in-shanghai.pdf) (accessed April 17, 2015). Stan’s last name is not given.
73. Heppner, *Shanghai Refuge*, 123.
74. Irene Eber, *Wartime Shanghai*, 191. Eber is unclear as to whether the bombs landed directly on Hongkou or not. She states “bombs continued fall on Shanghai, though not on Hongkou, even on subsequent days . . . Were the American bombs dropped on Hongkou inadvertently or by design?” She also claims that many ghetto residents including Shoshana Kahan believed that there were ammunition factories in Hongkou.
75. Dr. Peter Engler, interview by author, Berkeley Heights, NJ, August 13, 2014.
76. Ristaino, *Port of Last Resort*, 251.
77. Kranzler, *Japanese, Nazis & Jews*, 581.
78. Ristaino, *Port of Last Resort*, 259.
79. Elizabeth Hyman, “An Uncertain Life in Another World: German and Austrian Jewish Refugee Life in Shanghai, 1938-1950” (master’s thesis, University of Maryland, College Park, 2014), 68.
80. Kranzler, *Japanese, Nazis & Jews*, 581.
81. Hyman, “An Uncertain Life in Another World,” 78.
82. *Ibid.*



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# **It's Just a Jump to the Right: The Tea Party's Influence on Conservative Discourse**

author

**Richard D. Elliott**

## **BIOGRAPHY**

Richard D. Elliott is expected to graduate in spring 2018. He is an American studies and political science double major, a history minor, and a member of the Ronald E. McNair Post Baccalaureate Achievement (McNair Scholars) Program. He plans to attend graduate school and obtain a Ph.D. in Political Science, specifically studying national politics and political parties. Ultimately, Richard's goal is to become a political organizer, activist, and academic.

# DEMYSTIFICATION

This paper studies the correlation between Tea Party and mainstream conservative politicians' usage of harmful discourse. Having reviewed many individual speech analyses while a student at UMBC, I thought a study examining how political discourse has changed between 2008 and 2016 could investigate the Tea Party's ascendance to national prominence and its relationship with various types of rhetoric in political discourse. This topic first developed after I witnessed Donald Trump do shockingly well in the Republican primaries despite lacking clear policy stances or a political network. The lessons I learned from Dr. Bryan and Dr. Gorman of the American Studies Department and Dr. Drabinski of the Gender and Women's Studies Department served as the primary inspiration for this project. Dr. Kathy Bryan served as my primary mentor, although Dr. April Householder and graduate student Jiselle Providence also assisted me. This research began when I reached out to Dr. Bryan serve as my advisor for this project, my McNair Scholars Program Summer Research project.

## ABSTRACT

This study analyzes the correlation of speeches by members of the right-wing Tea Party caucus with mainstream conservative political discourse. The rhetoric of these politicians after their ascendance in the 2010 congressional elections was compared to the rhetoric used by John McCain, the Republican nominee in 2008, and Donald Trump, the Republican nominee in 2016 and current president-elect, to understand the correlation with other changes in conservative discourse. I studied this discourse shift using speech analysis to code for instances of negative discourse and establish a comparison between these election years while also noting rhetorical shifts evident among mainstream conservative politicians.

## INTRODUCTION

*But I think the - what the Tea Party movement demonstrates, and I think the, the, the enthusiasm that we're seeing from independents and Republicans, is that if Washington isn't going to change itself, then we're going to change Washington. And I think that's what we're seeing.*<sup>1</sup> - Senator John Cornyn, Texas (R), July 18, 2010

When Rick Santelli railed against newly inaugurated President Barack Obama's stimulus package as "intrusive government" in February of 2009, he breathed life into America's contemporary populist political movement: the Tea Party.<sup>2</sup> When his message was picked up by local activists across

the country (Fang 2013),<sup>3</sup> this amorphous coalition of activists, conservative politicians, and disaffected voters began to grow in political power and eventually ascended to national prominence in the 2010 congressional elections. Some of the most well-known and influential Tea Partiers elected that year included Senators Marco Rubio, Rand Paul, and Mike Lee.<sup>4</sup> The Tea Party movement is best characterized by its belief in a limited government and dedication to Constitutional originalism<sup>5</sup> along with vehement opposition to immigration (Tea Party Patriots Staff 2016) and the Affordable Care Act (Tea Party.org Staff 2016). The Congressional Liberty Caucus has a mission of “focus on specific issues like economic freedom, individual liberty, and following the Constitution.”<sup>6</sup> The Congressional Freedom Caucus was established in 2015 to be a “smaller, more cohesive, more agile and more active” group of conservatives. Both caucuses, although not explicitly Tea Party organizations, are affiliated with the Tea Party movement and have similar goals.<sup>7</sup>

The Tea Party is not a political party in the same sense as the Republican or Democratic Party but is instead a loose movement of activists and concerned citizens who intend to inspire change by working within the Republican Party rather than by forming a new political party. While technically not aligned with either major political party, every member of the Tea Party Caucus, Liberty Caucus, and Freedom Caucus has been a Republican (Bachmann 2012), while all 138 candidates with significant Tea Party support in 2010 ran as Republicans.<sup>8</sup>

In a 2012 poll, CBS News’ Brian Montopoli found that 54 percent of Tea Party supporters are Republicans, 41 percent are Independents, and five percent are Democrats; the one tie that binds them is frustration with and hostility toward the federal government. Fifty-three percent of respondents described themselves as “angry” with the way things are going in Washington, 88 percent disapproved of President Obama’s performance, and 92 percent believed that America was “on the wrong track.”<sup>9</sup> While the Tea Party is a powerful new force on the American political scene, it is difficult to explain exactly what its positions are, who comprises its membership, or even if it has a true leader, given its emphasis on localized leadership and political activity. When a 2010 *Washington Post* poll asked 647 Tea Party activists which national figure they believed represented their movement, 34 percent said “no one,” 14 percent said 2008 vice presidential candidate Sarah Palin, seven percent said nationally-syndicated radio host Glenn Beck, and only four percent said Tea Party Caucus founder Michele Bachmann.<sup>10</sup>

Professor Leigh Bradberry of California State University at Northridge and Gary Jacobson of the University of California at San Diego have investigated how attitudes toward the Tea Party shaped voting behavior in

the 2012 presidential and congressional elections. They believe that the extreme political polarization of 2012 was because the Tea Party is particularly active and vocal in its disagreement with President Obama and the congressional Democrats on a myriad of issues. They also argue that the attitude of “compromise is weakness” promotes ideological purity within the Tea Party, as politicians fear being “Cantor’d”—being ousted in the primaries by more conservative politicians. Bradberry and Jacobson concluded that Tea Party tensions would continue to flare if the winner of the 2016 presidential race was a Democrat, a prediction that will remain untested (Bradberry and Jacobson 2013).

Prior to the rise of the Tea Party, Senator John McCain was named the 2008 Republican nominee. However, his stance on immigration prevented him from exciting the conservative base.<sup>11</sup> So-called “Tancredoism,” named after staunch anti-immigration politician and 2008 Republican presidential candidate and House Representative Tom Tancredo, arose as a result of both weak Republican leadership in the aftermath of George W. Bush’s presidency and anti-immigrant fervor among the Republican base.<sup>12</sup> Mitt Romney, widely considered a moderate during his 2012 run, succumbed to Tancredoism, proposing a fence for the United States’ border with Mexico and becoming staunchly opposed to illegal immigration.<sup>13</sup> Romney tellingly selected Maricopa County, Arizona’s, Republican Sheriff Joe Arpaio, an outspoken opponent of illegal immigration,<sup>14</sup> as the chair of his Arizona campaign organization in 2012.<sup>15</sup>

Donald Trump’s successful 2016 campaign, which drew strength from his anti-immigrant and xenophobic rhetoric, should bring attention to how and why such harmful discourse has become normalized by a mainstream political party.

## LITERATURE REVIEW

Philosophers and authors from Plato to Orwell have feared the power of language to exercise influence over the populace (Chilton and Schäffner 2002). Linguistics expert Paul Chilton argues that discourse is essential to politics, as communication and persuasion are vital parts of public debate. He also notes that politics is predominantly conducted in language and that the words that politicians, commentators, and even parents at dinner tables use have a tangible impact on the political process (Chilton 2004). In *Politics as Text and Talk*, Chilton also notes that language signifies the “in” and “out” groups of society; politics is very much based on these groups and their perceived values. He argues that the development of human communication was a result of cooperative strategies, as opposed to the Machiavellian tendencies of rulers in their earliest days. As political scien-

tist Murray Edelman has stated, “language is not simply an instrument for describing events but is itself a part of events” and, following this definition, the language used to describe political events can influence political perceptions (Edelman quoted by Geis 1987). Joseph furthers this argument by stating that all language is inherently political by virtue of having the potential to shape power relations (Joseph 2006). In *Talking Power*, Robin Lakoff argues that the most powerful members of society are deemed more credible and thus, their language has more impact on the population at large. This belief that power translates to legitimacy means that micropolitics, the development and use of strategies that create and enhance power differences amongst individuals, is consequential and impactful: “If politicians say it, it becomes reality” (Lakoff 1990).

A number of scholars have investigated the differences in discourse and narrative construction between mainstream Republicans and Tea Partiers. Benjamin Schrader (2011) argues that the discourse of the Tea Party promotes structural violence, as its ideology is so individualistic. He also explores the ties between race and Tea Party discourse and how the movement promotes hyper-masculinity. A study examining the remaking of Republican conservatism into Tea Party ideology explains that the Tea Party’s opposition to the federal government is based on the idea that “hand-outs” are going to “undeserving groups,” a perception fueled by racial, ethnic, and gender stereotypes (Williamson, Skocpol, and Coggin 2011). In *The Dynamics of Political Discourse*, Fetzer, Weizman, and Berlin analyze public debates between Tea Partiers, Democrats, and independent candidates. The analysis of the three-way debates in Minnesota and Florida in 2010 demonstrates the contributions to public discourse of self-described Tea Partiers and how their ideological views differ from those of either Democrats or establishment Republicans (Fetzer, Weizman and Berlin 2015). Colorado State University’s Alex Coughlin pointed out the differences in narrative style, the painting of allies and enemies, and perspective between the *New York Times* and *Washington Post*, two liberal-leaning news outlets, and *teapartypatriots.org* and *teaparty.org*, the Internet heart of the Tea Party movement (Coughlin 2012). He also compares the rhetoric of the Tea Party to past populist movements and concludes that the Tea Party employs methods similar to past conservative populist movements, particularly the theme of ordinary folks opposing “out-of-touch” Washington politicians. Author Clarke Rountree argues that Tea Party rhetoric can be explained by three particular characteristics: evangelical fervor, oppositional stances, and anti-government policies. In particular, that evangelical fervor “bled over” into their political discourse and led to a stark increase in filibusters (Rountree 2013). To a degree, this increase in filibusters contributed to the rise of Tea Party culture by normalizing the rhetoric and tactics

they rely upon. Rountree describes this as “my-way-or-the-highway” governance. In *Change They Can't Believe In*, Professors Christopher Parker of the University of Washington and Matt Barreto of UCLA analyze how discourse differs between Tea Party elements and members of the mainstream Republican Party. For instance, they speak of the paranoia and conspiratorial nature of Tea Party discourse, which the authors assert means that Tea Partiers are not conservatives, but are truly reactionaries (Parker and Barreto 2013). Cleveland State University's Anup Kumar found that the Tea Party appropriated the Obama message of “change” and redefined it to mean strong antagonism to the “old guard” of Washington, namely Barack Obama, Harry Reid, and Nancy Pelosi, but also some prominent Republicans such as Speaker of the House John Boehner, who resigned because of opposition from Republicans in the House of Representatives.<sup>16</sup> He also argues that right-wing populists have used the tactics of left-wing community organizer Saul Alinsky to spread their message (Kumar 2011).

I utilize the theories of these researchers to better understand and explain the correlation of Tea Party-supported politicians' rhetoric and mainstream conservative discourse after their ascendance in the 2010 congressional election. Applying Chilton's theory that “talk matters,” I note specific changes in rhetorical style and language that were first employed by Tea Party-supported politicians after the 2010 congressional election and more recently used to great effect by Donald Trump, the 2016 Republican nominee and current president-elect.

## METHODOLOGY

In this study, I perform rhetorical analysis of speeches to understand how members of the Tea Party Caucus used language to frame political issues after their ascendance in the 2010 congressional elections and how their rhetoric is reflected in mainstream conservative political discourse. The study takes a cultural/linguistic approach, looking at changes in the frequency of fear-inducing language, political myths, dog-whistle rhetoric, conspiratorial accusations, and personal insults.

This study compares the speeches of the most mainstream of Republicans, the party nominees, analyzing speeches made prior to the Republican National Conventions in 2008 and 2016. To control as many variables as possible, I chose the same five types of speeches for both John McCain and Donald Trump: the campaign announcement speech, a foreign policy speech, an immigration speech, a speech to the American Israel Public Affairs Committee (AIPAC) Conference, and the speech after becoming presumptive nominee. The speeches by the five Tea Partiers after the 2010 congressional elections were each picked because they represented large



events: four of the five were speeches at conservative conventions and the other was Mike Lee's response to the 2014 State of the Union Address.

In theory, speeches by presidential candidates should be more moderate as they are intended to appeal to a wider swath of Americans, thus providing a more moderate estimate of the extent of harmful discourse than speeches by members of Congress, which can be tailor-made for strongly partisan constituencies and special interest groups (Hirano et al. 2010). This study tested the theory that the exposure of Americans to Tea Party discourse radicalized American political discourse and allowed extreme discourse to be utilized to great political effect; a theory I believe was supported by Donald Trump's victory in the general election.

To establish a baseline and identify the boundaries of mainstream conservative political discourse, I first examined the campaign announcement speech, a foreign policy speech, a speech on immigration, a speech to the AIPAC Conference, and the presumptive nominee speech from John McCain during his 2008 run. I then analyzed the language and rhetorical style of politicians who were supported by the Tea Party during the 2010 congressional elections, specifically looking for the number of instances of the particular rhetorical strategies I explain below. Finally, I analyzed Donald Trump's campaign announcement speech, a foreign policy speech, a speech on immigration, a speech to AIPAC, and his presumptive nominee speech during his 2016 run. I then noted the differences in usage of these rhetorical strategies between McCain's and Trump's speeches to chart the evolution of conservative discourse between 2008 and 2016, before examining the similarities in these same rhetorical strategies between Donald Trump and that of Tea Party-supported politicians in the 2010 congressional race to see how the rhetoric of Tea Party-supported politicians fits within the trajectory of mainstream conservative political discourse. Specifically, I looked for divisive discourse that leads to the excluding and isolating of certain groups, arouses fear in the general population, introduces misinformation to the political conversation, and otherwise poisons the political well. This tests for a corollary effect between the rise of the Tea Party and the rhetorical strategies they embraced, along with the normalization of their discourse, rather than testing for cause and effect. To better explore this discourse, I used analytical categories from several sources. The idea of exploiting myths as a political tactic is referenced in *The Politics of Language*. Political scientist Murray Edelman identified three types of political myths: the "Conspiratorial Enemy," the "Valiant Leader," and "United We Stand."

The "Conspiratorial Enemy" refers to the myth of a hostile out-group, which is perceived as different, homogenous, highly potent, or omnipotent and is supposedly conspiring to harm the in-group. An example would be

Donald Trump saying,

How does this kind of immigration make our life better?  
How does this kind of immigration make our country  
better? Why does Hillary Clinton want to bring people  
here—in vast numbers—who reject our values? Immi-  
gration is a privilege, and we should not let anyone into  
this country who doesn't support our communities – all  
of our communities (Trump 2016).

The “Valiant Leader” myth ascribes to the view that the political leader is benevolent and effective in saving people from danger and that the leader exhibits the qualities of courage and aggressiveness, as well as the ability to cope. An example would be Donald Trump saying,

We need somebody that can take the brand of the  
United States and make it great again. It's not great  
again. We need— we need somebody— we need some-  
body that literally will take this country and make it  
great again. We can do that (Trump 2016).

“United We Stand” statements support the belief that a group—be it a nation, state, or party—can achieve victory over its enemies if it will only work, sacrifice, and obey its leaders. An example would be Donald Trump saying, “This is how we won the Cold War and it's how we will win our new future struggles, which may be many, which may be complex, but we will win if I become president” (Trump 2016).

In Clark Rountree's *Venomous Speech*, editor Rebecca Cournalia delineates the “politics of fear,” with specific examples using fear regarding jobs (e.g., “taxes kill,” “regulations kill”). An example would be John McCain saying, “We are fighting a war in two countries, and we're in a global struggle with violent extremists who despise us, our values, and modernity itself” (McCain 2008).

Professor Ian Haney-Lopez's book *Dog Whistle Politics* explains how dog-whistle rhetoric, language holding a dual meaning for a targeted group, reinvented racist appeals to white Americans. While the language might be viewed as neutral to casual observers, it actually carries racist undertones to the specific targeted audience. Donald Trump demonstrated this when he said:

When Mexico sends its people, they're not sending their  
best. They're not sending you. They're not sending you.  
They're sending people that have lots of problems, and

they're bringing those problems with us. They're bringing drugs. They're bringing crime. They're rapists. And some, I assume, are good people. But I speak to border guards and they tell us what we're getting. And it only makes common sense. It only makes common sense. They're sending us not the right people (Trump 2015).

In *Change They Can't Believe In*, political scientists Christopher Parker and Matt Barreto noted the “conspiratorial nature” of Tea Party discourse, which I attach to the spreading of misinformation and references to conspiracy theories. In particular, statements regarded as untrue and carrying the labels of “Mostly False,” “False,” and “Pants on Fire” by Politifact on their truth scale or otherwise denoted as untrue by major news organizations meet these criteria. An example would be Sarah Palin saying “See, I tried to look into that transparency thing, but Joe’s meetings with the transparency and accountability board—it was closed to the public. Yeah, they held the transparency meeting behind closed doors” which was rated “False” by Politifact.<sup>17</sup>

I have also included the category of personal insults, such as calling national leaders “stupid” or “out of touch” because Donald Trump was branded as a bully and it has been theorized that his constant use of insults led to increases in bullying over the past year by the Southern Poverty Law Center (Costello 2016).

I then read each speech and coded each one for instances of harmful discourse in these categories. Table 1 shows the results and allows comparison of the number of instances of harmful discourse over time. Table 2 shows the number of instances across each category for McCain, Palin, the Tea Party-affiliated politicians, and Trump individually to show the changes over time.

# RESEARCH FINDINGS

TABLE 1. CUMULATIVE HARMFUL DISCOURSE OVER TIME

2008 MCCAIN	TRANSITION PERIOD 2008-2010	TEA PARTY SPEECHES POST 2010	2016 TRUMP
McCain's Campaign Announcement Speech <i>April 25, 2007</i> <i>12 instances</i>	Sarah Palin's Speech at the Republican National Conference <i>September 3, 2008</i> <i>37 instances</i>	Michele Bachmann's Speech at the Values Voter Summit <i>September 14, 2012</i> <i>54 instances</i>	Remarks Announcing Candidacy for President in New York City <i>June 16, 2015</i> <i>82 instances</i>
Address at the Hoover Institution on U.S. Foreign Policy <i>May 1, 2007</i> <i>7 instances</i>	Sarah Palin's Keynote Speech at the Inaugural Tea Party Convention <i>February 6, 2010</i> <i>54 instances</i>	Marco Rubio's Remarks at the Conservative Political Action Conference <i>February 9, 2012</i> <i>31 instances</i>	Donald Trump's Foreign Policy Speech <i>April 27, 2016</i> <i>68 instances</i>
Remarks to the National Association of Latino Elected & Appointed Officials in Washington, DC <i>June 28, 2008</i> <i>13 instances</i>		Ted Cruz's Speech at the 2012 Republican National Convention <i>August 29, 2012</i> <i>17 instances</i>	Donald J. Trump Addresses Terrorism, Immigration, and National Security <i>June 13, 2016</i> <i>69 instances</i>
Remarks to the American Israel Public Affairs Committee Policy Conference in Washington, D.C. <i>June 2, 2008</i> <i>13 instances</i>		Mike Lee's Response to the 2014 State of the Union Address <i>January 28, 2014</i> <i>12 instances</i>	Remarks at the AIPAC Policy Conference in Washington, D.C. <i>March 21, 2016</i> <i>69 instances</i>
Remarks Claiming the Republican Presidential Nomination <i>March 4, 2008</i> <i>10 instances</i>		Rand Paul's Remarks at the 2014 Conservative Political Action Conference <i>March 8, 2014</i> <i>16 instances</i>	Remarks Claiming the Republican Presidential Nomination <i>May 4, 2016</i> <i>30 instances</i>

After analyzing the speeches, I found significant increases in all categories of harmful discourse after the 2010 congressional elections. Table 2 shows the increased usage of discourse by speaker. Fear-inducing language was used by John McCain, with 22 total instances, but Donald Trump tripled that with a total of 66 instances. Fear-inducing language also increased in

usage after 2010 by both Sarah Palin and the Tea Partiers who were analyzed. Political myth usage increased dramatically, with McCain using 20 and Trump using 97. Finally, personal insults multiplied almost six-fold, with McCain using 13 and Trump using 71. The most interesting finding was that McCain had no instances of dog-whistle rhetoric or conspiratorial accusations in my analysis, whereas Donald Trump used these two forms of harmful discourse in 36 instances. Conspiratorial accusations increased to the point that Donald Trump's campaign misstatements were dishonored as Politifact's 2015 "Lie of the Year".<sup>18</sup> Dog-whistle rhetoric was increasingly aimed against Mexican immigrants, Muslims in the United States and abroad, and especially in questioning Barack Obama's racial and national heritage. The "Conspiratorial Enemy" charge was cast increasingly against prominent Democrats, the federal government as a whole, and even moderate Republicans rather than against foreign enemies of the United States such as Al-Qaeda and ISIS. The "Valiant Leader" and "United We Stand" subcategories within political myths also increased markedly.

TABLE 2. HARMFUL DISCOURSE INSTANCES

RHETORICAL STYLES	MCCAIN 2008	PALIN	POST-2010 TEA PARTY	DONALD TRUMP 2016	NUMBER OF INCREASES
Fear-Inducing	22	22	32	66	+44
Political Myths	20	34	40	97	+57
Dog-Whistle	0	4	11	22	+22
Conspiratorial Accusations	0	1	5	14	+14
Personal Insults	13	30	39	71	+58
Total	55	127	127	270	+215

## DISCUSSION

The increase in harmful discourse shown by this study suggests that conservative discourse has reached a point where the formerly taboo has become normalized, particularly because Donald Trump's rhetoric was a major factor in his success.<sup>19</sup> Multiple articles have been written about the rise of Trumpism: politics that relies upon the strength of personality and

strongman authoritarianism that is often reflected through the examples of harmful discourse highlighted by this study.<sup>20</sup> Since the election of 2008, there has been an increase in harmful rhetoric in conservative discourse. This began to appear with the Tea Party and continued to expand with the rise of Donald Trump. As harmful discourse continues to become normalized it has the potential to become an expectation with extremely dangerous implications for the political process and social climate of our country as the population of the United States becomes more diverse.

The primary limitations of my study were that I was not able to study every speech in any of the “eras of discourse” that I studied. The study did not address failed candidates in either 2008 or 2016, particularly to see if those who used more harmful discourse did better or worse than their contemporaries. The study also did not address shifts in liberal discourse during the same time period to assess changes in mainstream liberal discourse. Another issue is that there is varying scholarly criteria of harmful discourse and I had to narrow it down to five particular categories. This study was conducted before the 2016 general election and does not include speeches from the Republican National Convention nor the post-RNC campaign. Finally, the study is subject to personal biases, as harmful discourse is ultimately up to the person who is reading the speech and a more conservative individual may find less examples.

I plan to expand this study by analyzing the same six types of speeches from Mitt Romney in 2012, along with the Republican National Convention’s closing speech from McCain, Romney, and Trump respectively. I eventually want this study to feature those six speeches from every Republican nominee from Barry Goldwater in 1964 to the 2020 Republican nominee during the campaigning process for the primary elections. This would allow me to explain the narrative of who the perceived out-groups were within American society, how polarized the parties are, and otherwise understand America’s changing political landscape over the past 50 years. This study would also allow me to look at how various harmful political narratives (law and order, welfare queens, etc.) correlate with particular political policies.

## CONCLUSION

I conclude that Tea Party discourse has served as a precursor and correlated with the increased usage of harmful discourse by mainstream conservative politicians. This lends further credence to Parker and Barreto’s claim that the Tea Party is truly reactionary rather than just ultra-conservative, as it harkens to a non-existent past where taxes were low, the federal government was small, and America’s population was much more homogenous.

All five of the rhetorical strategies listed (fear-inducing language, political myths, dog-whistle rhetoric, conspiratorial accusations, and personal insults) have been employed in increasing amounts since the rise of the Tea Party to the national stage. That is a problem because this discourse has real-world repercussions and also has the potential to create a snowball effect of worsening discourse.

As former senior policy analyst Jeff Schweitzer wrote for the Huffington Post, the redefinition of truth in far-right circles has essentially crafted two separate political realities: one based in truth and the other based in fiction.<sup>21</sup> Without political discourse that is based on statistics and objective facts, compromise is essentially impossible. Delegitimizing harmful discourse in politics as a whole is a necessary step to reintroduce truth and civility to our national conversation and to close the “truth gap” that Schweitzer addressed.

## ENDNOTES

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# The Costs of Good Karma: Effects of Fangsheng on the Chinese Environment and Society

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## **BIOGRAPHY**

Caitlin Stone graduated from UMBC in fall 2016. She majored in asian studies and minored in Chinese language. She hopes to continue her education in graduate school while working as a research assistant. This research project has led her to consider focusing on environmental studies when she enters graduate school, but she is also interested in exploring master's degree programs for asian studies. When she is not researching or madly committing new vocabulary to memory she enjoys building Warhammer 40k models and playing video games.

# DEMYSTIFICATION

Fangsheng (放生), literally translated as life release, typically refers to the Buddhist practice of animal release in China. Fangsheng has a long and extensive history in Chinese culture, but the end of the Cultural Revolution allowed for a resurgence of the practice. As a result, animal release has the potential to wreak havoc on the Chinese environment and society. I chose this topic after volunteering to participate in a research conference before I selected a research topic. Luckily, a friend sent me a link to an *Economist* article about fangsheng. It sounded different and interesting enough to look into. Despite the difficulties researching it, I am glad that I decided to research this topic because it turned out to be really interesting and I feel as though the presentations related to this project strengthened my public speaking ability.

## ABSTRACT

Since the end of China's Cultural Revolution in 1976, there has been a resurgence of religious practices, some of which have had unintended environmental consequences in various places across the country. According to *The Economist's* September 2015 issue, the Buddhist practice of *fangsheng*, also called animal release, has been on the rise in China, especially among the younger, wealthier generation. Ritual animal release has been a significant cause of the introduction of large quantities of non-native animal species into China's environment. For example, a few thousand loach (a type of non-native fish) were liberated into Shanghai's Huangpu River at one time. These large numbers of animals heavily influence the likelihood of a non-native species becoming invasive, which can cause numerous problems. For instance, non-native bird species released in Hong Kong have recently raised concern on multiple fronts: in terms of the environment, increasing numbers of these birds are crowding out native bird populations in the area; in the arena of public health, they are believed to be a source of varying strains of avian flu. Animal release rituals also impact the economy, increasing demand amongst practitioners of Buddhism to purchase animals to liberate. To keep up with this demand, wildlife traders often re-catch recently liberated animals simply to place them back on the market. These animals are often quite expensive; many young people spend upwards of 5,000 yuan (about 765 dollars) per year on animals to release. Such side effects appear in multiple provinces as there are 281 different *fangsheng* organizations with at least one in every province and municipality, except Tibet. This paper aims to address these and other effects and concerns of *fangsheng* and propose some solutions to these problems.

## INTRODUCTION

In September 2015, *The Economist* newspaper published an article about the rising popularity in China of a practice called *fangsheng* (放生), a Buddhist ritual during which practitioners release animals that have been captured and placed on the market for sale as a source of food, traditional medicine, or as pets. The article describes a scene in which members of a *fangsheng* association gather along the banks of Shanghai's Huang Pu River to release thousands of fish every Saturday, calling attention to the practice and its unintended ecological and societal consequences.<sup>1</sup> The ritual is meant to show compassion for the animals, build up good karma, and serve as a means to make requests for worldly gains. The practice has been witnessing a resurgence in China since the death of Mao Zedong and the end of the Cultural Revolution in 1976. Over 200 *fangsheng* associations have been established for the sake of making the ritual more accessible to citizens both Buddhist and otherwise, as well as to earn money.<sup>2</sup> Almost every association releases tens of thousands of animals with each ritual and many hold rituals on a weekly basis. With these numbers of released animals, increasing concerns are being raised by conservationists. Many times, because of their economic convenience, the animals that are released are non-native species. When thousands of these non-native species are released at one time, the likelihood of them becoming invasive increases. These species can thus wreak havoc upon the environments into which they are introduced. At the rate in which these associations are appearing and releasing animals, there hardly seems a sustainable way in which this practice can continue without undergoing changes and adopting a few solutions that some Buddhist temples in other parts of the world have been striving to put into place.

## HISTORY OF FANGSHENG IN CHINA

The concept of animal release does not seem to have originated with traditional Indian (Hinayana) Buddhism, though many today believe this to be the case. In fact, the earliest examples of animal release occurred out of simple benevolence and as a result of government policies,<sup>3</sup> though the exact origins remain unclear.<sup>4</sup>

Buddhism came to China during the first and second centuries C.E. The original teachings struggled to spread within the country and began taking on more popular aspects of mysticism and magic that transformed the religion into what is known as Mahayana Buddhism in order to fill the philosophical void left by the departure of the Confucian system.<sup>5</sup> During the Tang Dynasty (618-907), the state suppressed the religion through a series of con-

fiscations and, even in its more popularized form, Chinese Buddhism was stripped of its status as the state religion. This systematic repression, as well as similar magical meanings, caused the Buddhist religion to almost merge with Daoism.<sup>6</sup> It is entirely possible that this meshing caused Buddhism to adopt the practice of animal release as a sign of benevolence.

Early written stories of practices of animal release imply that the act originated as a form of early indigenous practice.<sup>7</sup> Early hunting regulations issued by governors and kings, who supported and were influenced by Confucianism, placed restrictions upon the killing of animals during hunting and sacrifice rituals, including “off season” restrictions. These rules prevented citizens from killing pregnant animals, young animals, and entire animal families.<sup>8</sup> While this suggests that on occasion animals would be set free, it also implies that there had been more of a concern for the preservation of future game rather than mandating that hunters act with kindness towards the animals.

Aside from these regulations, there are stories of people releasing animals out of their own benevolence rather than following the expected practices set by the state. There are stories of the first Shang Dynasty king named Tang who, after leaving the city, came upon a man who had laid out four nets. This man was praying over these nets, asking his ancestors to make birds simply fall from the sky into them. Tang, distraught by what this would mean for the birds, folded up three of the four nets and instructed the man to say another prayer. This story indicates that using a lone net, similar to the way a spider uses a web, would allow any bird wise enough to avoid the net to go free.<sup>9</sup> Other stories of such benevolence involve more direct instances of animal release. One such story is about a Qin duke who returned sparrows to their nest upon the realization that they were of weak continence. Another tells of a man who purchased an old horse so that it may live out its last days in peace rather than working.<sup>10</sup>

The earliest written mention<sup>11</sup> of the ritual of *fangsheng* appears in Daoist text *The Liezi*. In its eighth book (also known as *Shuo Fu*) a New Year’s practice is described:

“The good people of Han-tan were in the habit, every New Year’s day[sic], of presenting their Governor, Chien Tzu, with a number of live pidgeons[sic] [for release]. This pleased the Governor very much, and he liberally rewarded the donors. To a stranger who asked the meaning of the custom, Chien Tzu explained that the release of living creatures on New Year’s day was the sign of a benevolent disposition. ‘But,’ rejoined the stranger, ‘the people being aware of your Excellency’s



whim, no doubt exert themselves to catch as many pigeons[sic] as possible, and large numbers must get killed in the process. If you really wish to let the birds live, the best way would be to prohibit the people from capturing them at all. If they have to be caught first in order to be released, the kindness does not compensate for the cruelty.' Chien Tzu acknowledged that he was right."<sup>12</sup>

While the theme of this story focuses on the yearly practice of animal release, it was not meant to teach the ritual to followers of Daoism. Instead this story was used as the overarching lesson of the book of *Shuo Fu* of *The Liezi* in that it taught followers to teach people to read subtleties of life either through careful observation or through an understanding achieved through familiarity, just as the stranger exercised in his observation of the described practice.<sup>13</sup>

On multiple occasions, when the practice of *fangsheng* is mentioned, there is a second practice of life or animal protection (尸生, *husheng*) that is invoked. While these two practices are related, they should not be confused as they have different implications.<sup>14</sup> The teachings of animal protection originated within the teachings of Hinduism. Since Buddhism has many of its roots founded within Hinduism, it is understandable that animal protection (*ahimsa* in Sanskrit) would be founded on similar teachings.<sup>15</sup> This is made apparent by edicts that the Indian Emperor Asoka had engraved onto stones, the contents of which ranged from providing healthcare to both humans and animals to building resting places along roads for them.<sup>16</sup> One Buddhist story details an influencing factor in life protection through a story about one of Buddha's past lives. As a deer, Buddha makes the ultimate sacrifice to protect a pregnant doe. The ruler in the story, seeing Buddha's selflessness, is driven to guarantee the protection of all deer in the park and eventually extends that protection to all animals in the realm.<sup>17</sup>

One Buddhist text, *The Brahmajala; Sutra of Brahma's Net* (the *Fanwang Jing* in Chinese), clearly justifies the practice of *fangsheng* as an act of compassion.<sup>18</sup> This is reflected in the quote "Bodhisattvas should practice the act of releasing animals due to the mind of compassion."<sup>19</sup> This indicates that the act of *fangsheng* was not always about procuring good karma, unlike the goals of today's practice. According to Buddhism, the reason behind displaying such compassion toward animals stems from the concept of reincarnation, which teaches that our essence and the essences of our family members lie within the animals. If one were to kill an animal, it is possible that they are either killing themselves or their parents.<sup>20</sup> The importance of the relationship between parents and children within the five relationships of Confucianism no doubt led to the strengthening of

this concept in China, particularly because of the popularity of Confucian teachings in the country.

By the Liang Dynasty (502-587), *fangsheng* as an integral part of Buddhism had become one of the key teachings of the religion. It had gained favor among ruling clans in Southern China during the second half of the Tang dynasty who began to practice and promote the ritual. Emperor Wu of Liang, for instance, was said to be so wholeheartedly dedicated to animal release that not only would he practice it himself, he would also ride around in chariots adorned in banners in order to encourage his people to do the same. Emperor Wu also built ponds, called *fangsheng chi* (放生池), into which fish and turtles could be safely released simply for the sake of *fangsheng* practice. Emperors Xianwen, Xiaowu, and Wenxuan (of the Wei, Jin, and Northern Qi dynasties, respectively) all put edicts into place ordering the people to release eagles into the mountainsides and forests.<sup>21</sup> The practice of *fangsheng* by various emperors and their support through advertisement, construction projects, and edicts cultivated the popularity of the practice among the common people and helped to ensure its longevity.

Today, however, the practice of *fangsheng* has begun to lose its roots within the teachings of compassion and protection; this is perhaps because of Mao Zedong's declaration of religion as a backwards concept and the suppression of religion during the Cultural Revolution. While many people across the globe participate in the ritual they are not necessarily Buddhists; indeed, increasing numbers of Christians have begun to participate in the releases. Aside from this new variety of practitioners, the goals and practices of *fangsheng* have also evolved to accommodate everyday lives of the people and to achieve worldly desires.<sup>22</sup>

The Beijing Yunjusi Fangsheng Husheng Association (北京云局寺放生户生: Beijing Yunju Temple Life Release and Protection Group) publishes the ten things that people pray for within China through the practice of *fangsheng* on their website:

1. To eliminate violence and death as a result of war,
2. For longevity, health, and less disease,
3. To avoid unexpected calamity,
4. For the endless prosperity of their descendants,
5. To have more children,
6. For a good salary,
7. For an auspicious and peaceful year,
8. To solve injustices and eliminate evils,
9. To bring Buddha's joy,
10. To be reborn in the Western Paradise, or Heaven.<sup>23</sup>

These ten things also appear in readily available *fangsheng* handbooks, implying that these “merits” are the standard set of prayers for the practice.

As mentioned before, there are more than 200 *fangsheng* associations in China with at least one in every province, except Tibet. As detailed by records kept by the Beijing Yunju Temple Fangsheng and Husheng Association, followers send in remittances using Alipay or another payment method and, based on the amount of money sent, purchase a sum of animals for release based on their own preferences.<sup>24</sup> These associations then purchase the requested animals from open markets and restaurants at prices that fluctuate with market demands.<sup>25</sup>

These associations vary greatly in terms of transparency regarding the cost and legitimacy of practices. The association in Beijing, for instance, tries to maintain full transparency. Within their records, fully accessible to the public, they include screenshots of text messages and payments; they even go so far as to supply bank account numbers and total sums of money within those accounts.<sup>26</sup> Other associations, such as Fangsheng Online (放生网) seem to be on the exact opposite end of the spectrum. When searching for contact information to ask questions, the website informs curious netizens that there are restrictions on the questions that may be asked. For instance, the questions “do you really release animals? (你是真的放生吗?)”, “are you fooling me? (你是骗子吗?)”, or “are your releases real or fake? (你是真放生还是假放生?)” are considered insults and will not be answered. There is also a lack of records on the website, largely because of administrators’ inactivity and lack of response to the large amount of questions that users post. Most responses from administrators tend to focus on addressing questions regarding remittances.<sup>27</sup> There are still other groupings of associations that maintain their privacy, but do not place restrictions on questions that may be asked. The Guangdong Fangsheng Association and Chaoyang Fangsheng Association are two groups that seem to be operated by a corporate entity; their logos are very similar, with the only difference being their names. Chaoyang is a city within Guangdong, so the sensible explanation for the similarity is that one corporate entity controls these and other associations in the province. The groups have a simple online “order” form to make requests and remittances easier and more comprehensive. The groups do not offer their records, but they do not seem to go out of their way to hide them either. The administrators also make an effort to participate in their forums.<sup>28</sup> Most of the groups that I have surveyed seem to be more transparent, however many of them have not responded to email inquiries that I have sent.

From the 4th century BCE to the Tang Dynasty, *fangsheng* had maintained its status as a religious act meant to show kindness and compassion towards animals. The popularization of the act has led to an evolution

causing *fangsheng* to become more about possible merits to be gained rather than simply being about compassion. The hundreds of associations that have appeared release animals on a daily, weekly, or monthly basis depending on their own personal preferences and locations. The number of animals that are released every year is in the millions. This has caused some conservationists to become concerned, particularly in regards to the environment and local ecology.

## ENVIRONMENTAL EFFECTS AND IMPLICATIONS

Invasive species, whether flora or fauna, are just about everywhere, ranging from brambles found in the woods in America to the mosquitoes buzzing above the pond at the park. Invasive species are defined as non-native, with the potential to cause harm to local animal populations and ecologies, public health, and/or economic well-being.<sup>29</sup> Any species may become invasive after it is introduced to a habitat outside of its native range and is then left unchecked to thrive in these new areas. Within China alone, at least 50 of the 100 most invasive species on the planet can be found.<sup>30</sup> These species are often the result of purposeful introduction for many reasons including aquaculture, “greening” of the environment, and religious practices such as *fangsheng*.<sup>31</sup> *Fangsheng* is a major source of releasing potentially harmful and invasive animal species, especially given that a few of the animals on the IUCN Red List of the most invasive species tend to be rather inexpensive.<sup>32</sup> Such species include *Trachemys Scripta Elegans* (red-eared slider turtles), *Lithobates Catesbeianus* (American bullfrogs), *Melopsittacus Undulatus* (parakeets), and *Hypophthalmichthys Nobilis* (bighead carp).

### TRACHEMYS SCRIPTA ELEGANS

*T. s. elegans* is listed among the 100 most invasive species in the world.<sup>33</sup> These animals tend to be quite popular as pets because of their initially small size and low price, as well as spikes in the popularity of *Teenage Mutant Ninja Turtles*.<sup>34</sup> Commonly referred to as red-eared slider turtles because of the reddish-orange spots behind their ears, they make hardy pets and have the potential to devastate environments to which they are released.

*T. s. elegans* have a native range from Northern Mexico through much of the United States and into Southern Canada. They are known to be “opportunistic omnivores,”<sup>35</sup> eating plant matter, fish, tadpoles, and even frog eggs when available. Their voracious appetites lead to them becoming too large to keep as pets for unsuspecting pet owners, driving people to then release them into the wild.<sup>36</sup> The situation is a little different in China

where the turtles are both farmed and imported for the pet trade, food market, and traditional medicine.<sup>37</sup> Temples and *fangsheng* associations alike purchase turtles for release from markets, street vendors, and restaurants for the sake of ceremonies; just as in the pet trade their low prices make them a popular choice.<sup>38</sup>

Once they are released into the wild, it becomes clear that these turtles have a competitive advantage over native turtle species. They have a lower maturity age, comparatively larger size, and higher rate of reproduction.<sup>39</sup> *T. s. elegans* competes for food, egg-laying sites, and basking spots, in addition to becoming increasingly aggressive with age. This species also carries nematodes, a type of parasitic worm, and other parasites which can be transferred to native turtle populations and diminish numbers within those communities.<sup>40</sup> This, in conjunction with its omnivorous diet and aggressive disposition, causes declines in native populations because of being crowded out and increasing death tolls.

Unfortunately, little has been done to monitor the movements and habits of the red-eared slider in China. It is believed, however, that this species has caused the crowding out of native species such as *Mauremys Sinensis* (Chinese stripe-necked turtles). Native to Southern China, these turtles have been found increasingly larger distances away from the sites in which they were previously found.<sup>41</sup> It is possible to hypothesize the effects that such invasions could cause by taking a look at instances in Taiwan. The Keelung River, about twelve kilometers North-East of Taipei, is one site of animal release for local temples.<sup>42</sup> This river saw an increase of *T. s. elegans* over a period of six years. In 1996, 68 sliders were documented while 698 *M. sinensis* were found. In 2002, slider populations had increased to 112 and *M. sinensis* was recorded at 567.<sup>43</sup> While it is not entirely clear how much these numbers are affected by trapping and release practices, it can be argued that *T. s. elegans* had possibly begun to outcompete its native cousin. The only way in which conservationists can truly understand the level at which the sliders are impacting native species and the environment, however, is through a higher level of education and awareness that may stimulate further research on the topic.

## LITHOBATES CATESBEIANUS

*L. catesbeianus*, similar to the *T. s. elegans*, is widely released for *fangsheng* practices because of its agreeable price.<sup>44</sup> The species, commonly known as the American bullfrog, was introduced to mainland China, Taiwan, and Daishan Island in 1959, 1924, and the 1990s, respectively, in order to be farmed as a food source.<sup>45</sup> Their calls tend to be loud, enabling them to be heard up to one kilometer away. The bullfrogs are brown with green hues and are the largest of anuran (frog) species.

*L. catesbeianus* is native to the Nearctic region — North America, Greenland, and parts of Mexico. They were brought into China as part of the food trade and can be found in Yunnan, Sichuan, Xinjiang, and Zhejiang provinces as well as the Zhoushan archipelago, just off the coast of Ningbo City in Southeast China.<sup>46</sup> In 2005, it was listed amongst the 100 most invasive species in the world, establishing itself in marshes and lakes because of its heavy aquatic dependency. American bullfrogs are labeled as generalist predators, consuming invertebrates and vertebrates indiscriminately. Their diets may consist of frog eggs, fish eggs, snails, or even their own kind. Their efficiency as predators has raised concern in terms of both food competition and predation. Like many other species, *L. catesbeianus* is a known carrier for disease. The species has been commonly associated with transmitting chytridiomycosis, an infectious disease caused by a zoosporic fungus called *batrachochytrium dendrobatidis*.<sup>47</sup> The anurans have also proven to be successful at avoiding predation by evolving both non-palatable eggs and minimally active tadpoles to avoid predatory attention.<sup>48</sup> These factors all give the species the advantage in areas to which it is introduced, and increases the likelihood of it becoming established as an invasive species.

The impacts of *L. catesbeianus* have proven difficult to quantify in the wild for two reasons: first, the condensed time frame in which studies may be performed in the wild do not cover much of the overall impact; second, it is difficult to extrapolate enough data in a manner that is relevant to the scale of the population.<sup>49</sup> These difficulties could explain the lack of numerical information about relationships between American bullfrogs and native anuran populations. One study, however, has proven that this species preys upon anuran species native to the Zhoushan archipelago and Daishan Island. The populations listed as the most at risk are *Bufo bufo gargarizans* (Zhoushan toads), *Rana limnocharis* (rice frogs), *Rana nigromaculata* (black-spotted pond frogs), and *Rana japonica* (Zhenhai brown frogs). The study found that there was a positive correlation between *L. catesbeianus* sizes and the amounts of native anurans they ate per day. As the frogs became larger, they ate more, ingesting up to two grams' weight of native anurans. The study also found that the bullfrogs prefer to eat the smallest of the four species for the sake of easier ingestion.<sup>50</sup>

The predatory habits of this particular anuran species are similar in the other parts of China to which they are introduced. Without any checks or regulations in place to monitor them, *L. catesbeianus* is highly likely to consume native populations to the brink of extinction.

## MELOPSITTACUS UNDULATUS

*M. undulatus* are more commonly referred to as budgies or parakeets. These birds are very common in the pet trade and are one of the most pop-

ular bird species because of their bright colors, ability to mimic noises, and their general hardiness as a result of selective breeding.<sup>51</sup> This species has been establishing itself in and around Hong Kong, though it is difficult to tell what percentage can be credited to *fangsheng*. Its popularity as a species for *fangsheng* and its popularity as a pet, however, are hypothesized to be causes for almost one quarter of the population found outside of captivity.<sup>52</sup>

*M. undulatus* is primarily native to Australia and prefer to inhabit semi-arid and sub-humid habitats.<sup>53</sup> These birds are a nomadic species and will travel long distances in search of food. While in the wild, they will form large flocks which have been known to reach population sizes numbering in the tens of thousands.<sup>54</sup> It is unclear exactly how many individual parakeets are in China, but it is believed that there are upwards of 10,000 breeding pairs. Their diets consist primarily of seeds and the birds are causing farmers increasing concern as they wreak havoc in fields.<sup>55</sup> As with other invasive species, the *M. undulatus* has proven itself to be a successful forager and rather aggressive when looking for nesting spots.

The specific effects of this species are not entirely certain, although much speculation has been made using general knowledge of the behavior of the species. Because of their large numbers and their overall hardiness, conservationists believe that *M. undulatus* are beginning to compete with native avian species in Hong Kong for nesting spaces and are increasingly crowding out such species. It is also believed that this species, along with other released, alien species (species such as *Padda Oryzivora* and *Pycnonotus Cafer*), is causing hybridization as they mate with native populations. Hybridization causes native communities to decline as each consecutive generation becomes increasingly different and the likelihood of sterilization increases.<sup>56</sup>

## HYPOPHTHALMICHTHYS NOBILIS

*H. nobilis*, commonly referred to as bighead carp, is one species native to China that raises concern regardless of its nativity. Their native range within the country is in the southeast, primarily within the Canton region. Named for the size of their heads and the strange placement of their eyes, they are also marked by black spots on their dorsal areas. They have been introduced to Europe, the United States, and western China by local governments and farmers, primarily for aquaculture.<sup>57</sup>

*H. nobilis* is a species of filter feeders that thrives in subtropical rivers. The general population in the native region has been on decline but in other areas outside of this region, populations have been surging.<sup>58</sup> Their large growth and reproduction rates make them highly competitive with other filter feeders in the areas to which they have been introduced.



These carp are readily available in markets and restaurants for consumers who prefer to purchase them live to maintain maximum freshness until prepared for a meal, causing them to be easily available for release practices.<sup>59</sup> Similar to *T. s. elegans* and *M. undulatus*, little research has been done to investigate the direct environmental impacts of *H. nobilis* when used for fangsheng.

It is possible, however, to speculate on possible effects of this species of carp from studies previously performed. One study, for instance, examined the effects of *H. nobilis* on the ecosystem of a plateau lake in western China. In the 1950s, this species was introduced to Lake Xingyun in Yunnan province in west China for the purpose of aquaculture by local farmers. Before the introduction of this species, the native *Cyprinus Pellegrini* (naked carp) was the fish that had thrived. Once established within the lake, *H. nobilis* began to out compete its native cousin, causing declines in the population of *C. pellegrini*. Not only did the population decline because of competition, but they also were declining as a result of the comparatively higher rate of reproduction demonstrated by *H. nobilis*. Since the introduction of the alien species into Lake Xingyun, yields of *C. pellegrini* have witnessed a sharp drop, from 50 percent in 1950, to 20 percent in 1960, to 10 percent in the 1970s, and finally to less than one percent since the 1980s.<sup>60</sup> Such drastic numbers offer evidence that, in conjunction with being harvested, the introduction of *H. nobilis* can cause detrimental effects to local, isolated ecosystems.

## PUBLIC HEALTH

The potential impacts of *fangsheng* not only threaten the environment and local ecology—the practice also has great potential to negatively impact public health. Internet searches for the ritual produce many videos revealing that practitioners have the habit of handling the animals with little to no concern for the possibility of disease transmission. Many of the people hold and carry the animals without gloves when performing releases and some others kiss the animals before letting them go in the wild.<sup>61</sup> The animals that are widely released, as with any other animal, are carriers for various diseases. Red-eared slider turtles, the most commonly released reptiles, are known transmitters of *Salmonella pomona* and many of the birds released for *fangsheng* are possible transmitters of Avian Influenza A (H7N9). These two diseases, combined with possible risk caused by independent release practitioners, should be enough to raise more than a little concern for the health and safety of the Chinese people.

Once a person becomes infected with the salmonella bacteria the symptoms of diarrhea, dehydration, fever, abdominal cramps, headaches,



and nausea or vomiting begin to arise.<sup>62</sup> Salmonella has the possibility of becoming invasive once a person is infected. Invasive salmonella can be life threatening and can lead to infections of the blood (bacteremia) or even an infection of the brain (meningitis). The CDC lists one of the key means of contracting salmonella as coming into contact with infected animals, or handling them and not washing your hands afterwards. The animals that cause the most concern of infection are red-eared slider turtles.

Almost every year in the United States there are an estimated 1.2 million cases of salmonella linked to coming into contact with reptiles and almost half of those are directly related to turtles. With increases in sales of pet red-eared sliders on the American market there are reported increases of salmonella infection. Small turtles, particularly those with carapaces of 4 inches or smaller, have been restricted from being freely traded in many countries, such as the U.S., Australia, and Canada because of their higher contamination rates. Children under 10 are also largely affected by salmonella as they tend to put their hands in their mouths after touching the turtles or even placing the turtles themselves into their mouths.<sup>63</sup>

*Salmonella pomona*, the strain most commonly associated with these pet turtles, was recently discovered in China in wild red-eared slider turtles.<sup>64</sup> This discovery was recently published in 2013, and its implications for public health have the potential to be detrimental to society. China imports more than 10 million red-eared sliders each year and triple that number are shipped to markets from domestic farms within the country.<sup>65</sup> Since most, if not all, of the animals that are purchased to be released for *fangsheng* practices are purchased from markets and restaurants, it is entirely possible that these animals are infected prior to their release and are thus infecting other turtles in the region. If these turtles are infected before being purchased on the market, then that implies that those who participate in the practice are handling ill turtles. Animals released during *fangsheng* are often purchased and released in large numbers, as evidenced by the Beijing Yunju Temple Life Release and Life Protection Group's records page on their website.<sup>66</sup> This is most certainly the case in the release of these turtles.

Avian Influenza A (H7N9) is another illness that has the potential to have detrimental effects of the health of the public. Discovered in March of 2013 in Shanghai, H7N9 is a relatively new strain of avian influenza.<sup>67</sup> Similar to other strains of avian flu, H7N9 is associated with the symptoms of high fever and coughing. Many cases have been known to develop into pneumonia, acute respiratory disease syndrome, septic shock, multiple organ failure, and even to cause death.<sup>68</sup> In some provinces, the mortality rate of lab-confirmed cases of H7N9 reaches almost 40%. Unlike other strains of avian influenza, birds infected with this strain show little to no

symptoms of infection.<sup>69</sup> This is largely concerning because there is no indication that H7N9 is present in an area until people start becoming sick.

It is currently theorized that H7N9 developed as a result of multiple interspecies transfers of H7 and N9 strains of separate viruses. Migratory birds (such as ducks or local bulbul populations) carrying one or both of these strains will rest at or around water sources shared by domestically kept fowl.<sup>70</sup> These strains mix as they are transmitted from migratory birds to farm animals, and are capable of surviving in water for several months.<sup>71</sup> The farm birds are later sent to be sold in live poultry markets where poor sanitary conditions make transmission of the disease from not only bird to bird, but also bird to human much easier. Many of the birds released for *fangsheng* are sold in the same markets as live poultry, or in close proximity to said markets. These birds are then kept in large numbers in small cages that are often stacked one on top of the other. Storage of *fangsheng* birds therefore further increases the ease at which H7N9 may spread.<sup>72</sup> Birds that have come into contact with H7N9 have the capability of transporting the virus on their feathers, even if not necessarily infected with the virus.<sup>73</sup>

There have been reported cases from the Canton region of China to as far west as Xinjiang and as far north (along the east coast) as Beijing.<sup>74</sup> The rate of the spread of the viruses has been rather quick among human populations.<sup>75</sup> Since H7N9 has an extremely low, almost non-existent, rate of transmission from human to human,<sup>76</sup> it is entirely possible to argue that the spread of the virus is a result of *fangsheng* releases and the patterns of migration that the birds may display once out in the Chinese ecosystem.

Two hypotheses could be made regarding transmission after the closing of live poultry markets (LPM). During 2013 and 2014, local governments in the southern provinces mandated a closure of LPMs within urban areas. During this period of closure, the amount of cases of infection dropped drastically. Only about ten cases were confirmed during this year-long period. This drop suggests that a significant proportion of the infections of H7N9 were linked to LPMs and the poultry sold at them. These ten cases can possibly be attributed to two factors: the first being that the farmers raising the poultry ended up contracting the illnesses; the second possibility is that the ten individuals who had contracted the virus had been handling infected *fangsheng* birds. There has been no research yet to determine one way or the other, however it is highly unlikely that these infections could be the result of a combination of these two possibilities because the infection rate would be higher and thus be more representative of this theory.

One other threat to public health that needs to be taken into consideration is the threat posed by individual actors' practice of *fangsheng* rituals. One particular case that had many Chinese netizens up in arms involved

a young woman releasing animals in a park in Guangdong province. A series of pictures surfaced on Weibo, a Chinese social media site, in which a woman was emptying a sack of poisonous snakes. Many of the people online latched onto these pictures and began attacking her, outraged that she would put people in such danger. Eventually, the woman was forced to close her Weibo account and make an apology, saying that she was sorry for “annoying” people but that she had released these animals into the wild. She denied having done so in a park, however many officials were still left doubting and spent time investigating the suspected area in order to ensure the safety of the public.<sup>77</sup> Claiming that she may have annoyed the public is an understatement. Netizens took to their keyboards and began hurling rude curses and flooding her social media accounts with messages to let her know just how they felt. Some people called for her to “sell [her] body to support public welfare” or even cursed her to not be reincarnated for ten lifetimes.<sup>78</sup>

Public health is always a consideration when evaluating any public or private practice. The threats of salmonella and avian flu are real side effects of participating in *fangsheng* rituals even though there has not yet been any research to draw clear direct links between cases and the practice. Many of the animals that are released are known to carry salmonella, and it is also known that the possibility of H7N9 transmission from farm poultry to migrating birds and vice versa is extremely likely. When discussing the impact of *fangsheng* on public health, it is necessary to examine the actions of individuals who release animals independently of *fangsheng* groups, as some of these actors may be releasing harmful and volatile animals into public areas such as parks.

## ECONOMICS

There is more to *fangsheng* than simply causing strain on the environment or possibly putting the health of Chinese citizens at risk. Economically speaking, *fangsheng* can be used as a means of measuring the wellbeing of the citizens by examining the amount of money people spend on participation. However, further implications also need to be taken into consideration in terms of the monetary and opportunity costs caused by the animals that are released. Despite people spending money on *fangsheng* pointing towards the health of the economy, the costs of the practice are potentially too great for the government to simply ignore.

While the Chinese people vary in general willingness to take part in *fangsheng* practices, those who do participate are willing to spend a large sum of money to do so. The personal wealth of participants varies. Prices of the animals fluctuate throughout the year, changing with the demands of

the market and supplies. For instance, a release performed by Beijing Yunju Temple's Life Release and Protection Group paid 5.6 yuan (\$0.86) per pound of large carp. Just a week prior to this release, the same carp cost the group 5.3 yuan (\$0.82). In November of 2015, the price had been 5.9 yuan (\$0.91) per pound.<sup>79</sup> Even with these fluctuations, members of the group seem to spend money that reaches an even amount of yuan. The amount of money spent ranges from 10 yuan per release to 500 yuan, depending on the individual as well as the animals they would like to release. For the release that took place on Sunday, April 17, 2016, one individual spent 1,600 yuan (\$246.90). This seems to be the normal in urban centers as well.<sup>80</sup> According to an article published by *The Economist* in September 2015, some people who participate may spend about 5% of their yearly salary on participation in *fangsheng* rituals. Some students may even spend their entire food budget for three weeks on the practice.<sup>81</sup> The amount of money that practitioners are willing to spend clearly points to a certain affluence enjoyed by a portion of the population. Spending so much money on these practices indicates that people are able to spend larger amounts of their discretionary income (income that is able to be spent on things such as vacations or entertainment after taxes and living expenses have been accounted for) on such a seemingly obscure aspect of the culture. This use of discretionary income shines some light on the status of the Chinese economy.<sup>82</sup> As the amount of discretionary income increases within a household, it shows that people are enjoying a level of security within the job market as well as becoming more confident in the overall health of the economy.

Even though there is an indication of the rise of discretionary funds within Chinese households, the economy is still feeling the impact of invasive species of both flora and fauna. The Chinese government loses about 20 billion yuan (about \$3 billion) per year in direct relation to invasive species and 100 billion yuan (\$14.6 billion) indirectly. This is about 1.5% of the Chinese GDP. These losses can be attributed to plants blocking waterways, animals preying upon other native or even farmed species, birds taking advantage of local agriculture via consumption, and the costs for the equipment and manpower to manage these invasive species.<sup>83</sup>

Some species may have been introduced by the government intentionally for aquaculture or, in the case of the Beijing Olympics, the "greening up" of the scenery. Some animals that are released for *fangsheng*, such as red-eared sliders or bighead carp, are such species that were originally released outside of their native ranges for farming purposes. As previously mentioned, these animals have a tendency to crowd out native animal populations or offset the local ecologies and negatively impact certain areas. Many of the species that are feeling these effects are also widely farmed.

Drops in local populations of native species impact markets as supplies drop and thus cause a hike in prices. Some common *fangsheng* birds, such as the red-vented bulbul, are known to cause trouble for farmers as they prefer ground seeds and fruits and vegetables for their diet. Red-vented bulbuls cause concern in many countries in the Pacific because wherever they become established there is a drop in agricultural output of various fruits, melons in particular.<sup>84</sup> Water hyacinths are plants that block waterways and, as a result, place limitations on important functions such as irrigation and aquaculture.<sup>85</sup>

Even with these monetary costs, opportunity costs also need to be taken into consideration. Opportunity cost is defined as any possible benefit that has been forgone as the result of opting to take a different action.<sup>86</sup> In the case of invasive species, the opportunity cost that arises is the need to manage them. Government workers and resources are used to artificially clear water hyacinths and manage wild turtle populations.<sup>87</sup> In some cases more directly related to *fangsheng*, police forces and other public safety officials may occasionally be sent out to wrangle poisonous snakes released by rogue actors. Much of the time spent by public safety officials must be spent, in cases like this, on physically tracking down the animals. The opportunity cost that these instances may cause ranges from infrastructure improvements to taking care of other public safety matters, such as stopping criminals. The case of the woman releasing venomous snakes of her own volition, for instance, required local police and animal control officials to spend much of the day analyzing the photo of the woman in the act to pinpoint exactly where she released the animals. After figuring this out, they then had to go out and track down each snake and safely remove them from the park.<sup>88</sup>

The economic tolls that could be caused by *fangsheng* are a good lens through which to examine the tolls on Chinese society. Invasive species, plant and animal alike, occupy a significantly large portion of China's GDP in both direct and indirect losses. These monetary setbacks, combined with the potentially large opportunity costs, overshadow the signs of the economic wellbeing of the Chinese people as evidenced by the amount of money brought in by the Beijing Yunjusi Fangsheng Association which can total between 200 and 500,000 renminbi (RMB) each release (about 30 to 70,000 USD) on a weekly basis.<sup>89</sup>

## THE ETHICS OF RELEASING

In 2008, Qing Dao Daily, a newspaper in Guangzhou, published an article detailing how some 8,000 birds had been found dead in the Baiyun park area of the city, an area well known as a site in which *fangsheng* practi-

tioners often released birds.<sup>90</sup> Even though the core reasons for the practice of *fangsheng* in Buddhism involves showing compassion for the animals that they are releasing, there is a circle of catch and release that is often created that defeats the purpose of the releases and causes the animals to become increasingly ill and ultimately die.

As previously mentioned, *fangsheng* originated as a means of showing compassion for all living beings. Over time, its popularization led to a transformation of sorts that caused the practice to be centered on ten merits that are common knowledge to all practitioners of the ritual. This popularization has, in turn, increased the demand for animals to release. When organizations and associations prepare for a *fangsheng* ritual, they place an order for animals. Hunters are then paid by local stores to go out and retrieve these animals. When the associations perform their releases later, those same hunters tend to wait near the practice so that they may then catch the animals and put them back on the market for the next *fangsheng* association.<sup>91</sup> Not only does this introduce a certain irony to the situation, but it also brings a bit of hypocrisy as this seemingly never ending cycle wears away at the health of the animals and leads to the death of many, as in the case in Guangzhou.

Experts in Guangzhou estimate that the entire cycle, coupled with the animals being released into non-native environments, causes abnormally high mortality rates. Birds, for instance, are estimated to have a death rate of 90% or higher once caught up in the cycle of catch and release.<sup>92</sup> Another concerning factor reinforcing these high rates is that the people who release them often do not care for how healthy an animal is. Thus, markets and shop keepers tend to treat the animals poorly on purpose to make them easier to catch later.

The potential impact that these animals may have on the environment also seems to go back to the teachings of Buddhism. One of the lessons, beyond taking care of animals and treating them with compassion, stipulates that followers of Buddhism also treat the environment with care and compassion.<sup>93</sup> Unfortunately, the potential havoc that commonly released animals may wreak upon the local environment and ecology do just the opposite, as these animals may overeat and cause drops in local native animal populations.

When discussing animal release within China, the act sounds very nice superficially. However, possible effects on the environment and society aside, the darker side of *fangsheng* that involves the endless loop of catch and release ruins the idea behind the practice. If the animals are suffering because of *fangsheng*, then the goal of showing compassion through release is rendered null and void. No amount of compassion would be able to justify the loss of life in order to release life.

## SOLUTIONS

As of now, there are no restrictions on the practice of *fangsheng* within China. The associations and temples are left unhindered to release as many animals as they please and as often as they please. There are trade restrictions on animals that may be released, but the black market provides what cannot be legally obtained. It is this lack of concern for the actions of associations, the general aloofness on the subject from the government, and the lack of education of the people that are causing problems.

One case, on the other side of the world, may offer some insight as to any possible solutions that may be reached beyond educating practitioners. Benkong Shi, an American Buddhist monk in New York City, has taken some measures to try and prevent detrimental environmental impacts at the hands of practitioners of *fangsheng*. Realizing that people from his temple were releasing red-eared sliders and goldfish into and around the pond in Central Park (despite doing so being illegal), he decided to offer a more environmentally friendly option for releases. He came to the realization that there are plenty of wildlife rehabilitators that release animals quite often without disturbing local ecology and decided to collaborate with a local turtle rehabilitation center to begin, what he calls, “compassionate release.” Since 2008, he has organized more than a dozen turtle-related compassionate releases and plans to work with bird rehabilitators as well.<sup>94</sup>

There are wildlife rehabilitators in China, as well as many wildlife conservatories. There are groups, such as Wildlife Ark, that have heard about Benkong Shi’s idea regarding compassionate release and find it an appealing solution.<sup>95</sup> Since there are rehabilitation centers that are willing to get involved, what this solution relies on is the willingness of associations within China. Based on the wide spectrum onto which these associations fall in terms of openness and transparency, some associations may be more open to the idea than others. Some of the more commercialized associations may possibly be interested if they can be assured of any possible profitability, others may be more inclined regardless of profit, such as those associated with temples, and others still may not be willing to at all. It is rather hard to gauge the opinions and willingness of associations to work with rehabilitators, as none that I contacted have responded.

Education is another major aspect that may alter the practice of *fangsheng*, especially in terms of what animal species are released. Some associations, such as the Guangdong Fangsheng Association, have been posting information to their blogs about some of the more popular animals, especially the red-eared slider, and their effects on the environment.<sup>96</sup> Many of these blog posts will also support the release of local native species and provide pictures to make identification easier. Benkong Shi has also led



education campaigns in both China and Taiwan about the possible detrimental effects of releases.<sup>97</sup>

## CONCLUSION

*Fangsheng* is an important religious ritual with deep roots in Chinese history. The first written mention, appearing in *The Liezi*, a Daoist text, illustrates the fact that the ritual is not simply a foreign religious concept and shows that people had concern for the lives of other creatures. Promotion by emperors in the forms of both public advertisement and the construction of *fangsheng chi* led to the popularization of the practice, which was possibly further ushered along by the Tang suppression of Buddhism. This suppression may have led to the fusion of Chinese Mahayana Buddhism and Daoism because of similar, spiritual undertones that were more easily relatable to the daily lives of the common people. The popularity of *fangsheng* survived throughout the Ming and Qing dynasties, as well as the Republican Era only to be met with resistance during the Cultural Revolution under Mao Zedong.

After the end of the Cultural Revolution, the liberalization of religion and other aspects of society led to a resurgence of the practice that can be seen today in the form of *fangsheng* associations. These associations have led to some concerns among the populace as questions of the legitimacy of these practices are raised often enough that some associations place restrictions on the questions that may be asked by curious outsiders. Other associations have been more open and transparent, offering as much information as possible, including bank account numbers. Some have maintained as much transparency as any other business, trying to ease concerns of illegitimacy while also attempting to turn a profit. These associations cater to the surge of popularization of *fangsheng* by setting up release practices as often as possible, even going so far as to perform *fangsheng* every day.

These practices, once concerned with showing compassion for the lives of other creatures, have become a means of obtaining karmic merits that range from ensuring endless prosperity for your descendants to gaining entrance into the Western Paradise. The merits hoped for are also represented by the popular releases of birds, turtles, and fish, which represent freedom, longevity, and prosperity, respectively. Unfortunately, the popular animal species that are released within these groups are invasive. The species of parakeets, red-eared sliders, bighead carp, and American bullfrogs are known to out compete native animals in terms of food, shelter, and basking places. Some of these even prey upon native species in the areas they are released in. These competitive and predatory behaviors have



the potential to cause detrimental effects to local ecologies and the environment by offsetting food balances and causing drops in local native animal populations through disease transmission, out competition, gene pool dilution, and predation.

Public health is also a concern when discussing *fangsheng* practices because of possible transmission of disease from animal to human. The major concerns are avian flu and salmonella as they have the potential to effect large amounts of people and become alarmingly severe. The lack of concern for the safe handling of the animals that are released is demonstrated by practitioners not wearing gloves and kissing the animals. The poor conditions in which the animals are kept cause the probability of disease transmission to increase.

It is also likely that the Chinese economy will feel detrimental effects of *fangsheng* because of invasive species, both plant and animal, occupying a relatively large portion of the country's GDP. The manpower required to tend to these species can have a heavy influence on the opportunity cost for the country as local and government agencies must spend time and energy controlling plant growth and cleaning up the messes created by independent actors. In spite of the potential impacts on the economy, a certain level of affluence can be seen among the Chinese population as a result as more people spend more money on these releases, using large portions of their salaries on the practice.

The Chinese environment and society are not the only things potentially damaged by the effects of *fangsheng*. The animals themselves are feeling the strain of popularization. The cycle of catch and release that has given birth to a new market to supply animals has been causing animals to be caught, released, then immediately caught again just to be released over and over again, resulting in them becoming increasingly ill and leading to abnormally high mortality rates. Many of the people performing releases do not show concern for the wellbeing of the animals, just so long as they are alive. This brings a certain hypocrisy into the practice as the original goal had simply been to demonstrate compassion. The strain that *fangsheng* places on the environment also contradicts some of the teachings of Buddhism, as it shows a lack of compassion for the environment as well.

In the face of all these detrimental effects, it would not do to simply ban the practice. The roots of the practice are too old and engrained into Chinese society. Mandating a prohibition of *fangsheng* would upset a large portion of the Chinese people. It is within the best interest of the citizens, the environment, and the Chinese government to place restrictions on the types of animals to be released and how often the practice may be performed by each association. It would also be a good idea for at least some, if not all, of these associations to partner with local animal rehabilitation cen-

ters in order to release native species into the areas to which they belong, following Benkong Shi's example of "compassionate release."

There are a few associations within the country, such as the Qinghai Lake Fangsheng Association, which focus on releasing very specific native species. The Qinghai Lake association, for instance, only releases the species of naked carp into the Qinghai Lake. This lake is one of many lakes which are the native ecosystems of the naked carp. The goal of these releases is to attempt to reverse the effects of overfishing and increase the local populations.<sup>98</sup>

As is evidenced by the Qinghai association and the temple in New York City, it is entirely possible for *fangsheng* groups to find sustainable means to release animals. An important step, which some groups are undertaking, is to educate the people of the effects on the environment, public health, economy, and the animals themselves. Without education, any solutions that could be proposed would likely be ignored and business would be conducted as usual. The goal in putting forth a solution is not to end the system, but to reform it and to make *fangsheng* friendlier to the environment and society. Hopefully, even after the education of society, the people will do more than say "you are right," as the governor in the story from *The Liezi* did.

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# EDITORS' & DESIGNERS' BIOGRAPHIES

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Maryam Banyahmad is graduating in May 2017 with a Bachelor of Fine Arts in Graphic Design and print media as her minor. Having been honored by the opportunity to design the *UMBC Review* has been an immensely rewarding experience for her. Maryam would like to thank her mentor Professor Guenet Abraham for her dedication, persistence, and guidance. She would also like to extend her thanks to the editors, Mr. Dylan Rogers Elliott and Ms. Emily Huang, who worked hard to create the latest volume of *UMBC Review: Undergraduate Research Journal*. Maryam is thankful to fellow designer Mr. Amir Khatirnia, whose creativity led to the creation of an effective design for the 18<sup>th</sup> edition of the *UMBC Review*.

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