

# ReCUR

Red Cedar Undergraduate Research

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Michigan State University



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Volume 1 Issue 1

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*Cloudy With a Chance of Rain*

**By Alyssa Meyer**  
James Madison College

### Artist Statement

“This piece like much of my artwork was born of an attempt to relieve the stress that comes with completing a James Madison degree. It is a mixture of India ink and acrylic white paint on canvas, which symbolizes my stress in the form of rain clouds.”

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# About ReCUR

ReCUR is a bi-annual publication of the Michigan State University Honors College that highlights the diversity and quality of our students' research and creative endeavors. In addition to providing Honors College students an outlet for publication of their work, ReCUR offers students an opportunity to learn about publication in a scholarly journal from multiple viewpoints: as a submitter, a member of the student editorial board or editorial staff. ReCUR also provides faculty, students and alumni a forum for reflection and assessment of emerging areas of scholarly activity.

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# Letter from the President

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I am delighted to write this introductory letter for the inaugural issue of the Red Cedar Undergraduate Research Journal (ReCUR), a bi-annual publication of the Michigan State University Honors College. Our university prides itself on offering numerous opportunities for undergraduates to engage in scholarly endeavors early and often. The faculty commitment to undergraduate mentorship is admirable, and we are continually encouraged by the growth of student participation in campus, regional, national and international conferences that highlight their scholarly pursuits. This journal represents yet another recognition of our dedication to high quality educational experiences.

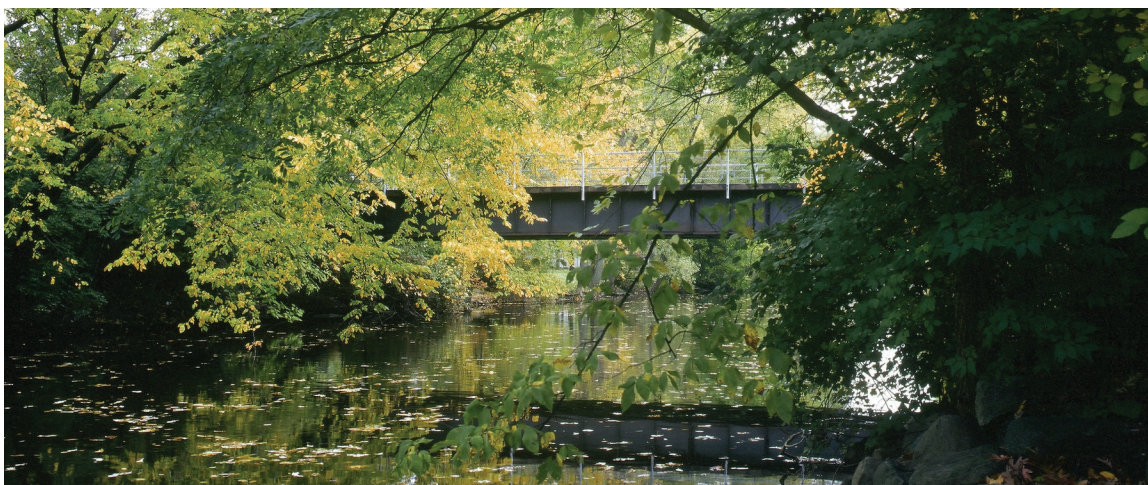
Michigan State University has a commitment to ensuring that students can reach their full potential and take bold steps to push forward into the frontiers of tomorrow. As a premier institution with an expansive world reach, we encourage our students to excel in the classroom, on the practice field, on performance stages, in laboratories, libraries and museums, as well as in the community. Quite simply, our goal is to ensure that graduates of our institution are equipped to be leaders in whatever field they choose. We believe that fostering creative and research pursuits enhances the overall student experience and makes a positive impact on the lives of others. Like our faculty and graduate students, undergraduates at Michigan State University are forging new paths and are determined to leave a positive and productive footprint across the globe.

It gives me great pleasure to be a part of the unveiling of ReCUR. As you read the submissions in this first issue, I'm sure, like me, you will be excited to see what comes next for the multi-talented undergraduates at Michigan State University.

Sincerely,

A handwritten signature in black ink, which reads "Lou Anna K. Simon". The signature is fluid and cursive, with a large initial "L" and "S".

Lou Anna K. Simon, Ph.D.  
President



**Red Cedar River in Early Autumn**



# Letter from the Honors College Dean

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Welcome to the inaugural issue of the Red Cedar Undergraduate Research Journal, ReCUR, a bi-annual publication of the Michigan State University Honors College. You will be inspired and excited as you read and examine the extraordinary work of the talented students featured in this issue. The intricate weaving of art and science throughout the pages highlights the multi- and inter-disciplinary strength of undergraduates at Michigan State University.

The goal of ReCUR is to demonstrate the scholarly successes of students in all majors, professions and disciplines at the university. We wanted to encourage undergraduates, faculty and others to continue to make advances in knowledge and to use this forum to communicate their passions and hard work. The Honors College at Michigan State University embraces the realities affirmed by the work of the Boyer Commission. Namely, that undergraduate research and creative works combined with active engaged learning is a high-impact practice that prepares students for successful futures as industry captains, community and government leaders, humanitarians and educators, parents, concerned citizens and a myriad of other convocations. Our commitment to undergraduate research remains strong and ReCUR is one more opportunity for undergraduates to shine and soar.

Words are not sufficient to express my extreme pleasure and personal honor to present this journal to you. Upon assuming the deanship of the Honors College in August 2007, it became immediately clear that there was a need and opportunity for a journal to highlight all of the exciting and cutting-edge research and creative works that our students are engaged in. An admirable vision for sure; yet the time had not yet come to bring the dream to fruition. Though the dream was deferred, I cannot be more pleased with what lies before you between the covers of this issue and more to come.

Without the right people, a vision will surely perish. But look what happens when you wait. There are many people who deserve credit for this fine journal that is before you. Clearly, much acknowledgement is due to the students responsible for the submissions that appear in this issue and those who submitted their work for review. A debt of gratitude is owed to the student editorial board, as well as the faculty and academic staff that recommended them for the position. It is awe inspiring to think about how the student editorial board worked with the associate editorial board to ensure that the journal would go to press with high quality submissions. Perusing the listing of the associate editorial board you will see that a high level of commitment was made to ReCUR by senior scholars who are all respected in their fields in their own right. From University Distinguished Professors to Associate Deans and Deans, all made time to mentor the student editorial board through the publication cycle.

We are especially proud of the managing and design editors, both undergraduates who demonstrate extreme talent, composure, commitment, dedication and quality of character. Finally, the tireless and selfless oversight and intellectual direction offered by the faculty advisors, Honors College staff advisor and chair of the associate editorial board are beyond measure. It is no small statement to say that all that is great about the journal is due to their insights and efforts. It's often said that a leader's job is to assemble a great team and then let them loose on the assignment. That is clearly the case for ReCUR. The editorial staff and student authors, composers, painters...are the heroes here. They gave all that they had and the result is a shining example of all that is great about Michigan State University.

Sincerely,

A handwritten signature in black ink that reads "Cynthia Jackson-Elmoore".

Cynthia Jackson-Elmoore, PhD  
Dean, Honors College

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# 2009 and 2010 National and International Fellowship and Scholarship Recipients

Each year, current MSU undergraduates and alumni are awarded highly competitive national and international fellowships and scholarships (NIFS). In this issue of ReCUR, we have profiled recipients of these prestigious awards.

## Jessica Muir *by Katelin McArdle*



Jessica Muir, an Honors College member and Physics and Astrophysics senior, is a 2010 Marshall Scholarship and 2009 Goldwater Scholarship recipient. Muir, who is from Romeo, MI, has been involved in an impressive array of undergraduate research projects from studying condensed matter

physics with Dr. Stuart Tessmer, to experimental high-energy physics research with Dr. Joey Huston, to completing her senior thesis in Astrophysics with Dr. Mark Voit.

Muir has also applied her knowledge and passion for science in other contexts. She has dedicated time to the Society of Physics Students, the MSU Coffee Club (the French Coffee Hour) and especially Science Theatre ([www.sciencetheater.org](http://www.sciencetheater.org)), a student-run organization that teaches students at area schools basic scientific concepts via attention-grabbing demonstrations. Jessica has been the Assistant Physics Director for Science Theatre since 2008.

As part of her Marshall funding, Muir plans to study theoretical physics at Cambridge University, United Kingdom. Doing so will allow her to build up to her goal of becoming an effective researcher and instructor. As for aspiring students in this field, Jessica offers helpful guidance: "Talk to people...ask questions about what they're working on. Try to get involved in research as early as possible. I've learned just as much, if not more, from my research work as from my classes."

## Kendell Pawelec *by Katelin McArdle*

Kendell Pawelec, a fifth-year Honors College student, has been recognized for her hard work and dedication by being awarded the Gates Cambridge Scholarship which



will allow her to obtain a DPhil in Materials Science at Cambridge University, UK.

Kendell, from the town of Howell, MI, is currently studying Materials Science and Engineering with a Biomedical Materials Cognate. She has also worked with numerous faculty in a variety of research projects, including a lab rotation with Dr. Donna Koslowsky studying mitochondrial DNA in *Trypanosome brucei*, research with Dr. Christina Chan investigating cellular responses to polyelectrolyte thin films, research with Dr. Robert Root-Bernstein on the Geography of Innovation and work in computational linguistics with Dr. John Hale.

Kendell also has a strong interest in the fine arts. She is a violinist in the Livingston Symphony Orchestra, and works on plein art painting (outdoor artwork in all weather).

After earning her DPhil at Cambridge, Kendell plans to work in the biomedical industry, where she "feels I can have the greatest impact on current medical technology." She also has learned valuable lessons when it comes to applying for scientific fellowships, and she offers this advice to other students: "Take a look at all of the great opportunities available for research and internships - not only within the US but all over the world."

## Nada Zohdy *by Sarah Blakeley*



The Truman Scholarship Foundation expects the most out of its winners, and Nada Zohdy, a 2009 awardee, has exhibited all the qualities expected. Zohdy feels particularly honored since this scholarship acknowledges students who are not only passionate about what they do, but

active as well. As a senior and member of the Honors College, she feels that her out-of-classroom experiences distinguished her as a leader more completely than her major of International Relations with Arabic and Economics minors.

Zohdy, who is from Rochester Hills, MI, has always been an active member of the MSU community. As a freshman, she and a friend created a coalition called Peace over Prejudice, a group committed to promoting inclusion between diverse persons. She currently holds the office of vice president in the Muslim Students Association, which has recently opened a Reflection Room for people of all faiths in Anthony Hall, and is co-chair of the Campus Interfaith Council, a part of ASMSU and a platform for positive relationships between faiths.

Zohdy sees the benefits of this scholarship in several different ways: it provides extensive networking, graduate schools are seeking her out and she has already participated in a weeklong leadership institute. She plans to become fluent in Arabic through a year abroad in Egypt. Her advice is simple to students wishing to excel: heed out of classroom experiences.

## Victoria McCoy *by Lori Bates*



Victoria McCoy is a Senior, Honors College member and 2009 recipient of the Goldwater Scholarship. She grew up in Wexford, PA, a town just north of Pittsburgh. The Mathematics and Geology major has participated in a number of activities, including serving as co-founder and president of the

Math Club and participating in the Herzog competition and Putnam exams.

Victoria's research has included studying scorpion taphonomy as a Professorial Assistant with Dr. Danita Brandt, examining bryozoan paleobiogeography with Dr. Robert Anstey, and participating in a trace fossils project in a Geological Sciences graduate seminar.

Her work has resulted in one published paper, one paper in press, and one paper in preparation. "[These projects] taught me about scientific research, formulating hypotheses, setting up experiments and analyzing results," said Victoria. "This is difficult to teach in a class, and is very useful for a career in the sciences."

Victoria plans to continue pursuing research as a university professor, studying either paleobiology or mathematics.

## Nathan Sanders *by Mark Kauth*

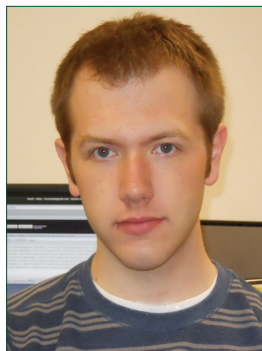


Nathan Sanders, an Honors College senior majoring in Physics and Astrophysics, is a 2009 Goldwater Scholar. Sanders, who is from Sault Ste. Marie, MI, has worked on a number of projects with faculty from MSU's Physics Department, namely Dr. Horace Smith, Dr. Ed Loh and Dr. Stephen Zepf.

Under the guidance of these faculty, Sanders studied the variable star AN Lyn, as well as aided in the construction of the Spartan Infrared Camera for the Southern Astrophysical Research consortium, which he used to study globular cluster populations of early-type galaxies. "This experience was really the foundation I needed," says Sanders. "I am applying to graduate schools at the moment to pursue a PhD in astrophysics." Outside of research, Sanders also participates in Science Theatre.

"The Goldwater Scholarship is really just a recognition of the phenomenal opportunities for research that MSU has provided to me," said Sanders on his reception of the Goldwater Scholarship. His advice for current students? "MSU's Undergraduate Research and Arts Forum (UURAF)," says Sanders. "It is a fantastic way to get a head start on a career in science."

## Andrew Baczewski *by Sarah Blakeley*



Andrew Baczewski is an Honors College alumnus and 2009 recipient of a Graduate Research Fellowship from the National Science Foundation. Baczewski, from Grand Rapids, MI, earned his BS in Mechanical Engineering in 2007 and has continued his education at MSU by pursuing an interdis-

ciplinary PhD in Electrical Engineering and Physics. Most of Baczewski's time is devoted to his research on mesoscopic electromagnets, or in his own words, he stud-



ies “how light behaves in very small things.” In addition, he is currently president of the Physic Graduate Organization and active in The Institute of Electrical and Electronics Engineers (IEEE), but still finds time to keep up with his outdoor activities such as biking and climbing.

Andrew credits his achievements to his undergraduate experiences at MSU. As a sophomore, he became involved in a study abroad where he began to think about research in engineering and physics. His research opened doors for him to expand his academic and cultural horizons. His ambition is to work as a professor, but his more immediate plans include a conference in Toronto where he will give three presentations on his research.

## Matthew Heintz *by Mark Kauth*



Matthew Heintz, a current PhD student in Evolutionary Biology at the University of Chicago, was awarded a 2009 National Science Foundation Graduate Research Fellowship. Heintz, an Honors College alumnus from Warren, MI, earned his BS in Zoology in 2004.

While an undergraduate at MSU, he was heavily involved in research, working with Dr. Kay Holekamp to study hyena behavior, as well as the dispersal behavior of Belding’s ground squirrels. “All of this research has helped give me the necessary experience and guidance that has enabled me to be successful,” says Heintz. Matthew is also a past Resident Mentor in Hubbard and Holmes Halls. In addition, he participated in the Zoological Student Association. “The ZSA was great for providing professional direction and networking to myself and other students sharing the same major,” says Heintz.

Heintz’s current career goals are to teach at the university level and to be strongly connected with the general public to inspire and educate students of all ages.

## Jessica Oswald *by Brian Lovett*

Jessica Oswald graduated from MSU in 2007 with a BS in Zoology. A current graduate student in Biology at the University of Florida, Jessica is a 2009 recipient of an NSF Graduate Research Fellowship.

Growing up in Marshall, MI, Jessica’s parents owned



a plant nursery; this early exposure to nature led to a passion for science.

During her time at MSU, Oswald spent extensive time volunteering at Pittsfield Banding Station in Vicksburg, MI, interning at Binder Park Zoo Animal Care and working in Dr. Shin-Han Shiu’s Plant Bio-

logy Lab.

As a Biology graduate student at the University of Florida, Oswald is pursuing the preservation of Peruvian tropical dry forest community avians. Jessica describes her drive to pursue academia, “While I realize that I can’t save the world, I want to at least try to make a difference.”

## Donald Vanderlan *by Lori Bates*



Donald Vanderlan, a current MSU graduate student and Honors College alumnus, is a 2009 recipient of an NSF Graduate Research Fellowship. Don, who is from Grand Rapids, MI, graduated with a BS in Electrical Engineering in 2009.

As a graduate student in Electrical Engineering, Don still works where he participated in his first research - the Biomedical Ultrasonics and Electromagnetics Lab. The summer after his freshman year at MSU, he was able to take part in an undergraduate research program at the lab, under the supervision of Dr. Robert McGough.

As an undergrad, VanderLaan also had the opportunity to teach labs. “Teaching was a really neat experience,” he says. “It’s hard to explain, but when you’re helping someone and suddenly a troublesome concept just ‘clicks’ for them, it’s really cool.”

In fact, Don enjoyed teaching labs so much that he hopes to continue to work with students and teach labs as a professional. ☺

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*Students interested in applying for these and other awards should contact Dr. Laura Symonds, NIFS Coordinator.*  
[www.honorscollege.msu.edu/nifs](http://www.honorscollege.msu.edu/nifs)

*Jessica Muir, Nada Zohdy and Nathan Sanders Photos © 2009 MSU Board of Trustees.*

# Highlights of the Honors College Literature

*Honors College Students have their work published in a wide range of scholarly journals. Below are summaries compiled by Managing Editor Katelin McArdle of previously published works.*

## Current Events and Controversies

Katie Gjerpen worked with Dr. Elizabeth Heilman and wrote an introduction for a book section about techniques for teaching current events and controversies in the social science classroom. Their introduction provides context for the approaches described by summarizing previous research in the field.

Gjerpen, K. and Heilman, E.E., Introduction to Current Events and Controversies, in *Social Studies and Diversity Education: What We Do and Why We Do It*, Heilman E.E., Fruja, R. and Missias, M., Ruteledge, New York, NY, 2010, pp. 223-225.

## Dielectric Material Discontinuity

Andrew Temme worked with Dr. Edward Rothwell to examine the “time-domain reflection coefficient for a pulsed TE<sub>10</sub>-mode wave incident on a dielectric material discontinuity in a rectangular waveguide.” The formula they calculated based upon their observations has applications in characterization of dielectric materials.

Rothwell, E.J., Temme, A.K. and Crowgey, B.R., Pulse Reflection from a Dielectric Discontinuity in a Rectangular Waveguide, *Progress In Electromagnetics Research* 97, 11-25, 2009.

## Downhill Folding of $\lambda$ -repressor

Steven DeCamp, working with Dr. Lisa Lapidus, investigated folding of  $\lambda$ -repressor at temperatures below the thermal midpoint in an ultrarapid microfluidic mixer after dilution of a denaturant. Based upon their results, they proposed that the accessibility of different unfolded states at high denaturant concentrations are different than those present at high temperature, the previous method used to study  $\lambda$ -repressor folding.

DeCamp, S.J., Naganathan, A., Waldauer, S., Bakajin, O. and Lapidus, L., Direct Observation of Downhill Folding of Lambda-Repressor in a Microfluidic Mixer, *Biophysical Journal* 6,1772-1777, 2009.

## Gender Relations and Migration

Anna Reosti, an Honors College alumna and current graduate student in Sociology at the University of Washington, worked with Dr. Linda Gjakaj on a paper that synthesizes the ways in which literature on gender and migration relates to the dynamics that precipitate migration.

Nawyn, S.J., Reosti, A. and Gjakaj, L., Gender in Motion: How Gender Precipitates International Migration, in *Advances in Gender Research*, Segal, M.T. and Demos V., Emerald Press, Bingley, UK, 2009, pp 175-202.

## Memorable Messages and Behavior

Carolyn LaPlante, working with Dr. Sandi Smith, conducted a survey regarding the impact of various types and sources of breast cancer information. From their work, they concluded that message topic and source are both significant factors in the recall and impact of the information the message intends to illustrate.

Smith, S.W., Munday, S., LaPlante, C., Kotowski, M., Atkin, C., Skubisz, C. and Stohl, C., Topics and Sources of Memorable Breast Cancer Messages: Their Impact on Prevention and Detection Behaviors, *Journal of Health Communication* 14, 293-307, 2009.

## Method of Organic Chemistry Synthesis

Clarissa Turton worked with Dr. Robert Maleczka to study a new method for synthesizing DuP-697 and its analogs, heterocyclic compounds with potential applications in drug development. Their work coupled two forms of synthetic methods to generate these compounds, which were previously very difficult to synthesize through traditional methods.

Kallepalli, V.A., Sanchez, L., Li, H., Gesmundo, N.J., Turton, C.L., Maleczka, R.E. Jr and Smith, M.R. 3rd, Divergent Synthesis of 2,3,5-Substituted Thiophenes by C-H Activation/Borylation/Suzuki Coupling, *HETEROCYCLES* 80, 1429-1448, 2009.

*(Continued on page 8)*



# The ABCs of Disordered Eating

Hollyce Balentine | Departments of Professional Writing and Spanish

## Alone

Living in a college dorm with two homesick friends, I feel bad telling them “no” when they ask if I want to grab dinner with them. So, I try to sneak in my meals. I choose to go to the cafeteria alone; I don’t like when people watch me eat.

## Book

When I was ten years old, my parents handed me one volume from a collection of six entitled, “Encyclopedia of Life and Health,” or something along those lines. The chapter was probably entitled “Puberty and its Effects” or something similar. I was shocked and disgusted to tears as I read about the menstrual cycle for the first time. My body was going to do what? Tampons go where? Too embarrassed to exit my bedroom immediately, I flipped to the next chapter of the book just for an excuse not to leave.

The next chapter was about nutrition. It talked about what nutrients are in different foods and what it means to have a balanced diet. It explained what calories are and how the body burns them. To gain weight, you eat more calories than your body burns in a day; to lose weight, you eat fewer calories than your body burns in a day. At the end of the chapter were lists of almost every food imaginable and how many calories are in a serving.

## Calories

I memorized the lists.

## Dad

My mom was always jealous of my dad’s metabolism. “I can’t believe it. You just quit eating a snack at night and you lose five pounds! And you’re already as skinny as a rail.”

During a family reunion at the beach, I heard her

talking to my aunt as I was walking down to the water. I was wearing a two-piece swimsuit.

“She’s got her dad’s build: knobby knees and skinny legs. Urg. Wish I had gotten good genes.”

## Evidence

The summer after my freshman year of college I went back to my parents’ house. They had moved to Northern Michigan after I graduated from high school, and I didn’t know anyone my age at all. They almost didn’t let me visit East Lansing even for those short 50 hours at the end of June. The loneliness was too much.

If I woke up in the morning and my parents were gone, I ate ice cream for breakfast straight out of the carton with a knife so there would be no evidence of scoop marks.

## Four O’Clock

One night when I was eleven years old, I woke up at 4:00 AM, pains shooting through my empty stomach as it growled and churned. I had only had 400 calories for dinner that night. The hunger pains had never woken me up before, and I panicked because that’s what happens to people with eating disorders. I’m dying. Heart racing, I snuck out to the kitchen and ate some Wheat Thins with shaking hands.

## Goal Weight:

90 pounds

## Hungry

After Sunday service at church, the elderly ladies set out cookies and coffee in the fellowship hall for people to eat. After taking several, my mom asked repeatedly, “Holly, don’t you want a cookie?” I looked away and said I wasn’t hungry. That was what I told

myself. “You don’t eat cookies because you’re hungry,” she taunted. I stood firm.

### III

I argued with myself that what I was doing was perfectly healthy. I secretly did my research: websites, textbooks, eating disorder literature, whatever I could get my hands on. Scouring the lists of symptoms, I picked out the ones I did not have. Therefore, I told myself, I am not ill.

## Jam

Jam, depending on the brand and flavor, has approximately 40 calories per tablespoon. Peanut butter has 100.

## Klondike Bars

In middle school, the television commercials would chant their corny jingle at the audience: “What would you do-o-oo for a Klondike Bar?” The thought made me cringe. They’ve got over 400 calories in them. I’d do almost anything to not eat one.

## Lemon

When Ghandi fasted, he ate or drank nothing except water with lemon.

## Mom

She judges. “How can they eat that much? Doughnuts and Coke? That is disgusting. No wonder they’re fat! Show a little restraint. At least I try to be healthy, I just have a slow metabolism.”

She despairs. “My stupid medicine, making me gain weight. I’m trying to lose it, but it’s so hard, it’s not fair. I’d be hungry all the time. How can stars be so skinny? I guess I’m just destined to be fat.”

She compares herself to me. “Oh, look, you’ve got your mom’s bumper butt! Not as skinny as you used to be, huh?”

## Numb

The first thing I did every day when coming home from high school was to head to the kitchen and grab a snack or two or four. Grease, sugar, starch, whatever. It was mechanical, mindless, reckless: reach, bite,

chew, swallow. It kept going, out of my control; I was numb. I ate until my stomach hurt.

As soon as I was done, a wave of panicked guilt swept over me and my heart beat faster, but I was too scared to throw it all up. I promised myself that I would fast tomorrow.

## Obsessed

Before coming to college, I spent several hours mapping out my classes and the buildings that had cafeterias. I made a schedule for every single day, listing what time I would eat each meal, where I would eat each meal, how much time I would have to eat, and how many calories I was allowed to have each time.

## Pretty

Between the ages of 12 and 17, the first thing I did when I met a new girl was to scope out her thighs and see if they were bigger or smaller than mine.

## Quiz

Junior year of high school my neighbor friend insisted that we take one of those goofy online quizzes from Seventeen Magazine that was supposed to determine if you had healthy eating habits or not. For her, it was all in good fun. She had no clue that I was freaking out. I lied about my answers because I did not want her to know.

It said that I should loosen up and quit worrying so much about food.

## Ribs

When I was eleven, one year into it, they juttled out and almost hurt to touch.

## Shame

“She eats,” my mom said. “She’s just really thin.”

“It’s probably just one of those phases,” my dad told my grandmother. “I mean, she must just have a fast metabolism. She eats three meals a day.”

I lurked just around the corner, blushing, hearing every word. They had no idea that I counted calories and was starving myself.

## Thinspiration

On Pro-Ana (Pro-Anorexia) and Pro-Mia (Pro-Bulimia) websites, other starving girls will post “thinspiration,” pictures of twig-like models and actresses that have probably been airbrushed to perfection. They are supposed to motivate us to lose weight by insisting that we are not good enough the way we are.

## Uvula

If you touch your uvula, you will throw up.

## Vacuum

It felt empowering when I was empty, even though the hunger made me weak during the day and kept me awake at night. If my stomach growled, that meant I had won. Beauty was pain. Victory was mine.

## Water

Tips and Tricks #12: Drink a ton of water. It has no calories, but it fills up your stomach so you’ll eat less.

## Xanthic

(adj): of or pertaining to a yellow or yellowish color.

One of the signs of long-term anorexia is the yellowing of the skin.

## Yogurt

The Yoplait 6-ounce regular yogurts contain 170 calories apiece. The custard style ones, my favorite, contain 190.

## Zero

I was speechless and numb when I finally grew out of my size zero jeans. I kept them, firmly deciding that I would lose the weight and fit back into them again. I never did. Eventually, I cut them to pieces.

Even a one would be too small.🔪

### Editor’s Note

*If you believe you or someone you know is suffering from an eating disorder, please talk with a professional at the MSU Counseling Center ((517) 372-6666) or a family physician.*

## Highlights of the Honors College Literature

*(Continued from page 5)*

### Small Art Markets and Community

Caitlin Annatoyn worked with Dr. Toby Ten Eyck to investigate a small, midwestern art market, and how actors there viewed the role of art in the larger community. Their work addressed a less commonly investigated subject, as most work focuses on large art markets such as New York and Paris.

Ten Eyck, T.A., Kaltz, J., Annatoyn, C., Brininstool, A. and Yousif, S., If you Build It, Will They Come? An Inside Look at a Small Art Market, *The Open Sociology Journal* 3, 1-8, 2010.

### Taphonomic Patterns in Modern Molts

Victoria McCoy worked with Dr. Danita Brandt to study recurrent taphonomic patterns in modern scorpion carcasses and molts, which they extended to the fossil record. Their work defined criteria for distinguishing molts from carcasses, using the characteristics of chelicerae position, walking legs position and body line.🔪

McCoy, V.E. and Brandt, D.S., Scorpion Taphonomy: Criteria for Distinguishing Fossil Scorpion Molts and Carcasses, *Journal of Arachnology* 37, 312-320, 2009.



# The Effects of Acid Sphingomyelinase Deficiency on Bone

Sarah McKee, Lindsay Martin, Gloria Perez and Laura R. McCabe | Department of Physiology

## Abstract

Bone formation is a dynamic process, regulated by many factors, including phospholipids called sphingomyelins. Sphingomyelin availability is regulated by sphingomyelinases, enzymes that break sphingomyelin down into ceramide; ceramide regulates bone development and remodeling. Sphingomyelinase 3 has been shown to affect bone development. Therefore, we hypothesized that acid sphingomyelinase 1 (ASMase) would also affect bone development and remodeling. We obtained male and female mice with a deletion (knockout, KO) of the gene for ASMase, and examined the effects on bone parameters compared to wild-type (WT) littermates. ASMase KO mice had an increase in the inner perimeter of cortical bone and in the bone marrow area compared to WT mice. We also found a significant increase in bone peroxisome proliferator-activated receptor gamma (PPAR $\gamma$ ) levels, a marker of adipocytes. Taken together, we conclude that the decreased levels of sphingomyelin observed when ASMase is absent indicate the important role of this enzyme in bone formation and development.

## Introduction

Bone is a dynamic tissue. It is constantly remodeling by reabsorbing old bone and reforming new bone. These processes can be affected by damage to the bone, limb disuse or use, disease and by hormonal changes (1). Effects can lead to positive or adverse changes in bone density. For example, increased loading of a limb stimulates bone formation and bone density. In contrast, inflammatory diseases, such as type I diabetes and inflammatory bowel disease, can cause deterioration in bone density and strength. Recently, our lab determined that these diseases increase the levels of inflammatory factors (such as tumor necrosis factor (TNF)) inside bone and suppress bone formation (2).

Bone has a complex structure. It is comprised of two types of bone: trabecular (spongy) and cortical (compact). Cortical bone is the hard material that makes up the outside layer of bones, while trabecular is the inner, more web-shaped bone. Bone remodeling is regulated by the interactions of two types of cells, osteoclasts and osteoblasts. These cells differentiate from hematopoietic and mesenchymal stem cells, respectively. Osteoclasts attach to the mineralized bone surface and resorb old bone, while osteoblasts form new bone in the cavities created by the resorption of old bone. Osteoblasts and osteoclasts communicate with each other through several signaling pathways including TNF receptors (1). TNF works to suppress osteoblast maturation and viability while stimulating bone resorption. Correspondingly, in our disease models, we see an increase in osteoblast death that parallels an increase in TNF levels.

Sphingomyelin is a major lipid component of all cell membranes. Sphingomyelinases are a family of enzymes, of which there are at least 3 in mammals, that can catalyze the breakdown of sphingomyelin by cleavage of the phosphorylcholine linkage to produce ceramide (3). Acid and neutral sphingomyelinases are the enzymes that catalyze this breakdown of sphingomyelin to ceramide. Ceramide is released into the cytoplasm and by unknown mechanisms contributes to the regulation of cellular differentiation, proliferation, apoptosis and senescence (4, 5). It does this by cell surface receptors which either accept or reject cellular signals. Ceramide has been described to activate proteins that internalize the TNF receptors triggering apoptosis (5). Inhibition of sphingomyelinase can make cells resistant to the apoptotic effects induced by diverse stimuli (3).

To further understand the roles of sphingomyelinases in biological processes, the effects of deletions of genes from this family have been studied in mice. Only one report examined the effects of sphingomyelinase on bone. Specifically, mice deficient in neutral sphingomyelinase 3 (SMPD3) were shown to have retarded longitudinal growth

of bones, increased bone mineral density, and massive malformation of long bones and joints (6). Acid sphingomyelinase I (ASMase) is different from the neutral sphingomyelinases because it is found in the endolysosomal compartment within cells rather than the endoplasmic reticulum membranes where neutral forms are found (6), so its function in bone cell regulation is possibly different. Based on the role of sphingomyelin in the regulation of inflammation, TNF signaling and cell survival, we hypothesized that this pathway could also contribute to the regulation of bone remodeling. Therefore we set out to study the bone phenotype of mice deficient in ASMase. By understanding how bone growth is regulated, we can develop therapeutics that target harmful mechanisms observed in bone related diseases.

## Methods

### *Mouse Model*

Adult male and female wild type and ASMase null mice (7) from Dr. Gloria I. Perez (8) were used to examine the effects of sphingomyelin on bone development. Mice were generated by mating of heterozygous animals (8). All mice were kept on a light/dark (12 h/12 h) cycle at 23°C, and received food (standard lab chow) and water *ad libitum*. Mice were euthanized at 16 weeks old and tibiae were immediately removed, freed from soft tissue, snap frozen in liquid nitrogen and stored at -80°C (for RNA analysis) or fixed in 10% neutral buffered formalin. Wet organ weights were determined immediately. Glucose measurements were made by using blood obtained from the lateral saphenous vein and a glucometer (Accu-Check instant, Boehringer Mannheim Corporation, Indianapolis, IN). Animal studies were conducted in accordance with the standards of the Michigan State University Institutional Animal Care and Use Committee.

### *Micro-computed tomography ( $\mu$ CT) analysis:*

Fixed bones were scanned using a GE Explore Locus  $\mu$ CT system at a voxel resolution of 20  $\mu$ m obtained from 720 views. Each run contained control and knockout bones, and a calibration phantom to standardize grayscale values and maintain consistency. Based on auto threshold and isosurface analyses of multiple bone samples, a fixed threshold (1,400) was used to separate bone from bone marrow. Corti-

cal bone analyses were made in a defined 2 x 2 x 2 mm cube in the middiaphysis immediately proximal to the distal tibial-fibular junction, with the exception of cortical bone mineral content (BMC) and density (BMD), which were measured in a 0.1 x 0.1 x 0.1 mm cube. Trabecular bone analyses utilized a region of trabecular bone defined at 0.17 mm distal to the growth plate of the proximal tibia extending 2 mm toward the diaphysis, and excluding the outer cortical shell. Trabecular bone volume fraction (BVF), BMD and BMC were computed by GE Healthcare MicroView software application for visualization and analysis of volumetric image data.

### *RNA analysis*

Frozen tibiae were crushed under liquid nitrogen conditions prior to RNA extraction. Pulverized bones were homogenized in TRI reagent solution to isolate the total RNA (Molecular Research Center, Cincinnati, OH) and RNA extracted. RNA integrity was confirmed by formaldehyde-agarose gel electrophoresis. Synthesis of cDNA from RNA was accomplished using the Superscript II kit with oligo dT12-18 primers per manufacturer protocol (Invitrogen, Carlsbad, CA). cDNA (1 $\mu$ l) was amplified by PCR in a final volume of 26  $\mu$ l by using the iQ SYBR Green Supermix (Bio-Rad, Hercules, CA) with 20 pmol of each primer (Integrated DNA Technologies, Coralville, IA). Primers for gene amplification by real-time PCR (RT-PCR) (iCycler, Bio-Rad) were osteocalcin, cathepsin K, PPAR $\gamma$ , aP2 (9); BCL-2 was amplified using 5'- CTG AGC TGA CCT TGG AGC -3' and 5'- GAC TCC AGC CAC AAA GAT G-3', and BAX was amplified using 5'- GAC AGG GGC CTT TTT GCT A - 3' and 5'- TGT CCA CGT CAG CAA TCA TC - 3'. RT-PCR was carried out for 40 cycles and data were evaluated using the Cycler software. Each cycle consisted of 95°C for 15 sec, 60°C for 30 sec (except for osteocalcin, which had an annealing temperature of 65°C) and 72°C for 30 sec. Amplicon specificity was determined by melting curve analysis, size and sequence analysis.

### *Statistical analysis*

All statistical analyses were performed using Microsoft Excel data analysis program for student's t-test. Values are expressed as a mean  $\pm$  standard error.

## Results

We investigated the impact of sphingomyelinase deficiency on several bone-specific parameters in wild-type (WT) and knockout (KO) mice (Table 1). The females, as expected, were smaller than the males in both WT and KO backgrounds. Specifically, compared to corresponding age-matched male mice, the body mass of female WT and KO mice were 20% and 24% less, respectively. The female heart, kidneys, muscle and visceral fat were also reduced compared to males. Deficiency of sphingomyelinase did not affect body, heart, kidney or spleen mass in either sex. However, the KO mice had decreased femoral and visceral fat pad mass in both sexes (Table 1). The femoral fat pad mass was significantly lower in male (19%) and female (32%) KO compared to WT mice. Similarly, the visceral fat pad mass decreased by 45% in male and 49% in female KO compared to WT mice. Deficiency of sphingomyelinase also decreased muscle mass (tibialis anterior) but this was only significant in male mice (13%).

Next, we examined the effect of sphingomyelinase deficiency on the skeleton (Table 1). As expected and

consistent with smaller body size, female trabecular bone parameters (BMC, BMD and BVF) were always smaller/less than what was observed in the males. Surprisingly, deficiency of sphingomyelinase had no effect on the trabecular bone in the KO mice in either sex. However, when we examined the cortical bone, we found that the inner perimeter was significantly increased in both male and female KOs, by 9% and 13% respectively. The outer perimeter remained the same. Thus, the marrow area increased in the absence of sphingomyelin in both males (17%) and females (28%).

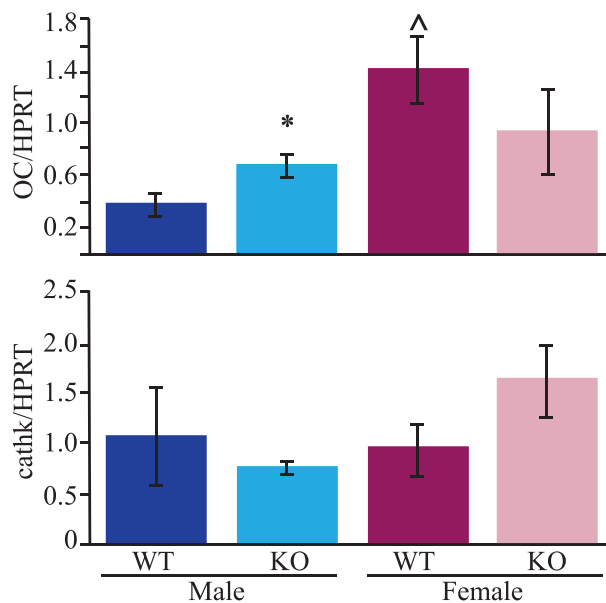
To determine how bone changes were occurring, we measured molecular markers of osteoblasts and osteoclasts (Figure 1). Levels of osteocalcin (OC) mRNA, a marker of mature osteoblasts, were significantly increased in the male KO compared to WT mouse bone, but there were no significant changes in the female mouse bones. OC levels were, however, significantly increased in female WT compared to male WT mice. Levels of cathepsin K mRNA, a marker of mature osteoclasts, were not significantly altered in ASMase deficient mice.

**Table 1** Bone specific parameters of WT and KO mice

	Male		Female	
	WT	KO	WT	KO
Blood Glucose (mg/dl)	178.6 ± 5.5	176.0 ± 9.6	184.5 ± 26.2	238.1 ± 42.5
Body Mass (g)	26.7 ± 0.6	26.8 ± 0.8	21.5 ± 1.05 <sup>^</sup>	20.4 ± 1.06
Heart (mg)	158.5 ± 13.0	134.8 ± 3.5	110.6 ± 6.6 <sup>^</sup>	110.4 ± 9.1
Kidneys (mg)	369.9 ± 6.5	353.6 ± 12.4	298.8 ± 11.0 <sup>^</sup>	287.6 ± 12.8
Spleen (mg)	94.0 ± 5.9	100.4 ± 5.6	83.6 ± 7.0	90.0 ± 11.4
Femoral Fat Pads (mg)	208.5 ± 11.8	169.2 ± 10.4*	208.4 ± 21.7	143.4 ± 21.9*
Visceral Fat Pads (mg)	57.8 ± 8.1	31.9 ± 6.0*	57.8 ± 8.1	17.9 ± 3.8*
Tibialis (mg)	83.9 ± 1.9	73.5 ± 2.8*	83.9 ± 1.9	56.9 ± 3.8
Liver (mg)	1.27 ± 0.87	1.57 ± 0.044*	1.27 ± 0.87	1.08 ± 0.046
<b>Trabecular Bone</b>				
BMC	0.74 ± 0.05	0.71 ± 0.04	0.74 ± 0.05	0.62 ± 0.05
BMD	302.9 ± 37.7	239.9 ± 14.1	191.3 ± 8.5 <sup>^</sup>	208.1 ± 17.0
BVF	12.9 ± 2.0	9.7 ± 1.7	5.5 ± 0.6 <sup>^</sup>	6.52 ± 1.5
<b>Cortical Bone</b>				
Thickness	0.297 ± 0.009	0.283 ± 0.014	0.261 ± 0.014	0.253 ± 0.015
MOI	0.182 ± 0.010	0.202 ± 0.010	0.127 ± 0.018 <sup>^</sup>	0.149 ± 0.01
Inner Perimeter	2.77 ± 0.06	3.04 ± 0.05*	2.55 ± 0.07 <sup>^</sup>	2.91 ± 0.07*
Outer Perimeter	4.64 ± 0.09	4.85 ± 0.13	4.18 ± 0.09 <sup>^</sup>	4.49 ± 0.09
Marrow Area	0.57 ± 0.03	0.68 ± 0.02*	0.47 ± 0.02 <sup>^</sup>	0.64 ± 0.03*
Cortical Area	1.07 ± 0.04	1.08 ± 0.061	0.84 ± 0.06 <sup>^</sup>	0.905 ± 0.06
BMC	0.019 ± 0.0008	0.018 ± 0.001	0.014 ± 0.0012	0.014 ± 0.0012
BMD	851.8 ± 33.9	981.2 ± 31.8*	880.6 ± 38.8	885.98 ± 41.8

Mice were euthanized at 16 weeks of age, and organ mass, bone density and volume parameters were obtained. KO mice show decreased muscle and femoral (fem) and visceral (vis) fat pad weights. Values reported are mean ± SE from male WT (n=13) and KO (n=8) and female WT (n=10) and KO (n=7) mice. MOI, moment of inertia. \*Statistically different, p<0.05, relative to wt controls of same sex. <sup>^</sup>Statistically different, p<0.05, relative to female WT compared to male WT.





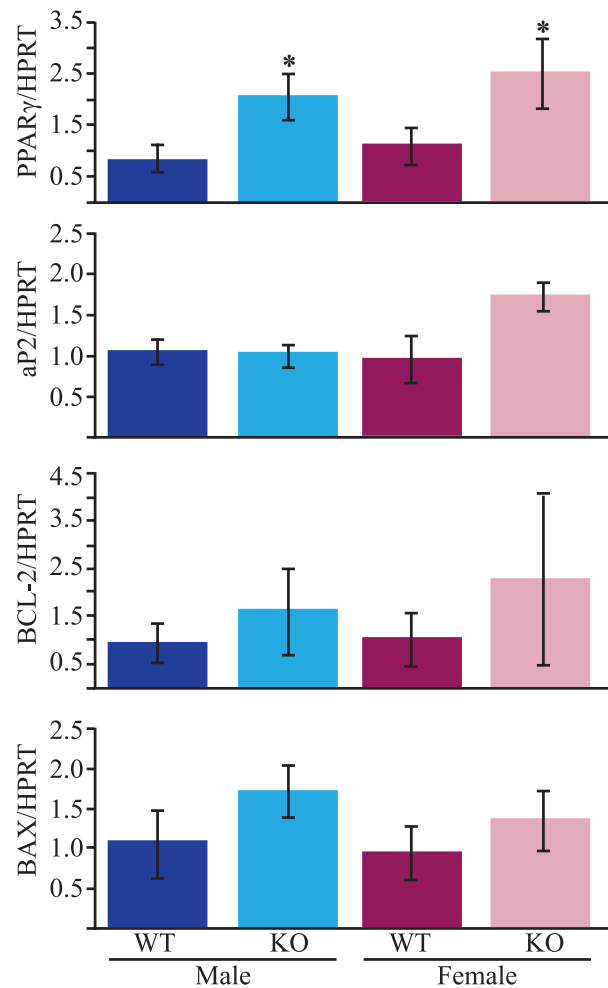
**Figure 1** Graphs show levels of osteocalcin (OC) and cathepsin K (cathK) examined by real-time PCR using HPRT as a housekeeping gene. Values reported are means  $\pm$  SE obtained from male WT (n=4) and KO (n=8) and female WT (n=7) and KO (n=5) mice. \*Statistically different,  $p < 0.05$ , relative to wt of same sex. ^Statistically different,  $p < 0.05$ , between male and female wt.

We also examined the level of fat in bone by measuring molecular markers of adipogenesis and mature adipocytes. Levels of PPARgamma mRNA, a marker of adipogenesis, were significantly increased in the bones of male and female KO mice compared to sex matched WT mice (Figure 2). Levels of aP2 mRNA, a marker of mature adipocytes, were not altered in the bones of sphingomyelinase deficient mice.

Ceramide is known to cause apoptosis in cells (4, 5). The lack of sphingomyelinase in the KO mice should decrease ceramide levels, which could increase osteoblast viability. Therefore we measured mRNA levels of two apoptotic regulatory factors. BCL-2, an anti-apoptosis factor, mRNA levels were not significantly altered in the KO compared to WT mice. The mRNA levels of BAX, another pro-apoptotic factor, were also unchanged (Figure 2).

## Discussion

Sphingomyelinases determine the availability of sphingomyelin in cells. Neutral sphingomyelinase has been shown to cause dwarfism and bone development (6). Therefore, we hypothesized that acid sphingomyelinase would also affect bone development. We



**Figure 2** Graphs show levels of PPARgamma (measure of adipogenesis), aP2 (measure of mature adipocytes), BCL-2 (anti-apoptotic factor), and BAX (pro-apoptotic factor) examined by real-time PCR using HPRT as a housekeeping gene. Values represent means  $\pm$  SE obtained from male WT (n=5; except BAX, n=3) and KO (n=9) and female WT (n=7) and KO (n=4) mice. \*Statistically different,  $p < 0.05$ , relative to wild type controls of same sex.

examined ASMase KO mice to understand the effects that the deletion has on bone development and remodeling. We found significant changes in the cortical bone structure. Inner perimeter and marrow area increased significantly in the KO mice, but there was no change in the cortical bone density. In previous studies, it has been found that lengthening of bone results in a wider marrow area while bone density remains the same, and that this shift produces structural strength (10). The moment of inertia, MOI, is a measure of cortical bone strength. Our analysis showed no significant change in the MOI of the KO mice. Although we observed a general trend toward increased strength, this was not statistically significant. Therefore, the strength of cortical bone is not altered by deletion of ASMase.

We found an increase in the marrow area in ASMase  
[www.recur.msu.edu](http://www.recur.msu.edu) | 12

KO mice compared to WT. The marrow area houses the bone marrow, stem cells and fat. Levels of osteocalcin, a marker of mature osteoblasts housed in the marrow area, were increased in the male KO mice, even though bone density did not increase. We also found that there were significantly higher levels of osteocalcin in the female bone. In previous studies, it has been shown that osteocalcin levels increase with age. However, changes occur at different rates in males and females, with levels increasing linearly in males and exponentially in females (11). This could explain why there were greater levels of osteocalcin in female WT compared to male WT.

Fat is also found in the marrow area. We found an increase in PPAR $\gamma$  levels, but no increase in aP2. This observation is possible because PPAR $\gamma$  is a marker for adipogenesis, while aP2 is a marker for mature adipocytes. Therefore, at 16 weeks of age the cells that had differentiated into pre-adipocytes had not yet fully matured. These results indicate that maturation of adipocytes is dependent on ceramide signaling, and specifically ASMase activity. To measure this further, we can examine the number of mature adipocytes in the region distal to the growth plate.

Many significant changes have been found in past studies in correlation with the levels of ceramide in body cells. Ceramide is known to induce apoptosis in cells of the liver and skin (8). We found the amounts of apoptosis factors were not changed, thus ceramide could have a different effect in bone than other organs. Perhaps this effect is toward the differentiation of stem cells to fat, as PPAR $\gamma$  was increased in both male and female KO mice.

Taken together, these findings demonstrate that acid sphingomyelinase deficiency affects multiple cells in the bone including osteoblasts, osteoclasts and adipocytes. To further understand the effects of sphingomyelinase 1 on bone, complete cartilage analysis could be performed on WT and KO mice (including mRNA markers of cartilage cells and morphological analysis of the growth plates). Also, it would be interesting to determine whether acid sphingomyelinase plays a significant role in bone formation when bone loss from an inflammatory disease is already present, such as in type I diabetes. If so, acid sphingomyelinase could be targeted to treat bone formation defects. ♡

## Acknowledgements

The authors thank Regina Irwin and Katie Motyl for technical assistance, scientific input and assistance with analyses.

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# It's the Journey

Michelle R. Martinelli | Residential College in the Arts and Humanities

I am from magnetic pincushions,  
from polyester taffeta and gingham cotton  
from silver lamé and matching bobbins.  
I am from tired, stitching fingers  
and aching feet and backs from standing on my kitchen table  
while my mother hand-stitched our hems.

I am from homegrown thriving tomatoes and green peppers,  
from adjacent green beans and basil plants,  
from homemade pesto and chicken cacciatore.  
They are the smells that I savored but never tasted.  
I am from cigar smoke and cherry wood humidors;  
they are the smells that elicit memories of  
holidays, birthdays, Petoskey.

I am from the Bard and the Boss,  
from hummos in a blender and two flavors of coffee.  
from the fire in my grandfather, the civil rights activist,  
to the passion of my legal-minded father;  
from the UAW to the restrictions of a wheelchair.  
From the stories the curling photographs share  
to the secrets lost in passings,  
leaving us to suppose what happened and dream of earlier times.  
I am from the noble risks they took and lucky gambles they made.  
I am from a town that lies beneath fabricated waters,  
a village that once belonged to Caesar,  
and a war-torn city that we will never know until  
the Da Vinci's last rifle bullet is fired.🌱

## Author's Statement

*I wrote this piece, "It's the Journey," in response to George Ella Lyon's poem, "Where I'm From," as an assignment to create my own version of a poem similar to Lyon's poem. As Dr. Lyon explains on her website, "Where I'm From" has widely been used as a writing prompt, a process that she encourages. When composing this poem, I reminisced about my childhood experiences and their significance in my personality and character development.*



# "I'm an Art Major." "...Oh."

Diana Busby | Department of Studio Art





### Artist's Statement

*This comic is the first of many comics that I produced at Michigan State University. For my first assignment, I was to script and illustrate an artist statement, which plays a key role in developing one's self as an artist. ♡*



# Finite Element Analysis of a Beetle's Forewing

Ashley Kulczycki and Seungik Baek | Department of Mechanical Engineering

## Abstract

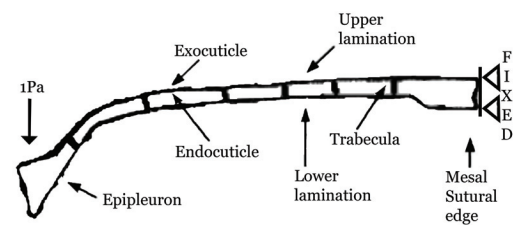
Mechanical properties of biological materials are often studied for information that can be used to improve the design of synthetic biomaterials. Beetles have been examined due to the availability of millions of different species and their long process of evolution, which has selected beetles with properties adapted to their surroundings. In order to gain insights that might improve the design of lightweight composite structures, we analyzed the structure and mechanical properties of the *Allomyrina dichotoma* beetle's wing. Finite element analysis (FEA) was performed on a male and female forewing to determine where the stresses occur in the forewing. Two, two-dimensional cross-sections of the wings were created in COMSOL Multiphysics. The resulting von Mises stress and the normal and shear stresses were analyzed from an applied loading. From these figures, lower stress levels were shown on the female forewing in comparison to the thinner male wing design. The von Mises and normal stress plots show the most stress around the outside edges, with minimal stress towards the middle of the wing. Additionally the results show low levels of shear stress around the whole part, with only one area of concentrated stress. These results demonstrate that the female forewing design is a better model for most lightweight composite structures unless a more economical, lighter design is needed, in which case, the male forewing is a better model.

## Introduction

Lightweight composite structures have many different applications in medicine, aeronautics, and construction engineering. One potential source of information that might improve the design of lightweight composite structures is found in nature, specifically with beetles. With over six million species and a long evolutionary history, each species of beetle has adapted to its unique surroundings. The beetle's forewing is of particular interest because the beetle is a flying

creature and everything on the beetle must be as light as possible. In addition, the beetle's forewing is its main defense against foreign elements or creatures. This is especially important for the female *Allomyrina dichotoma* beetles because they do not have a horn like the male species. These characteristics make a beetle's forewing a useful model for lightweight composite structure design.

The beetle's forewing is comprised of several parts (reviewed in Ref. 1; Figure 1). The outside of the wing is the exocuticle, which is mainly comprised of proteins. The top and bottom layers of the wing, called the upper and lower laminations, are comprised of chitin fiber and protein layers. The chitin layers found towards the middle of the wing are called the endocuticle and are connected to the trabeculae. These trabeculae are found in the void lamination, which creates a sandwich plate structure. Other important features of the beetle's forewing are the epipleuron, which is the outside edge of the wing, and the mesal sutural edge, the opposite edge.



**Figure 1** Cross section of a beetle's forewing with key characteristics and finite element analysis constraints and forces labeled. Re-drawn from Ref. 1.

For this study, a two-dimensional (2D) representation of the beetle wing was examined to explore the stresses found from an applied load. Since male and female beetles have different forewing thicknesses, male and female models were tested and compared with each other.

## Methods

### Creation of 2D CAD figure

We created a 2D CAD model in SOLIDWORKS DWGEditor (Dassault Systèmes Solid Works, Cam-



bridge, MA) by importing a previously published model of the beetle forewing scaled to the reported size dimensions (1). We generated models for both the male and female beetle forewings because their lengths and heights differ slightly by gender. By picking key points in the figure, the cross section was traced with the line and curve options in SOLDIWORKDS DWGEditor. This step simplified the cross section, eliminating unnecessary details that would be too computationally intensive for the FEA. These drawings were then exported as AutoCAD 2000 ASCII DXF files.

### COMSOL Analysis

After creating the 2D profile of the beetle's forewing, the profile was imported into COMSOL Multiphysics 3.4 (COMSOL AB, Stockholm, SE). For this 2D profile, we used the 2D plane stress option. The profile was imported into COMSOL as curves, which we fit to an area. This area was converted into a mesh, which was refined two times, creating a fine mesh for this profile. The computation time was slightly increased due to the mesh refinement. The meshes are shown in Figure 2a and 2b.

We used the meshes we created to assign profiles. A different material was created for both the male and female forewing profiles. To define a new material, the user must define several material properties including the modulus of elasticity, Poisson's ratio, a thermal coefficient and density and thickness of the material. We identified an approximated value for the modulus of elasticity in previously published work (2). We obtained and calculated the remaining values needed from previously published data (1). More specifically, we calculated the area of the forewing from the tensile test results (force/stress) reported in reference (1). We calculated the volume of the wing by multiplying this area by the previously reported thickness values (1). From here, we calculated the density of the forewing by dividing the volume by the previously reported mass (1). These values are shown in Table 1. The thermal coefficient and Poisson's ratio values were left at the defaults since they do not affect the stress on the forewing. For future study, the Poisson's ratio could be analyzed and calculated from experimental values (2).

After defining the material, we applied boundary conditions. For these tests, the mesal sutural edge was held fixed. This edge was selected since it is where the wing attaches to the beetle. A 1 Pa follower load was then applied to the epipleuron, the opposite edge. The

**Table 1** Values used to create materials in COMSOL

	Male	Female
Mass <sup>1</sup> (g)	0.151	0.160
Stress Applied <sup>1</sup> (MPa)	130.7	127.9
Force Applied <sup>1</sup> (kN)	28.1	35.6
Area <sup>2</sup> (mm <sup>2</sup> )	215	278
Thickness <sup>1</sup> (μm)	54.0	69.7
Volume <sup>2</sup> (mm <sup>3</sup> )	11.6	19.4
Density <sup>2</sup> (kg/m <sup>3</sup> )	13,000	8,250
Shear Modulus of Elasticity <sup>3</sup>	1 GPa	

<sup>1</sup> Reported in (1);

<sup>2</sup> Calculated from values in (1)

<sup>3</sup> Estimated from (2)

value of 1 Pa was chosen due to it being large enough that a deformation was visible but not enough to have the profile fail. Applying the force on the opposite edge of the forewing produces the maximum moment at the fixed constraint. For reference, Figure 1 shows where the fixed and the 1 Pa load boundary conditions were applied. With the loads applied, the solve function of COMSOL was used to view the results from the boundary conditions.

More specifically, COMSOL solves the equilibrium equations of linear elasticity,  $\nabla \cdot \sigma = 0$ , where  $\sigma$  is the Cauchy stress tensor and  $\nabla \cdot$  is the divergence operator. For an isotropic material, the constitutive relation is given, using the index notation, by

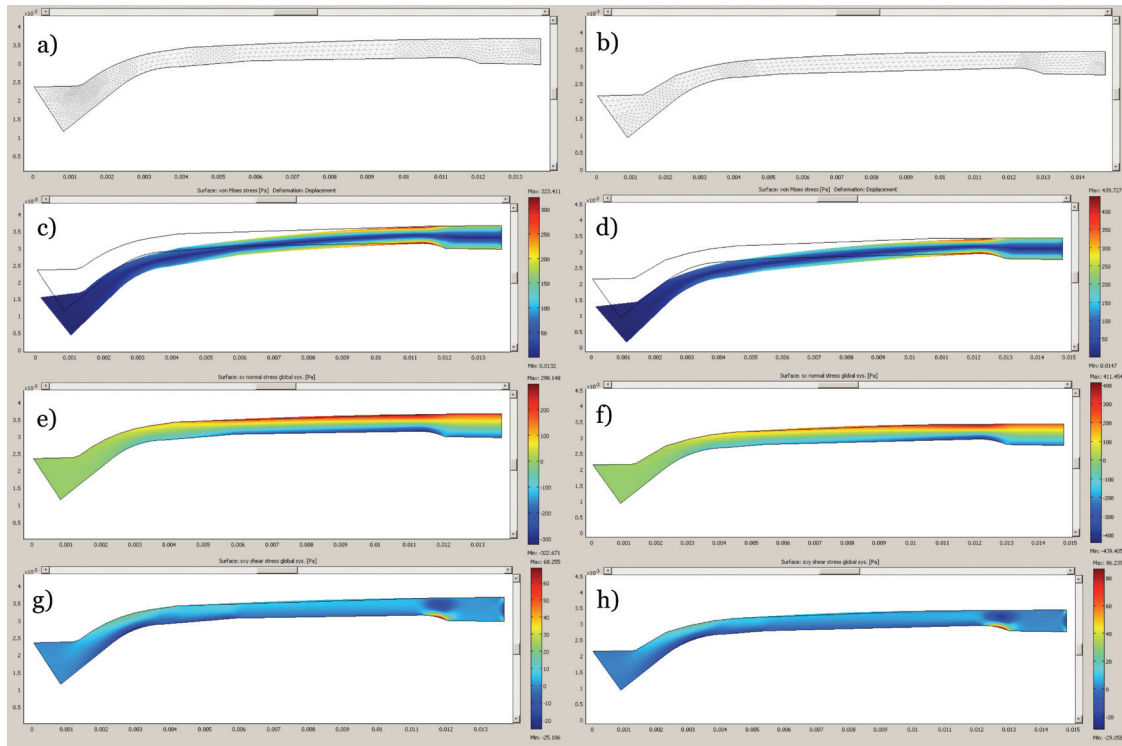
$$\epsilon_{ij} = 1/E [(1 + \nu)\sigma_{ij} - \nu\delta_{ij}\sigma_{kk}] \quad (1)$$

where  $\epsilon_{ij}$  is the ij component of the strain tensor,  $\nu$  is Poisson's ratio, and  $E$  is Young's modulus. Further explanation can be found in COMSOL's help files and documentation.

## Results and Discussion

### Von Mises stress

After 0.5 seconds, COMSOL solved the model and displayed the von Mises stress. The von Mises stress is a scalar stress value used to predict material failure. To compute the von Mises stress, COMSOL uses the Cauchy stress relationship. Figure 2c shows the results for the female forewing, while Figure 2d shows the



**Figure 2** Comsol Stress Analysis. The finite element mesh of the a) female forewing and b) male forewing; Von Mises stress deformation due to 1 Pa load on the c) female forewing and d) male forewing; Normal stress deformation due to 1 Pa load on the e) female forewing and f) male forewing; Shear stress deformation due to 1 Pa load on the g) female forewing and h) male forewing.

results for the male forewing. The outlined shape is the original profile for comparison against the deformed shape with the color-coded, stress levels. As shown on the scale on the right side of each figure, the female forewing experiences 323 Pa, which is significantly less stress than the male forewing of 440 Pa. This follows the prediction that the stress on the female forewing would be less due to it being thicker. These figures also show that the high points of the stress occur at the area where the forewing tapers off the most near the mesal sutural edge.

### *Stress in the x-direction and plane*

To understand the location of the maximum tensile and compressive stresses, the settings were changed to view the normal stress in the x-direction and x-plane. For the profiles, the x-axis is the same as the x-direction. These results are shown for the female and male forewing in Figures 2e and 2f, respectively. To simplify the figures, only the original profile is shown. For Figure 2e, the maximum normal stress is 298 Pa and the minimum is -323 Pa, and for Figure 2f, the maximum normal stress is 411 Pa with a minimum of -439 Pa.

Comparing Figures 2e and 2f to 2c and 2d reveals that the maximum stress for the von Mises stress is

almost the minimum stress on the normal stress plots. This means that the maximum stress that the beetle forewing experiences is compressive.

As expected, the top of the profile is in tension and the bottom of the figure is in compression. Figures 2e and 2f also reveal that the difference in maximum tensile and compressive stresses is the same for both male and female forewings in spite of their differences in size and thickness.

### *Shear distribution*

Another important design consideration is how much shear stress the profile experiences. Even though an object is able to withstand the normal forces, the object may fail due to the amount of shear stress acting on it. With this in mind, a plot of the amount of shear stress in the forewing was created for both female and male forewings, shown in Figures 2g and 2h, respectively. As with Figures 2e and 2f, only the original shape of the forewing is shown.

Analysis of the figures reveals that the maximum normal and shear stresses occur in the same location. For Figure 2g, the maximum shear stress is 68.3 Pa with a minimum of -25.1 Pa, and Figure 2h has a maximum shear stress of 86.2 Pa with a minimum of

-29.1 Pa. As anticipated, the amount of shear stress the profile experiences is significantly less than the normal stress it experiences. It is also important to note that the shear stress,  $\tau_{xy}$ , in Figures 2g and 2h is the shear stress on the plane perpendicular to the y-axis. This can be slightly different from the plane of the outer edge of the profile. Theoretically, there should be no shear stress at the outer edges of the profile, and the shear stress should increase the further it is away from the edges. With a thin forewing, there is not as much of an increase in shear stress. The figures also show that both forewings experience the same amount of negative shear stress; however the maximum shear stress vastly differs between the male and female forewings.

#### *Potential differences with biological forewings*

It should be noted that there is a region of very little stress in the middle of both of the forewings. This is the void lamination, which for simplicity was left as being purely void. In actuality, this area is filled with trabeculae for structural support. Prior research has investigated the structure of the chitin and protein layers and shown that there is a special interlacing between the two that creates a higher strength in the material (1,3,4). With COMSOL, there was no easy way to represent this structure. Therefore, the structure was left out of our simulations. This absence is a limitation of this method of analysis because the presence of the trabeculae would cause less deformation in the forewing. However, this simplification does not interfere with the interpretations of the comparisons between male and female forewings because trabeculae are present in similar amounts in both sexes.

Even with these limitations, COMSOL showed that there are many advantages to this design. The void lamination region in the beetle's wing model is advantageous for many reasons. Without having the chitin and protein layers in that region, it decreases the overall weight of the wing. Even though it creates more normal stress on the upper and lower laminations of the wing, it allows the wing to experience a lower maximum shear stress.

#### *Comparison of parameters between male and female*

From the figures it appears that the female *A. dichotoma* beetle forewing design is the optimal structure. Even though prior literature (1) has found it to be slightly heavier, the thicker upper and lower lami-

nations prove to make it an advantageous design. As shown in the figures, the female forewing design creates a significantly lower normal stress and a lower shear stress.

## Conclusions

To conclude, we examined properties of male and female beetles' forewings to gain insights into how their design differences impact stress tolerance. Due to a beetle's need to fly and given that the forewings are on the outside of the exoskeleton, each wing needs to be light and strong. The results showed that the female forewing has a design that experiences less stress overall than the male forewing and that the majority of the stress for both occurs near the mesal sutural edge. Therefore, we concluded that the female forewing design is a better model for most lightweight composite structures unless a more economical, lighter design is needed, in which case, the male forewing is a better model for design.

Future research could examine how the profile would perform with additional loads applied to it. 3D FEA may also reveal additional differences between the male and female forewing. ♡

## Acknowledgements

Thanks to Chris Hunley for instruction on COMSOL Multiphysics 3.4, and Dr. Baek for his suggestions and mentoring.

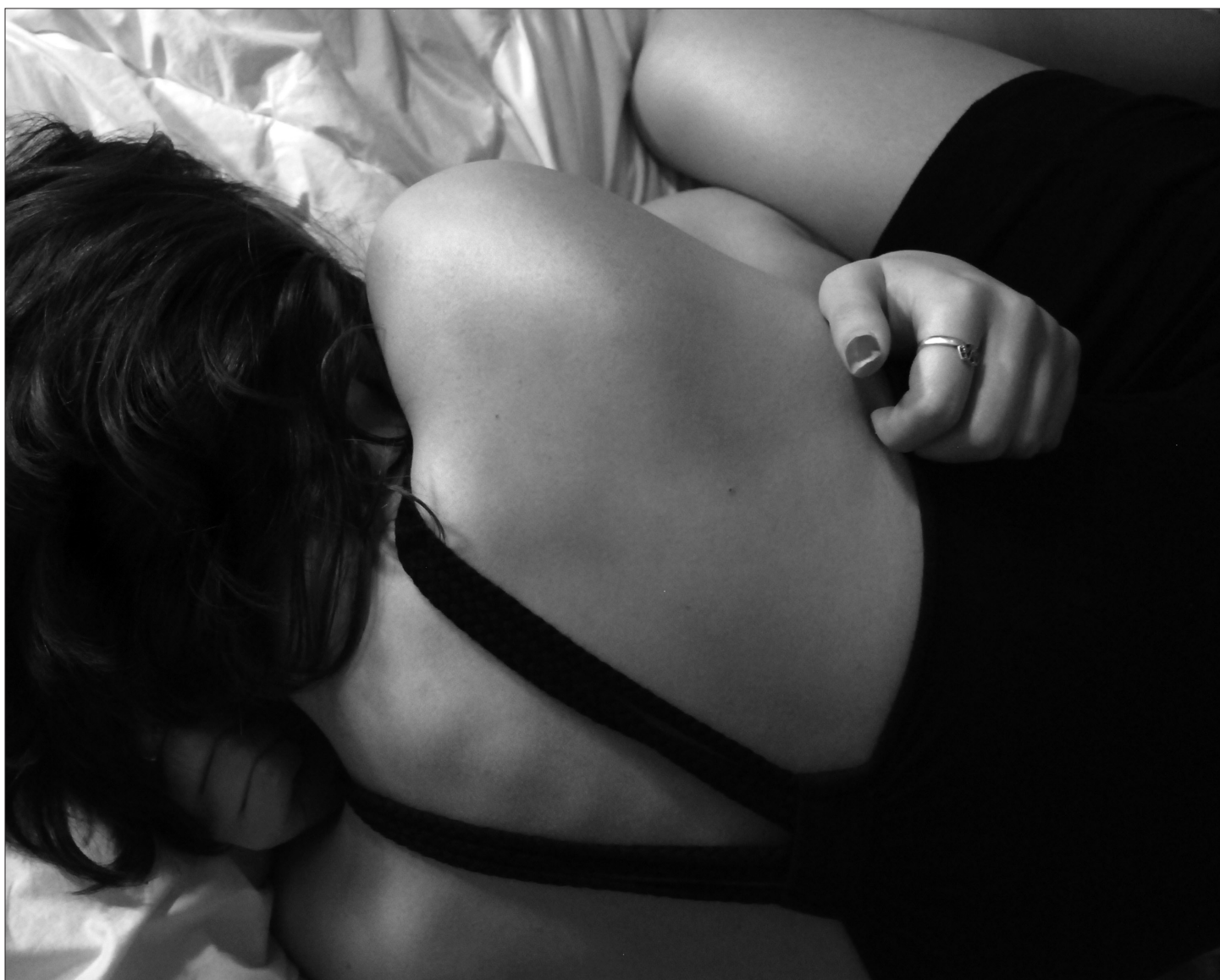
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# “I Am Still Like a Cat. No. A Kitty. A Cute, Cute Kitty.”

Satpreet Kahlon | Departments of Studio Art and Art Education



# With your Thoughts

Alex Kreger | College of Music

The image shows a musical score for the piece "With your Thoughts". It features six staves: Bb Tpt., Vln., Vcl., A.B., Pno., and D.S. The score is in 4/4 time and includes various dynamics such as *ff*, *f*, *fff*, and *p*. There are also performance instructions like "arco" and "build to climax". A box with the number "9" is in the top right corner, and the word "rit." is written above the Bb Tpt. staff.

*An excerpt of the score, which is available in its entirety online*

## Composer's Statement

In "With your Thoughts," I sought to create a through-composed piece that would allow for comfortable dialogue between improvising jazz musicians and notation-bound classical musicians, in a setting that is stylistically neither jazz nor classical, but rather somewhere in between, incorporating influences from rock and ethnic folk music as well.

With the exception of the violin and cello, I intended this piece to be performed by jazz musicians, although these parts also require somewhat of a classical background. Therefore, I used notational methods comfortable for improvisers, giving them room to breathe and create spontaneously while being as detailed as possible in directing the flow of the piece. Particularly, the drum part makes use of slash notation and many textual cues, which have been the most successful way to communicate my intent to a jazz drummer. Also, due to balance issues, I have not marked dynamics on the drum part, for the drums must remain soft (relatively speaking in comparison to the full dynamic range of the instrument) for most of the piece. Instead, I have suggested dynamics with textual cues, the rest being left to the discernment of the musician to support the rest of the ensemble without overpowering it.

After performing the work several times with my ensemble, we have gotten to the point where even the string players can feel more relaxed with their parts, and the group can make decisions spontaneously in the manner of a jazz sextet rather than a classical chamber group. One particular section where this was the case is marked with an asterisk (\*) in the score; at this point the string players deviated from their written out parts to join the jazz musicians in free improvisation. Such was my intent with much of the piece, for it to come across with the spontaneous energy generated by an improvising ensemble, and with a unity between the classical and jazz musicians that masks (or renders irrelevant) their varying backgrounds. ♡

*A recording of "With your Thoughts" is available online and on the audio CD that accompanies the print version.*

# Main-stream Lace

Alexandra Ghaly | Departments of Interdisciplinary Humanities and Anthropology

Main-stream lace;

take its elegance, its image made grainy by an  
absence of light, and—just barely—and painfully—  
captured,  
before, it, like breath, is lost in  
starch-stiff cotton,

cracking and crinkling and marred  
like hope glossed over lips and  
smeared on

the back of a hand, sweaty from the force of  
miscarriage, or  
a dead son's uniform, one tiny, unobtrusive hole over the  
left breast, or  
a white veil  
coated in red dust  
cut out of the earth by  
horse hooves.

Take lace,

the amphora of passion, and  
peel it from my thighs—  
linger a moment:  
let your tongue tidy  
our milky excess; then,  
slide that lace beneath a  
wedding cake,  
the bride and groom, or  
bride and bride, or  
groom and groom  
peering down at us with  
button eyes.

Adorn with lace:

a coffin sheet,  
a harlot's dress,  
a cupcake wrapper—  
and, with lace-lined tissue, wipe away  
our sweat and tears, now made unsacred, as  
the Father's final  
tantum ergo  
splashes over us,  
our long shadows stretching on and on—  
left without an exit wound, the small, lead ball  
lodged deep inside  
the tirailleur;  
his spilled regalia garnished  
the reddening  
Thiaroyese soil—  
the strangest fluid leaking from  
one tiny, unobtrusive hole  
over the left breast. ♣



# Incorporating Interdisciplinary Understanding for K-12 Students using a Biomimetic Device

Joshua T. Whitman, Stanley C. Hunley, Seungik Baek | Department of Mechanical Engineering  
Xiabo Tan | Department of Electrical and Computer Engineering  
Drew Kim | Office of the Dean, College of Engineering

## Abstract

Biomedical engineering is a rapidly growing discipline. One way to attract new students to this discipline may be to provide greater emphasis of the way in which biomedical engineering connects engineering to biomedical sciences. Because crucial decisions regarding whether or not to pursue an engineering career are often made prior to college entry, we devised a simple project for junior and senior high school students that clearly conveys the relevance of engineering to biomedical contexts. The experimental device we designed incorporates principles from physics, biology, engineering analysis and cutting-edge technology into a single, integrative project. More specifically, we designed a build-and-test device that is an actuator that simulates the action of sarcomeres (individual contractile units of muscle fibers) during muscle contraction, which demonstrates how creativity in engineering design may be inspired by natural phenomena. We used this device during summer programs for junior and senior high school students and found that junior high school students had more difficulty completing the assembly of the device in the allotted time. Although high school level students were able to complete assembly on time, they were not able to complete all of the challenge questions that tested comprehension of the fundamental biological and engineering principles involved in the allotted time. Further, relatively few participants indicated that this program was their favorite activity in the lab experience. Based on these observations, we have recommended changes to the program.

## Introduction

One rapidly growing field of engineering within

the United States is biomedical engineering (1). According to the U.S. Department of Labor, biomedical engineering jobs are projected to grow the fastest among all occupations through 2010, and to supplement this increase in demand, universities throughout the country have begun incorporating biomedical engineering programs into their undergraduate curriculum (2).

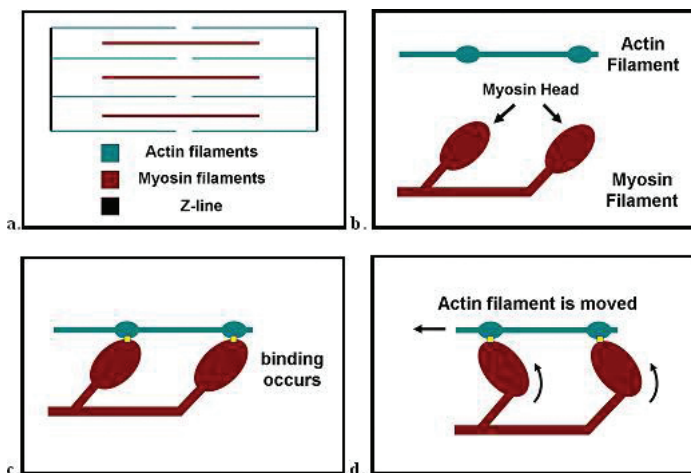
Research on K-12 recruitment into engineering and technological fields is beginning to reach a consensus that crucial decisions about pursuing an engineering career are often made between the sixth and eighth grades (3). Thus, we hypothesized that outreach programs promoting pre-engineering projects will expose students to engineering concepts and motivate interest in engineering fields.

Based on these ideas, we designed a relatively simple project that would expose students to the engineering analysis and critical thinking skills necessary to be successful in the biomedical engineering field. Such multidisciplinary projects have been recommended by the National Research Council, whose members have emphasized incorporation of math and statistics into interdisciplinary biology curriculums (4).

An additional desired outcome of the project is to increase the involvement of underrepresented groups in engineering, particularly women. According to current reports, male undergraduate engineering students outnumber female undergraduate engineering students nearly four to one (5). Conversely, female student enrollment in biological science programs is three times greater than in engineering programs (5). As such, a strategy to include more women in engineering may be to introduce engineering concepts from a biological perspective, providing students with a clearer connection between the two fields. Previous studies on integrating biological and engineering concepts into lessons have proven successful (6).

In order to begin to test these hypotheses, we developed a biomimetic device that was used to supplement lecture material that illustrated the connections between biological and engineering concepts in a program developed for junior and senior high school students. The biomimetic device was based on the function of the sarcomere, the basic contractile unit of a muscle cell in the human body.

On a simplistic basis, the sarcomere is comprised of four main components: the actin filament, the myosin filament, the myosin head and the Z-line (reviewed in Ref. 7, Fig. 1). Several steps are required to generate sarcomere lengthening or shortening (7).



**Figure 1** (a) Large-scale, simplified view of a sarcomere. The actin filaments are attached to the Z-line and are moved by myosin heads on the myosin filament. (b) Close-up of the configuration of actin and myosin filaments before activation. (c) Binding of actin and myosin filaments before the myosin head power stroke. (d) Configuration of actin and myosin filaments after myosin head power stroke. The myosin head moves the actin filament while the position of the myosin filament remains fixed.

Action potentials generated in the brain travel down nerve fibers and trigger release of the neurotransmitter acetylcholine (ACh) at a particular skeletal muscle group. ACh stimulates the release of calcium within the intracellular space of skeletal muscle cells. The binding of calcium to a component located on the actin filament (known as Troponin C) releases the chemical bond holding a myosin head. Then, via ATP hydrolysis, the myosin head rotates and binds to another site on the actin filament in an event known as the power stroke of the myosin head. Finally, multiple power strokes are completed until the sarcomere reaches the desired contraction state.

The scale of sarcomere contraction is very small and therefore large numbers of sarcomeres are required to work in unison to produce a noticeable movement. For example, a typical myofibril may contain 4500 sarcomeres, a muscle fiber may contain anywhere between 5 and 10,000 myofibrils, and an average adult human may contain approximately 250 million muscle fibers (8). Using this information, we may calculate a rough average of 5.625 quadrillion (that is,  $5.625 \times 10^{15}$ ) sarcomeres in an adult human. The body is innervated such that in an individual muscle, all of its muscle fibers are stimulated simultaneously. Therefore, all sarcomeres in a particular muscle group act in unison to produce a desired contraction, and it is the summation of small forces from each sarcomere that is responsible for noticeable body limb movements (8).

### *Biomimetic Properties of Electroactive Polymers*

Electroactive Polymers (EAP) have been coined “artificial muscle” due to their relatively quick response, which has been employed for biomimetic applications (9). Ionic EAP function via the movement of ions throughout an electrolyte sandwiched between two conducting layers on either side. Therefore, EAP must be submerged in water to allow the movement of ions, making it a perfect candidate to simulate myosin head movement within an inter-cellular space (10). These properties of EAP made it an ideal candidate for our device that simulated a sarcomere.

## Methods

### *Office of K-12 Outreach in Engineering Education*

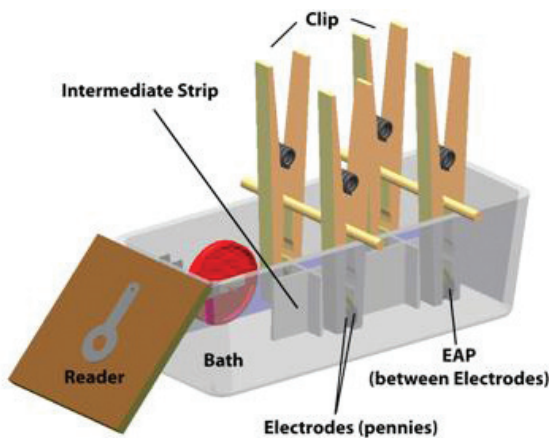
One goal of the Office of K-12 Outreach in Engineering Education at MSU is to attract prospective engineering students from schools throughout the area. One way that the office meets this goal is to provide opportunities for students to visit MSU and learn more about ongoing research in engineering. Visiting students have the opportunity to engage in hands-on projects designed to show how an engineer could solve a given problem. Additionally, visiting students interact with people from a variety of engineering disciplines, which allows them to observe the career possibilities within engineering fields.

Two specific summer programs offered to students

by the Office of K-12 Outreach in Engineering Education at MSU are Wireless Integrated Microsystems (WIMS) and Women in Engineering (WIE). WIMS is a five day residential experience for seventh and eighth grade students with a B+ or better average in math or science courses, who are interested in becoming engineers and have been recommended by their math or science teacher for participation. WIE is a five day residential experience for tenth, eleventh and twelfth grade women with a 3.0 or better GPA (or top 15% cohort ranking), who are interested in becoming engineers and have been recommended by their math or science teacher for participation. More information about both programs is available at [egr.msu.edu/future-engineer/programs/summer](http://egr.msu.edu/future-engineer/programs/summer).

### *Biomimetic Device Design*

We used a class of EAPs called ionic polymer-metal composites (IPMCs) as actuators in our biomimetic device. We used the deflection of EAP to push an intermediate strip and reader to a measurable distance. Then, we determined the amount of work done on the system based on the measured weight of the intermediate strip and the amount of distance pushed. A schematic of this device is shown in Figure 2.



**Figure 2** Schematic representation of biomimetic device.

In its broadest sense, the device in Figure 2 uses electrical input to produce a deflection in multiple pieces of EAP, the motions of which are combined in parallel to produce a linear displacement of an intermediate strip. The following list summarizes the relationship between major design features in the biomimetic device and their corresponding biological components:

1. Wiring: Muscle Innervation
2. Reader: Body Limb
3. Clip / EAP: Myosin Filament / Myosin Head
4. Water (Bath): Intercellular Space
5. Electrical Input: Action Potential
6. Intermediate Strip: Actin Filament
7. Electrodes (Pennies): Proteins to conduct Chemical Signals
8. Power Source / Voltage Regulator: Brain

### *Assessment of Program Quality*

We designed assessments to measure how effectively the biological and engineering lessons were presented and the students' overall enjoyment while working through the project. Assessments in previous interdisciplinary bioengineering projects included exams administered before and after the project was completed and a feedback ranking scale based on a five-level agreement survey (6). Following these methods, we designed questions to determine both the amount of knowledge gained by the students during the project and their overall enjoyment while completing the project. After completing the project, the students were assessed according to the criteria found below.

1. Retention: Were the physiology questions answered correctly?
2. Construction: Was the device built within the time limit?
3. Calculations: Were calculation questions answered correctly?
4. Critical Thinking: Were challenge questions answered correctly?
5. Enjoyment: Was this the favorite activity of the visit?

Possible outcomes for the tasks were "Yes," "No" or "Did not Respond" (or "Did not Complete"). In Enjoyment, "No" means that the participant chose another activity as his/her favorite.

An asterisk indicates that the assessment of objectives for the project was varied with respect to the age group of participants. Thus, participants in WIMS were asked to simply construct and test the device, answer basic physiological questions, and provide enjoyment feedback, whereas WIE participants were



also asked to perform engineering analysis and answer challenge questions within the allotted time period. For the challenge questions, one had to synthesize the knowledge based on the given equations for analysis to determine a single characteristic of the system, and then use that characteristic to design a solution for a problem of a much larger magnitude. The first challenge question asks the student to observe the system and determine how much work must be done by a single strip of EAP. The next question then involves using that characteristic number to then determine the number of sarcomeres necessary to generate movement within a physiologically relevant weight. This problem therefore provides a means to understand the magnitude of sarcomere function (e.g., the sarcomere alone provides a very small force, but given enough of them, they generate enough force to move a body limb).

### Test populations and conditions

The project was first piloted as part of student visits for Wireless Integrated Microsystems (WIMS) on July 2, 2009, specifically as part of the Cardiovascular and Tissue Mechanics Laboratory experience. A total of 17 visiting students (12-14 years, approximately 80% male) were asked to construct the bath and the intermediate strip and then assemble the device. The participants constructing the biomimetic device were allotted roughly 20 minutes to complete the project. Thus, we pre-assembled certain components of the device to hasten the construction process.

The second project was piloted for Women in Engineering (WIE) on July 9, 2009, which consisted of 21 participants (15-17 year old, 100% female), who completed this project as part of the Cardiovascular and Tissue Mechanics Laboratory Experience. These students were not only asked to build the device (which was again partially pre-assembled) within the 20-minute time period, but were also asked to complete calculations and challenge questions.

## Results

### Wireless Integrated Microsystems (WIMS) visit

For the WIMS visit on July 2, 2009, we observed that many students had difficulty constructing the intermediate strip and consequently in the first trial,

no groups were able to completely finish the building and testing of the device within the allotted 20 minute period. In the second and third WIMS trials, the intermediate strip was pre-assembled so that students needed only to finish constructing and wiring the device. In these trials, all students were able to fully assemble and test the device. Figure 3 summarizes the results from this visit.

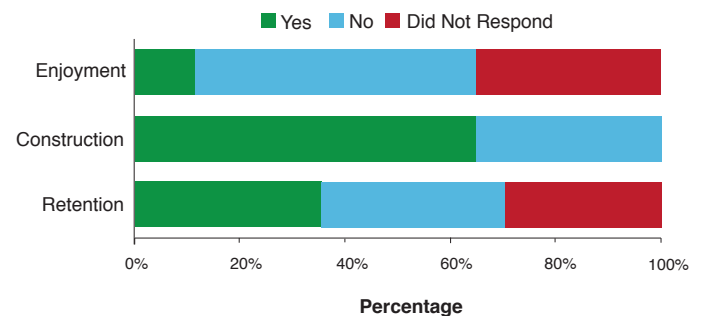


Figure 3 Assessment results for WIMS students

For the WIE visit on July 9, 2009, we observed that all groups were able to completely construct the device within the 20 minute time period, and most successfully completed the calculations. However, only about 30 percent were able to correctly answer the challenge questions, the remainder of which did not respond. The results from this visit can be seen in Figure 4. These results demonstrate that 20 minutes is insufficient for fully completing the project. Also, like the WIMS visitors, the majority of respondents did not list the experience as their favorite activity, claiming that the computer simulations were most interesting.

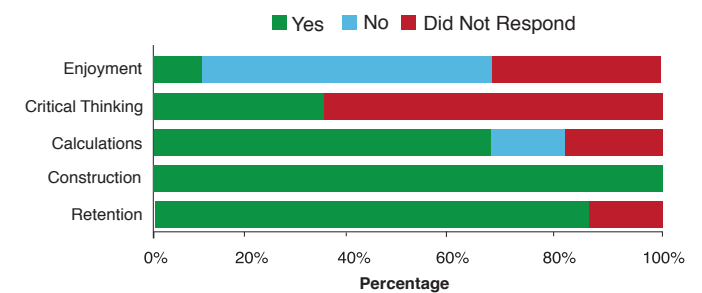


Figure 4 Assessment results for WIE students

## Discussion

Our project allows an “active learning environment,” which thrives not only on the interactions be-

tween students and teachers, but also helps in forming successful group learning sessions (11). However, there are areas for improvement, which will be addressed in the following sections.

### *Construction*

For our previous trials, time constraints limited the amount of time set aside for completing the project, and may have limited the quality of the experience. Upon realizing this need, we pre-assembled parts of the kit to speed up building times, although the device is designed to be constructed independently. Therefore, we recommend that this project may be expanded over the course of two individual time periods, one time period would be used for the lecture material, and the second time period would encompass the building session and worksheet questions. Previous multidisciplinary, collaborative projects completed over a four-week period have shown success (12). However, we anticipate that our biomimetic device program can produce a comparable experience in a shorter period of time, that is, over two lecture periods, and plan to test this in future studies.

Even with enough time to construct the device, there may also be technical shortcomings when testing the device. When the EAP was activated, we observed degradation of the penny electrodes resulting from the addition of electrical current. Degradation generally occurred gradually after the sixth use of the electrodes. Further investigations will be necessary to determine when the penny electrode becomes completely ineffective. Thus, the increase in electrical resistance between the electrodes and the EAP resulting from degradation of the penny may contribute to a decrease in the observed deflection. However, this shortcoming may actually serve as yet another connection between disciplines, namely physics and chemistry. Thus, for yet another interdisciplinary project, an instructor may adapt the lecture to address such issues.

### *Knowledge Retention*

Based on the results from Figures 3 and 4, we observed that given the same amount of time, the participants from the WIE group were able to more effectively answer the retention questions. Based on these results, we conclude that the students in the WIE group are better prepared to answer these questions. These differences in performance may be due

to several differences between the groups, including age (15-17 year old students in WIE compared to 13-14 year old students in WIMS), gender (100% women in WIE compared to approximately 20% women in WIMS) or other differences in preparation or interests between the two groups. Once these differences are better understood, we can develop assessment questions that are modified in order to suit the understanding level of a given audience.

### *Enjoyment*

Based on the feedback from students shown in Figures 3 and 4, we observed that the vast majority of students visiting the Cardiovascular and Tissue Mechanics Laboratory seemed to be more impressed with computer simulations and patient-specific imaging techniques than the biomimetic device. This result may be attributed to the lack of a pronounced visual indication for success when completing the project, namely that the deflection of the reader reaches a maximum of 3 mm for successful trials. Because such deflections may be difficult to recognize with the naked eye, the meaning of the experiment may be difficult to convey in the absence of the supplementary lecture. Therefore, a computational simulation of the expected behavior for the device may be an effective method to not only convey the synthesis of the background information, but also act as a visual guide when constructing the device. Moreover, the success of using computer simulations to aid in learning has been documented in previous studies (13).📍

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## Highlights from the National Press

*Several Honors College Students were published by United Press International (UPI). Their work is summarized by Managing Editor Katelin McArdle.*

### Technology's Impact on Mecca Pilgrimage

Daniel Redford's article describes the emergence of cell phone and other electronic device usage during the Mecca pilgrimage in Saudi Arabia. Some followers of Islam are concerned that this threatens the sanctity of the pilgrimage, while others celebrate technology's ability to realize the sharing of faith with others.

[upi.com/Features/Culture\\_Society/2010/01/08/Cell-phones-Internet-interrupt-Mecca-pilgrimage-traditions/12628860435441/](http://upi.com/Features/Culture_Society/2010/01/08/Cell-phones-Internet-interrupt-Mecca-pilgrimage-traditions/12628860435441/)

### Religious Tolerance Studied in Africa

Thomas Morrissey's article explains MSU professor David Robinson's ongoing grant project to document in print, video and audio the Muslim people of Ghana and Senegal. The research aims to illustrate and discover the peacefulness and coexistence of various religious groups in the region.

[upi.com/Features/Culture\\_Society/2010/01/08/Professor-collects-tales-of-religious-tolerance-in-Africa/12590830815019/](http://upi.com/Features/Culture_Society/2010/01/08/Professor-collects-tales-of-religious-tolerance-in-Africa/12590830815019/)

### Technological Innovations and Religion

Jeremy Blaney's article describes the ways in which technology is changing our interactions with religion. New innovations, such as an iPod App for the Qur'an, are changing the ways in which people integrate their faith into everyday life. However, others feel trepidation or dislike for this new way of spirituality. 🌐

[upi.com/Features/Culture\\_Society/2009/11/11/Youre-a-Muslim-Theres-an-app-for-that/12579646575612/](http://upi.com/Features/Culture_Society/2009/11/11/Youre-a-Muslim-Theres-an-app-for-that/12579646575612/)



# Searching, a Documentary

Nicholas Baker | Department of Telecommunication, Information Studies and Media

It was a rainy, fall Thursday evening when we arrived in Holly, MI. Because we had never been to Holly before, our production team was on edge. The weather and edginess made everyone quieter than usual.

Two weeks earlier, we contacted Samantha Harris, a senior in the MSU College of Communication Arts and Sciences and the executive director of the Michigan Paranormal Research Association (MPRA). Samantha's claim that she heard voices and saw black shadows of demons and spirits as a child made me interested in seeing if she and her paranormal investigators were the real deal.

During the first night that we met with Samantha and her associate director, Kyle Gask-Wilson, we sat at their kitchen table for hours discussing the project and their own investigations. As a producer, it was important to remain open to what they were saying. So often in television, the filmmaker has already determined whether the paranormal exists. We wanted to produce an objective piece about this group to let the audience decide whether or not they believe in the paranormal.

The location for the majority of the taping was the Historic Holly Hotel. A once fully functioning hotel during the days of prohibition, the Hotel is now home to a restaurant, a banquet room and a basement comedy club. What makes the Hotel an excellent location for an investigation is the nearly 140 years of history that has occurred there.

Since it opened in 1863, the building has experienced two devastating fires. The first fire occurred on January 19, 1913. The second fire occurred exactly sixty-five years later, to the day and to the hour. It would not seem to be more than a coincidence if someone could explain how either fire started. The more 'haunting' part of the story is that there has never been a definite accounting of how many people lost their lives during the two fires. It has been rumored, according to the Hotel owner, that many children perished in the two blazes.

Before the MPRA was allowed into the hotel to set up the equipment, my production team, which included three other students, set up our equipment ensuring



*MPRA director Samantha Harris (left) and associate director Kyle Gask-Wilson (right) review infrared footage of mysterious light orbs.*



*The investigation team point to a spot of reported suspicious activity in the comedy club.*



*Lisa Simon (left) and Bridgett Shipway (right), perform an electronic voice phenomenon (EVP) session in the upstairs "bride's room".*

that we were covering every move they made. Our microphones, video cameras and still cameras saturated the three floors of the hotel.

For six hours we taped non-stop. Two cameras followed the group throughout the night. After we wrapped up all our cables and got into the car, we emitted a collective sigh of relief and excitement.

There was certainly a sense of something being in that building that none of us had felt before. Equipment batteries drained faster than normal, and a few times they came fully charged off the charger and died immediately when the camera or light was turned on. Upon reviewing the tapes in post-production, digital blips and tape errors occurred only in certain rooms of the hotel; errors that could not be explained by even the most experienced broadcast engineers. ♣

To really understand the MPRA and decide for yourself if you believe in spirits, check out the documentary at [www.recur.msu.edu](http://www.recur.msu.edu).

*Searching is co-produced by MSU students Claire Church, Melissa Olsen and Matthew Gordon. This film is under consideration by several film festivals across the country. Freight, another film produced by this group of students, was recently recognized by the SINE film festival in Rhode Island.*

The graphic features the text 'WE DARE YOU' in large, bold letters. The word 'DARE' is green, while 'WE' and 'YOU' are white. A Spartan helmet icon is integrated into the letter 'A' of 'DARE'. Below this, 'MICHIGAN STATE UNIVERSITY ALUMNI ASSOCIATION' is written in smaller white and green letters. The background is a dark green with a subtle pattern of small white and green shapes.

**WE DARE YOU**  
MICHIGAN STATE UNIVERSITY ALUMNI ASSOCIATION

Dare No. **10**

You are among 36,000 alumni and friends who have dared to stay connected to our Alma Mater by joining the MSU Alumni Association. But there are still hundreds of thousands of Spartans out there who don't belong. *Pass on the dare.*

*The We Dare You Challenge is a grassroots call to action to our alumni and friends. Dare to show your pride as a Spartan by joining your Michigan State University Alumni Association. Your membership matters.*

**BELONG - ACCEPT THE DARE AT [WWW.ALUMNI.MSU.EDU](http://WWW.ALUMNI.MSU.EDU)**

**Editor's Note:**

Those artists, authors and composers who were interested in sharing additional interpretations of their work provided a brief "Statement" which accompanies their work.

# Marred

Christine Collins | Department of Linguistics

I do not know what lives inside of me anymore.  
I am not sure how to find out,

except for by poeming a net down past where the light shines,  
all the way down to my swollen feet,

heaving it back up again with trembling elbows,  
and snatching up its contents before they scatter away.

My feet swell and ebb under this sky as waves swell and ebb,  
the surface of them rises and falls as if it were salt water.

Am I eroding the world outside of me?  
Everything that surrounds me is land,

yet I have become a holding place for seas.  
Oceans have poured themselves into my feet.

There must be fish inside of me, swimming up my body,  
placidly circumnavigating the blood cells in my blue veins,

pushing through me with their simple eyes and mouths;  
miniscule glassy eyeballs peering out of the caves

in my coraled foot bones;  
clutches of starfish latched onto the underside of my skin;

or things without vertebrae,  
creeping with slow motion towards my heart. 🐠



# Osteoblast Attachment and Growth on Novel TiAlNb Alloys

Marc A. Schlaud, Robert J. Friederichs, Melissa J. Baumann and Carl J. Boehlert | Department of Chemical Engineering and Materials Science

## Abstract

Titanium (Ti)-based alloys are commonly used in orthopedic applications, such as knee and hip replacements. Because of its known ability to bond to bone, we compared the biocompatibility of the commonly used titanium-aluminum-vanadium (Ti6Al4V) alloy with two newly developed titanium-aluminum-niobium alloys (Ti15Al33Nb and Ti21Al29Nb) in which niobium (Nb) was substituted for the potentially harmful vanadium (V). We characterized, quantified and compared attachment and growth of osteoblasts (OBs), a specific type of bone-forming cell previously shown to attach to titanium alloy implants, between the three titanium alloys, Ti6Al4V, Ti15Al33Nb and Ti21Al29Nb. Scanning electron microscopy (SEM) was used to observe OB morphology on the Ti alloy substrates. Similar OB attachment and growth were found for the three alloys at 1, 2 and 4 hours and 1, 3 and 5 days, respectively (no significant differences observed at  $p < 0.05$ ). Characteristic OB morphology was observed on all Ti alloy substrates. Overall, the OB cell attachment, growth and morphology of the TiAlNb alloys were comparable to those for Ti6Al4V alloy. Based upon these results, we conclude that these new titanium alloys show significant promise as a replacement for existing titanium alloys used in biomedical implants.

## Introduction

Orthopedic implants are increasingly important, as our average life expectancy increases and the incidence of joint injury and disease continues to climb (1). These implants become necessary due not only to injury, but more often to the onset of degenerative conditions such as osteoarthritis (2). It is important to ensure that the materials used for such joint replacements are mechanically robust and biocompatible. Not only must

they have the proper strength, elasticity, fatigue, and creep and corrosion resistance, they must also be biocompatible, non-toxic and non-carcinogenic.

One of the most commonly used joint replacement materials for total hip replacements is Ti6Al4V (3). Its mechanical properties are well suited for use as the femoral stem component of a total hip replacement (3). It is also inherently corrosion resistant and exhibits a high degree of biocompatibility with bone and its surrounding tissues. However, there are shortcomings with this widely used alloy. Ti6Al4V implants are subject to wear, releasing metal debris into the surrounding tissue (4). These vanadium-containing wear particles have been found to be toxic (5). It is therefore desirable to find a titanium alloy with similar mechanical properties and biocompatibility, but lacking the potentially toxic wear debris.

Titanium-niobium alloys are a potential alternative to Ti6Al4V based alloys. Studies with monocytes, a specific type of human white blood cell, have shown that TiAlNb alloy particulates are non-toxic (6). (Evidence of non-toxicity of TiAlNb alloy particulates is significant because some biomaterials commonly used in joint replacement have shown adequate biocompatibility in the bulk form, but elicit an undesirable response in particulate form (7-9)). Shapira et al. have investigated the *in vitro* biocompatibility of human OB-like cells on Ti6Al7Nb as compared to Ti6Al4V and found similar biocompatibility (10). In addition, TiAlNb alloys have comparable fatigue lives to Ti6Al4V, while having up to three times greater wear resistance (11). They also have similar elastic moduli, a key parameter for joint replacement materials because of the negative effects associated with improper load transfer and the resulting bone resorption for stiffer metals (12).

Two of the most promising Nb-containing alloys in terms of their mechanical properties, Ti15Al33Nb and Ti21Al29Nb, have been chosen for further comparison to Ti6Al4V. While these two Nb-containing alloys have desirable mechanical properties, their

relative biocompatibility characteristics must still be established. Osteoblasts (OBs) are bone-forming cells that have been shown to attach to Ti alloy implant materials (13-19). Ideally, these alloys should allow OB attachment comparable to Ti6Al4V in order to be considered as a substitute for this widely used implant material. The purpose of this study was to determine the *in vitro* behavior of an OB clonal cell line on two novel Nb-containing alloys with respect to a Ti6Al4V control.

## Methods

### *Preparation of Alloys*

The TiAlNb alloy processing and composition is described elsewhere by Boehlert et al. (11). No heat treatments were performed on these materials after processing and thus all alloys were evaluated in the as-processed condition. The Ti6Al4V was a commercially acquired sheet of extra-low interstitial condition biomedical grade alloy (Barnes Aerospace, Lansing, MI). Nine samples were prepared for each of the three alloys (Ti15Al33Nb, Ti21Al29Nb and Ti6Al4V). Samples were 2 cm by 2 cm, with thicknesses ranging from 1.5 to 0.5 mm. Each sample was sequentially polished from an 82  $\mu\text{m}$  finish to a 28  $\mu\text{m}$  finish, down to a 16  $\mu\text{m}$  finish. The Ti15Al33Nb and Ti21Al29Nb alloys, both in atomic %, are respectively Ti6.8Al51Nb and Ti10Al48Nb in weight %.

After polishing, the samples were given an industry standard surface treatment to induce an oxide layer that has been shown to increase biocompatibility and cell attachment. This peroxide treatment increases oxide thickness and the surface hydrophilicity by encouraging hydroxyl group attachment (20). Following the method of MacDonald et al., samples were sonicated successively in isopropanol, acetone, xylene, acetone and 1 M ammonium hydroxide for 5 min each (20). They were then rinsed with deionized water and sonicated for 10 min in 40% nitric acid. The samples were rinsed 3 times with deionized water and placed in an oven at 165°C for 10 min for sterilization. They were then placed in a mixture (1:1:5 by volume) of 25% ammonium hydroxide ( $\text{NH}_4\text{OH}$ ), 30% hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) and deionized water at 80°C on a hot plate and manually stirred for 5 min. This was followed by transfer into a separate mixture (1:1:5 by volume) of 32% HCl, 30%  $\text{H}_2\text{O}_2$  and deionized water at 80°C with manual stirring for 5 min. The samples

were finally washed twice with deionized water and then once with ethanol and stored in 6-well polystyrene cell culture plates inside the sterile cell culture hood, approximately 24 hr before initial OB seeding.

### *Cell preparation and growth*

MC3T3-E1 mouse OBs were grown in complete media, a solution of  $\alpha$ -minimum essential media and 10 vol % fetal bovine serum (Atlanta Biologicals, Lawrenceville, GA). The OBs were prepared for seeding by trypsinization (0.5% Trypsin/EDTA, Life Technologies, Carlsbad, CA) from their culture plates. Cells were counted with a hemacytometer, then centrifuged and resuspended in fresh complete media. To ensure confluency, cells were seeded on the Ti-alloy specimens at a density of 11,320 cells per  $\text{cm}^2$  following protocols previously established in our laboratory (21). For the attachment studies, OBs were incubated for 1, 2 and 4 hours on Ti15Al33Nb, Ti21Al29Nb and Ti6Al4V samples. For the growth studies, OBs were incubated for 1, 3 and 5 days (21). The growth study cells were fed with complete media two days after seeding. Four days after seeding, cells were fed with differential media, containing complete media with  $\beta$ -Glycerol Phosphate, Penicillin/Streptomycin and ascorbic acid (Sigma-Aldrich, St. Louis, MO). The cell studies were performed with nine samples of each alloy composition, three for each time interval with  $n=3$ .

### *Quantification of OB Attachment and Growth*

At each established interval, the cell-laden samples were washed with phosphate buffered saline (PBS) to remove any free-floating OBs, and fixed using a solution of 3.7% formaldehyde (Sigma-Aldrich, St. Louis, MO) in PBS for 10 minutes. They were then permeabilized using 1% Triton X-100 (Sigma-Aldrich, St. Louis, MO). The nuclei of the attached OBs were stained with Hoechst 33342 stain (Life Technologies, Carlsbad, CA) and mounted in glycerol solution (1:1 volume ratio of PBS to 98% glycerol) (Mallinckrodt Baker, Phillipsburg, NJ) in preparation for imaging and counting. The specimens were imaged using a Spot RT camera (Diagnostic Instruments, Inc., Sterling Heights, MI) attached to a Leica DM IL fluorescence microscope (Leica Microsystems, Wetzlar, Germany). They were exposed to light at a 355 nm wavelength in order to induce fluorescence of the Hoechst stain. Ten images were captured from each

sample at 20x magnification in order to quantify OB attachment and growth.

### Characterization of OB Morphology

One sample of each alloy was seeded with OBs then cultured for 48 hours and subsequently imaged using a SEM (JEOL 6300F, Tokyo, Japan) set at a 20 kV accelerating voltage in secondary electron mode. OBs were fixed with 3.7% formaldehyde for 10 minutes then dehydrated with 25%, 50%, 75% and 95% by volume ethanol in water for 10 minutes at each step. 100% ethanol was used as a final step for 10 minutes. Samples were then critical point dried with CO<sub>2</sub> and gold coated with a thin 21 nm thick coating (EMSCOPE SC500).

### Statistical analysis

Statistically significant differences ( $p < 0.05$ ) were identified using 1-way ANOVA testing and subsequent Tukey's post-hoc testing. Statistical software (Minitab® 15) was used to run 1-way ANOVA and Tukey's tests using material and time separately as independent variables.

## Results

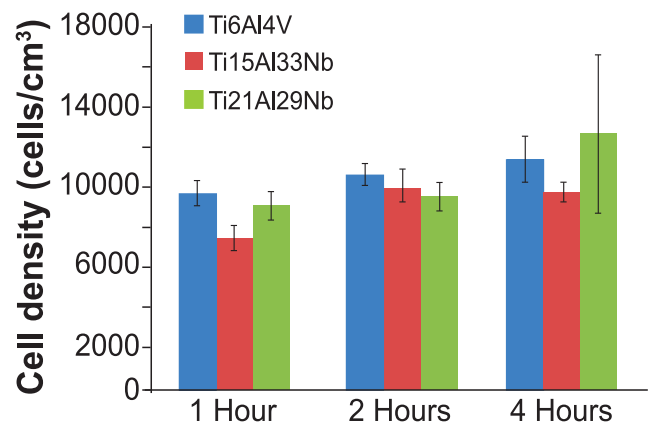
We compared the biocompatibility of TiNb alloys to TiV alloy through *in vitro* assays of OB attachment, growth and morphology.

### Attachment

OB attachment was measured at 1, 2 and 4 hours and plotted as a function of time. No significant differences ( $p < 0.05$ ) in OB attachment were shown between Ti6Al4V, Ti15Al33Nb or Ti21Al29Nb alloys at 1, 2 or 4 hours. OB density on Ti15Al33Nb at 1 hour was significantly lower than OB density on Ti15Al33Nb at 2 and 4 hours (Figure 1). Despite this initially lower OB density on Ti15Al33Nb alloys, compared to the same alloy at later time periods, the mean OB density on Ti15Al33Nb was not statistically different from the Ti21Al29Nb or Ti6Al4V alloys at any time period. This is an indicator of similar biocompatibility at early time periods (Figure 1). OB density on Ti6Al4V and Ti21Al29Nb alloys did not increase significantly over 1, 2 or 4 hours.

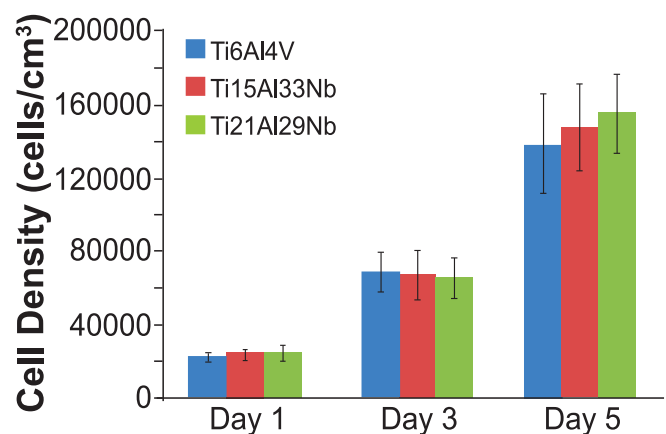
### Growth

OB growth was measured at 1, 3 and 5 days and plotted as a function of time (Figure 2). Densities on days 1,



**Figure 1** OB cell density on Ti21Al29Nb, Ti15Al33Nb and control Ti6Al4V. Data was collected after 1, 2 and 4 hours and run in triplicate. Significant differences ( $p < 0.05$ ) were found between Ti15Al33Nb at 1 hour and Ti15Al33Nb at 2 and 4 hours. No significant differences ( $p < 0.05$ ) were seen among alloy types at 1, 2 or 4 hours. Error bars represent standard error of the mean.

3 and 5 were not significantly different between alloys ( $p < 0.05$ ) (Figure 2). OB densities after 1 and 3 days of culture were not significantly different when compared to the same alloy over time. OB density was significantly higher ( $p < 0.05$ ) after 5 days of culture compared to 1 and 3 day OB density when comparing the same alloy over time (Figure 2). This indicates increased OB density and subsequent cell replication after 5 days of culture compared to 1 or 3 days.



**Figure 2** OB cell density on Ti21Al29Nb, Ti15Al33Nb and control Ti6Al4V over 1, 3 and 5 days. All samples were run in triplicate and significant differences were found using 1-way ANOVA and Tukey's post-hoc testing ( $p < 0.05$ ). No significant differences were found between alloy types at 1, 3 or 5 days. Day 5 OB density was significantly greater than day 1 and 3 OB density when comparing the same alloy across all time periods. Error bars represent standard error of the mean.



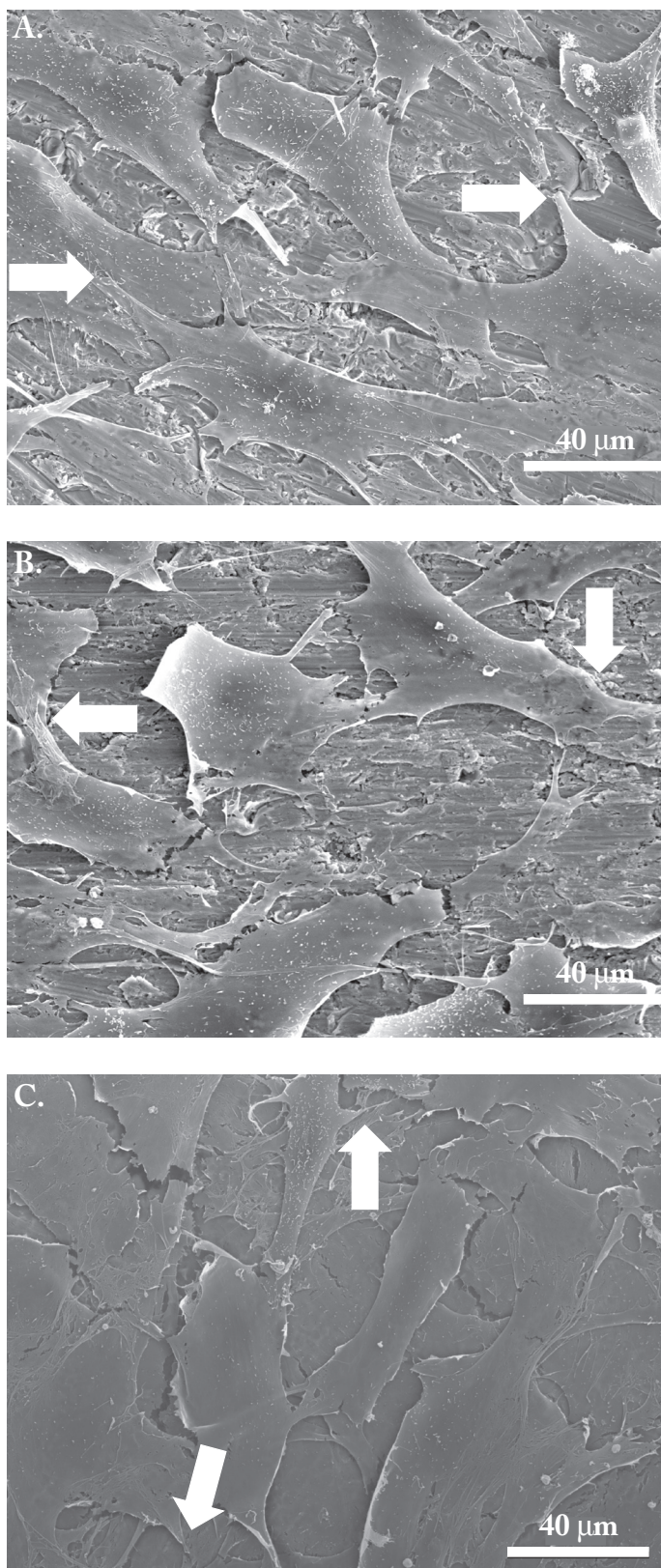
### Morphology

In order to examine morphology, OBs were allowed to attach to Ti21Al29Nb, Ti15Al33Nb and Ti6Al4V metal coupons for 48 hours. SEM revealed OBs attached to each substrate exhibiting a flattened elongated polygonal shape with noticeable early filopodia extending outward from the cell body (Figure 3). This morphology is characteristic of OBs growing on biomaterials and is similar to other published results (22-27). Points of attachment between OBs and the underlying Ti substrates were also observed on each alloy type.

### Discussion

Load-bearing joint implants must have both mechanical properties targeted to joint loading and superior biocompatibility. Ti6Al4V alloys are established as an industry standard orthopedic biomedical alloy. However, Ti6Al4V alloys contain vanadium, which is toxic and susceptible to wear. The wear particles from Ti6Al4V have been shown to be toxic (5), which is why it is imperative to investigate potentially safer alternatives. The mechanical properties of TiAlNb alloys are comparable, or even superior, to the Ti6Al4V alloy which makes them a potentially better material in load-bearing joint implants (6, 10, 12). Earlier studies have demonstrated the biocompatibility of milled TiNbAl particles using animal models, however the *in vitro* biocompatibility of coupons of TiAlNb had not been investigated prior to these studies (28).

We evaluated *in vitro* biocompatibility using osteoblasts to compare the industry standard Ti6Al4V to Ti21Al29Nb and Ti15Al33Nb and found that these Nb containing alloys have comparable early stage *in vitro* biocompatibility. Initial cell attachment and growth assays showed similar biocompatibility of Ti21Al29Nb and Ti15Al33Nb to Ti6Al4V at each time period evaluated. All alloys showed increased ( $p < 0.05$ ) growth at 5 days compared to 1 and 3 days indicating a period of higher cell replication. Based on the results of the attachment and growth assays, the Ti21Al29Nb and Ti15Al33Nb alloys have comparable biocompatibility to the Ti6Al4V alloy. Examination of OB morphology in the SEM images on all three Ti alloy substrates provides further evidence of the similar biocompatibility of Ti21Al29Nb and Ti15Al33Nb to the industry standard alloy, Ti6Al4V. OBs showed characteristic spreading and spiculation on



**Figure 3** Secondary electron SEM images of OBs spreading on the surfaces of A) Ti21Al29Nb, B) Ti15Al33Nb and C) control Ti6Al4V at 1000X magnification. The white arrows denote points of attachment between OBs and the underlying Ti alloy substrate. Similar characteristic OB morphology is observed on all Ti alloy substrates.

Ti substrates, despite differences in alloy composition.

The longer time frames of the growth study compared to the short times used in the attachment study help further establish the *in vitro* biocompatibility of these TiNb alloys as compared to the widely used Ti6Al4V material. Although the Ti15Al33Nb alloy initially exhibited lower attachment at 1 hour compared to 2 and 4 hours, it should not be ruled out as a potential replacement for Ti6Al4V as it was still receptive to cell attachment and growth at longer time periods (Figures 1 and 2). Shapira et al. demonstrated the biocompatibility of Ti6Al7Nb compared to Ti6Al4V via cell attachment, growth, differentiation, morphology and detection of growth factors using longer time periods (up to 7 days) in their evaluation (10). Their results suggest that the presence of Nb may induce earlier OB maturation compared to Ti6Al4V. *In vitro* studies characterizing the differentiation behavior of OBs on Ti21Al29Nb and Ti15Al33Nb with Ti6Al4V as a control should be performed in a manner similar to Shapira et al. in order to observe any effects of alloy stoichiometry before *in vivo* testing is conducted.

Based on these initial findings, both Ti15Al33Nb and Ti21Al29Nb alloys show promise as a replacement for Ti6Al4V. These titanium alloys may provide a safer alternative to the industry standard Ti6Al4V that carries the risk of toxicity. 🌱

## Acknowledgements

This work was funded by the research programs of Associate Professors Baumann and Boehlert. Thanks to Dr. Jeff Quast (former MSU PhD graduate student) for assistance with alloy preparation.

The authors would like to thank the Honors College Professorial Assistantship program for funding Rachel Kamish who assisted with cell culture, sample preparation and biological data processing. We also thank the Center for Statistical Training and Consulting at MSU for offering support with the statistical methods and software used in this study.

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### Editor's Note,

Titles of articles in reference list were excluded due to space constraints.



# About the Contributors

Katelin McArdle | ReCUR Managing Editor  
College of Arts and Letters

## Nicholas Baker and Claire Church



Nicholas Baker, a third year student from Davison, Michigan, and Claire Church, a second year student from Lansing, Michigan, are co-producers of the film “Searching,” on pages 30-31. Both are members of the Honors College, and each is pursuing a major in Media Arts and Technology in the College of Communication Arts and Sciences. When asked about the idea for this project, they described their inspiration: “For our TC 341 class, our professor, Troy Hale, assigned a documentary to the class

and while thinking of our topic, we stumbled upon an article in The State News about a young couple who created an organization to search out spirits.” Both Claire and Nicholas are part-time student directors for the Big Ten Network StudentU, in addition to being student producers for the MSU Sports Broadcasting Department.

## Hollyce Balentine



Second year Honors College student Hollyce Balentine, from Traverse City, Michigan, is the author of “The ABCs of Disordered Eating”, on pages 6-8. She is majoring in Professional Writing in addition to pursuing a second major in Spanish. When

asked about her inspiration for this piece, she replied, “This piece was the product of one of my creative writing classes here at State. The format was inspired by a published piece of creative nonfiction we read in class.”

## Diana Busby



Diana Busby, whose work “I’m an Art Major.” “...Oh” can be seen on pages 15-16, is a third year student from Charleston, West Virginia. She is studying Studio Art in the College of Arts and Letters. When asked about the origins of this work she responded,

“I created this work under the instruction of Ryan Claytor, who was a great inspiration to me. Without his guidance, I might have never become interested in comics as an artistic medium, and it is thanks to his teachings that I continue to pursue art today.”

## Christine Collins

Christine Collins, a second year student in the Honors College from Ann Arbor, Michigan, wrote the poem “Marred” on page 32. She is majoring in Linguistics in the College of Arts and Letters. Asked about the background of the poem, she said, “In the spring of ‘09 I took a poetry workshop class taught by Diane Wakoski and learned how to use poetry to confront my own health problems. “Marred” was written on a humid day in April, when my feet wouldn’t fit into my shoes and I, not knowing why, decided quite naturally to put them into a poem instead.”

*Editor’s Note:* Photo Unavailable

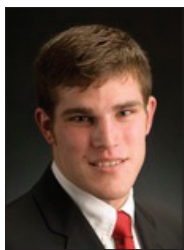
## Carlee Forbes

Carlee Forbes, the designer of “Mali meets Michigan,” featured on the back cover, is a fourth year Honors College student from Kalamazoo, Michigan, who is currently pursuing two majors, Residential College in the Arts and Humanities and also History, as well as a minor in French and a specialization in Museum Studies. A description of her work and its inspiration can be found on the inside back cover.

*Editor’s Note:* Photo Unavailable



## Robert Friederichs and Marc Schlaud



Robert Friederichs and Marc Schlaud, co-authors of “Osteoblast Attachment and Growth on Novel TiNbAl Alloys” on pages 33-37, both graduated from the College of Engineering in 2009 with a degree in Materials Science and Engineering. Robert, who is from Rochester Hills, Michigan, is an alumnus of the Honors College and current graduate student at Cambridge University, UK. When asked about his undergraduate research experience, he noted, “My passion for science and discovery led me to pursue a summer research internship with Dr. Melissa Baumann after

my first year at Michigan State... My interactions with my mentor have supplemented my coursework and made me realize my passion for research. I have pursued graduate studies as a direct result of my undergraduate research experiences.” Marc, who is currently employed as a Quality Engineer at W.L. Gore and Associates in Flagstaff, AZ, describes his experience in undergraduate research: “I became involved in undergraduate research with Dr. Baumann after completing two of her classes and meeting with her as my Honors College advisor many times, allowing me to learn about and gain an interest in her research. Working in a research setting with Dr. Baumann, I learned a great deal more than I would have exclusively in a classroom setting.”

## Alexandra Ghaly



Alexandra Ghaly, the author of the poem “Main-stream Lace” found on page 24, is a second year student in the Honors College from Tarpon Springs, Florida. Alexandra is pursuing a double major in Interdisciplinary Humanities and Anthropology.

## Satpreet Kahlon



Satpreet Kahlon, a third year Honors College student studying Art and Art Education in the College of Arts and Letters, is the creator of “I Am Still Like a Cat. No. A Kitty. A Cute, Cute, Kitty.” on page 21. Satpreet

was born in India, grew up in Chicago, and attended high school in Muskegon, Michigan. She shared her inspiration behind her artwork: “From the time when I was six years old, kneeling in front of my living room window for hours at a time, a piece of ornate Christmas wrapping paper taped to the window so that I could trace the swirly pattern onto its backside, I have been thinking about art. And I have never stopped thinking about it. It fills my brain. It fills my eyes. It fills my arms, my legs, my chest. It fills every part of me, starting with my lungs and ending with the space between my fingers. It is something I carry. It is something I carry with me. And everything I create is a piece of myself that I have gathered to give to you.”

## Alex Kreger



Alex Kreger, a second year student in the Honors College from Brookfield, Illinois, composed the piece “With your Thoughts” on page 22. Majoring in Composition, Jazz Studies and also Piano Performance in the College of Music, Alex described his inspiration for the piece: “This piece was an attempt of mine to bring together in dialogue performers from diverse musical traditions; to create a common ground on which they could communicate and transcend genre borders without becoming a “crossover” project. My composition professor Ricardo Lorenz gave me invaluable advice and support throughout the whole process; his guidance has helped me develop my style as a composer as well as determine my course of study here at MSU.”

## Ashley Kulczycki



Ashley Kulczycki, whose research paper, “Finite Element Analysis of a Beetle’s Forewing,” is found on pages 17-20, is a fourth year student in the Honors College from Troy, Michigan. A Mechanical Engineering major in the College of Engineering, Ashley described how her research project began: “Dr. Baek was my deformable solids instructor, and I asked if I could do an honors option for the class. He suggested a research project and encouraged me to submit the paper for this publication, further expanding my educational experience at MSU.”

## Michelle Martinelli



Michelle Martinelli, a second year student in the Honors College from Grosse Pointe, Michigan, is the author of “It’s the Journey” on page 14. Michelle is majoring in the Residential College in the Arts and Humanities. She explained the background of her work: “This piece was originally an assignment for Dr. Laura Delind in her RCAH 292A class, and we were instructed to create our own version of George Ella Lyon’s poem, “Where I’m From.” In order to do this, I explored the concept of where I am from and how I would define that to another person. I reminisced about my childhood experiences and how they have melded together to form the person that I am today, and I referenced different experiences in my version. Each reference is personally significant in my life and has somehow contributed to my personality and character.”



## Sarah McKee

Sarah McKee, the author of the article “The Effects of Acid Sphingomyelinase Deficiency on Bone” on pages 9-13, is a second year student from Arlington Heights, Illinois. She is a member of the Honors College and is currently studying Physiology in the College of Natural Science. Sarah described how her work on this research began:

“My mentor is Dr. Laura McCabe. I began research in her lab last summer. I have learned a great deal about the steps that go into research and how one gets from raw data to a publication, in which Dr. McCabe has been guiding me through many of the steps.”



## Alyssa Meyer

Alyssa Meyer, whose painting “Cloudy With a Chance of Rain” is the cover of this issue, is a third year Honors College student from Houghton Lake, Michigan. She is in James Madison College, double majoring in Political Theory and Constitutional Democracy as well as International Relations. She described the role that art occupies in her life: “I have been painting since I could pick up a brush. It has always been my means of expressing what is on my mind or in my heart. In college, it has become a wonderful stress reliever from all my Madison work.”



## Joshua (J.T.) Whitman

J.T. Whitman, a second year Honors College student from Dewitt, Michigan, is the author of “Incorporating Interdisciplinary Understanding for K-12 Students Using a Biomimetic Device”, on pages 24-29. J.T. is a Mechanical Engineering major in the College of Engineering. When asked about his research, he said, “I became involved with undergraduate research through the Honors College Professorial Assistantship program in which I joined Dr. Seungik Baek’s Cardiovascular and Tissue Mechanics laboratory. My participation in the lab has equipped me with many valuable experiences and allowed me to become a better-rounded student.”



# Closing Remarks from the Provost

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It is a joy to greet you in this inaugural issue of the first journal published by the Michigan State University Honors College. I was excited to learn in 2009 that the journal was not just a dream, but would soon become a reality. By the fall, it was clear that the commitment of faculty and students across campus would result in an effort to mount not just a successful journal, but a community of scholars dedicated to advancing undergraduate research and creative works. The Red Cedar Undergraduate Research Journal (ReCUR) brings together the creative work and research of some of the best and brightest undergraduates at this fine institution.

The Journal's editorial board and staff have worked to showcase many of the wonderful educational opportunities at Michigan State University and to expand these opportunities by providing students with the chance to be part of the publication process. From serving on the editorial staff and student editorial board to submitting their own work, there are a myriad of opportunities for students to be a part of ReCUR. Judging by the number of faculty members who have volunteered to serve as mentors to the student editorial board, it is clear that the Journal is more than a fine scholarly journal; it is a labor of dedication and commitment.

I applaud the student authors, their faculty mentors, and everyone on the campus of Michigan State University who endeavored to bring ReCUR forth. I look forward to many more issues highlighting the fine work that our students continue to do.

Sincerely,

A handwritten signature in black ink, appearing to read "Kim A. Wilcox". The signature is fluid and cursive, written over a light-colored background.

Kim A. Wilcox, PhD

Provost and Vice President for Academic Affairs



**Eustace-Cole Hall, Home of the Honors College**



# Location for CD of Performance of “With your Thoughts” in Print Version of ReCUR

Also available at [www.recur.msu.edu](http://www.recur.msu.edu)



## About the back cover

*Mali meets Michigan*

By Carlee Forbes  
Residential College in the Arts and  
Humanities

### Artist's Statement

*My creative project came out of a study abroad to Mali in 2008; on this trip I was acquainted with my faculty mentor, Chris Worland. In the spring of 2009, I took her creative workshop on textiles and was able to complete this piece, a hybrid of American and West African textiles, to serve as a memory and conversation starting point about my experiences in Mali. ♡*





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