

ReCUR

Red Cedar Undergraduate Research

Michigan State University



2015

Volume 5

ISSN 2375-401X

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About ReCUR

ReCUR is a publication of the Michigan State University Honors College that highlights the diversity and quality of our students' research and creative endeavors. Each issue of ReCUR accepts submissions from Honors College students and from participants in the University Undergraduate Research and Arts Forum (UURAF). In addition to providing students an outlet for publication of their work, ReCUR offers students an opportunity to become familiar with the editorial process as a member of the Editorial Staff or Student Editorial Board.

Contact ReCUR

Honors College
Eustace-Cole Hall
468 E. Circle Drive, Room 105
East Lansing, MI, 48824

Phone: 517-355-2326

E-mail: recur@msu.edu

Website: www.recur.msu.edu

About Citation Formats

As ReCUR is an interdisciplinary journal, we respect the citation formats of the various fields of our authors. Thus readers will notice in-text and reference list differences depending on the style guide the author has submitted. General stylistic issues are edited per the *Chicago Manual of Style*.

About the Cover

The cover is a collage inspired by the different research topics explored in this issue. As suggested by the silhouettes, the topics vary greatly in nature, ranging from the Vietnam War to animal husbandry. Nevertheless, the harmonious composition represents ReCUR's objective of showcasing the diversity of research being conducted at Michigan State University.

-Linh Dao

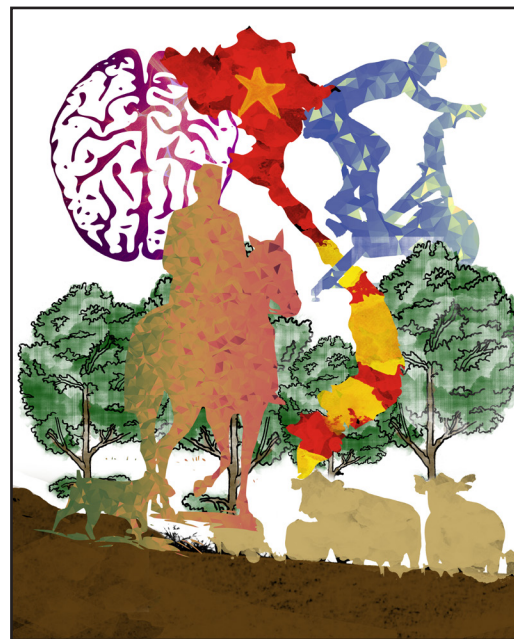


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Feature: One Book, One Community

Feature: Student-Run Publication Breaks Boundaries

Exceptions Hosts “Accessible Art” at Broad Art Museum

Lauren Link and Casey McDougall

Department of Writing, Rhetoric and American Cultures

Exceptions journal is the product of a student’s research at MSU and his passion for bringing a more humanistic element to scientific breakthroughs on blindness.

Launched in 2013 by then MSU Honors College senior Craig Pearson, *Exceptions* has expanded to become a creative arts journal, web community, and on-campus organization, all in one. Editorial staff members work together at MSU—and remotely from Cambridge, England, in Pearson’s case—to produce this uniquely inclusive publication.

What sets *Exceptions* apart is its mission to showcase the perspectives of individuals who are blind or visually impaired.

The journal solicits submissions from across the country in order to highlight a diverse spectrum of experiences from people with vision loss. Content featured on the journal’s website includes poetry, short story fiction, nonfiction narratives, music, and tactile art. The first print edition of *Exceptions* was published in spring 2015, shortly followed by an audio book available on the journal’s website.

The editorial staff was eager to create something new and undertook the audio book production with zeal. “Our editors did the voiceover for the audio book and we recorded it at the Library of Michigan in Lansing, through the Braille and Talking Book Library,” said managing editor Katie Grimes. “They were wonderful, they let us use their recording studio for free and helped us whenever we had questions along the way.”

On April 24, 2015, *Exceptions* hosted an event titled “Accessible Art” at the Eli Broad Art Museum on MSU’s campus. Members of the ReCUR Editorial Staff had the opportunity to attend the event and interviewed two members of its editorial staff.

The event was the product of university-wide interdisciplinary cooperation.



Photo by: Stepheni Schlinker

Michigan State University student Jordyn Castor experiences a textile painting while listening to the poem that inspired the piece of art.

Students enrolled in Professor Robin Silbergleid’s poetry course with wrote original poems for the exhibit, which were used as inspiration for students enrolled in Professor Alisa Henriquez’s studio art course. The art students created paintings with tactile elements that guests could experience both visually and through touch.

The exhibit featured paintings mounted adjacent to the poems, displaying a wide range of interpretations by students and appealing to visitors both sighted and blind. At the event, Michael Hudson, the director of MSU’s Resource Center for Persons with Disabilities (RCPD), gave a talk on museum accessibility. A behind-the-scenes documentary highlighting the creation of the exhibition was also featured.

Jordyn Castor, a computer science major at MSU who is also blind, enjoyed her time as a visitor at the exhibit. She appreciated the different interpretations of the poems that the art students depicted.

She said, “there was Braille on a couple of them. That was really cool and they did a really good job.”

The staff of *Exceptions* hopes to reach more individuals like Jordyn, and to encourage them to submit their work.

“I think it’s important to recognize that blindness is not a ‘problem to be fixed,’ but an authentic part of people’s human experience—and what better way to access that human experience than through stories and art?” said Pearson.

He and the *Exceptions* staff convey this in every aspect of the journal, from the print and audio publications to the blog available on their website.

The “Accessible Art” event was an opportunity for the entire MSU and East Lansing community to gain insight into others’ different experiences of the world. Sighted visitors were able to appreciate the exhibit as a means of reaching out to people who may not traditionally get to experience art.

Cale Felker, a junior human biology major at MSU, said, “it was cool to see other people interacting.”

He and another student spoke to ReCUR about the social stigma held toward people with disabilities, which often lead to their exclusion from activities that haven’t been adapted for their disability. Events hosted by *Exceptions* and other disability-inclusive organizations strive to erase that stigma.

When asked what has been most rewarding about his work with *Exceptions*, Pearson answered, “getting to meet our incredible contributors—people across the visual ability spectrum who have phenomenally diverse experiences and points of view—has been deeply rewarding. I’ve spoken with an Afghan war veteran, a MasterChef winner, and an award-winning scientist, just to name a few. The fact that they are blind is just part of a much bigger story.”

For more information about *Exceptions* and to experience the journal firsthand, visit exceptionsjournal.com.



Photo by: Stepheni Schlinker

The editorial staff of *Exceptions* (left to right): Natalie Phillips, Zach Reilly, Lana Grasser, Savannah Smith, Katie Grimes, Phil Olson, and Erin Surge. Not pictured: Craig Pearson.



Photo by: Theresa Abalo

Attendees of “Accessible Art” were encouraged to touch every painting for the full experience.



Photo by: Stepheni Schlinker

Michael Hudson, the director of the Resource Center for Persons with Disabilities (RCPD), and his daughter interact with a painting at the “Accessible Art” event.

From Technical Assistant to Total Antagonist: Stanley Sheinbaum and Vietnam

J. Andrew Stables | James Madison College

By 1965, the United States had begun its formal military operations in Vietnam, sending more troops into combat by the day. While many people defended the presence of American troops in Vietnam, there were a growing number of groups consisting of academics, students, and progressives who were opposed to the war. This emerging debate between prowar and antiwar factions brought hundreds of students to the union building at the University of Oregon one May evening for a university-planned teach-in. Here, a list of speakers including politicians and academics alike gathered to evaluate and critique American policies in Vietnam (Levitas). As reported by the *New York Times*, this teach-in drew students and community members from all walks of life, creating an atmosphere where “freshman argued fearlessly with senior professors” and “[p]latoons of ‘Greeks’—fraternity men—debated with intellectuals they ordinarily ignore as ‘smokies’” (Levitas 25). In essence, the scene was full of debate.

Included in the group of speakers at the teach-in was a man named Stanley K. Sheinbaum, a former employee of Michigan State University (MSU). His role at the teach-in was unique, for he had experienced the adverse effects of American foreign policy in Vietnam while campus coordinator of an MSU technical aid project known as the Michigan State University Advisory Group (MSUG). After a speech by antiwar Senator Wayne Morse of Oregon, Sheinbaum approached the podium full of energy, but became so overwhelmed that he “passed out [for a moment while] holding onto the lectern” (Sheinbaum quoted in Ernst 125). Nevertheless, Sheinbaum recovered to give a thorough explanation of the real problems with American state-building policies in Vietnam. This speech capped a major transition in his life, an about-face from advocating containment in Vietnam only five years before.

Sheinbaum’s change of values reflected a stark contrast from the main goals of Cold War American foreign policy at the time, which focused on containing Soviet Communism at all costs. After graduating from Stanford University with a master’s degree, he was hired by MSU in 1955 to teach economics and serve as the campus coordinator for the MSUG (Sheinbaum and Meis 32, 36). While Sheinbaum started this position with high hopes of what American experience in public policy, economics, and security—which he referred to as “know-how”—could do for the “backward Vietnamese,” Sheinbaum’s experiences on the project eventually exposed him to the less-glamorous sides of state building (Sheinbaum 9). He realized the cookie-cutter method whereby the United States tried to employ unilateral capitalist and democratic systems in countries with widely different backgrounds would not necessarily succeed. He therefore left the MSUG to critique American policies in Vietnam, later becoming a staunch antiwar advocate. Ultimately, Sheinbaum was able to change the public’s views on involvement in Vietnam from procontainment to prodisengagement by sharing his experiences of the effects of misguided state-building policies, making him a pioneer academic of the nonradical antiwar movement.

Before exploring Sheinbaum’s initial support of containment and overseas development, more must be said about the state building and the MSUG itself. The United States had emerged as the world’s leading democratic superpower after World War II. However, the Soviet Union quickly rose to a superpower status as well, posing a new threat to democracy through communism. As the new defender of the free world, the United States again faced the challenge of how to make the world safe for democracy. In the early years of the Cold War, it was determined that the solution would be through massive financial and technical aid programs, such as the Marshall Plan in Europe.

Such large-scale financial aid and technical development later became known as state building (Dreyfuss, Sheinbaum, and Scheer). South Vietnam was one example of American state building, where a high vulnerability to communism from the north, coupled with a troubled history of foreign occupation, made democratic development crucial yet costly. Knowing the demands of state building were high, the United States government incorporated universities into their plans for technical assistance to provide the additional resources and manpower that were required. MSU was chosen to provide this technical support to South Vietnam due to its special connections with the nation's new leader Ngo Dinh Diem, forming the MSUG in October 1954 (Ernst 12). The MSUG sought to reform South Vietnam by providing technical assistance in the areas of public administration, police administration, and civil servant training in order "to create a new whole: a composite, really, of other, western and modern states" (Ernst xi; Carter 14). Even though aid given on this basis had the potential to be exploitive, many people believed using the knowledge of the developed world to modernize the third world was crucial to its survival in the modern era.

Thus Sheinbaum began his employment at MSU with high hopes, for he felt that the MSUG provided a great way to show America's rising potential as a catalyst for positive change. He, like many of the "Greatest Generation" who had fought in World War II, felt that America would be able to save the world from persecution and political avarice (Sheinbaum and Meis 36). Consequently, the state-building activities of the MSUG appeared to him as a means by which to achieve stability in Southeast Asia. In East Lansing, MSU's changing role was met with much enthusiasm in the late 1950s. Sheinbaum reflected these sentiments in a 1957 edition of the *Michigan State University Magazine*, where he wrote that the university's old slogan "The State is our Campus" was "being replaced by another more encompassing one: 'The World is Our Campus'" (Sheinbaum 9). Both MSU and many other American universities found international assistance programs as the perfect way to impart their time-honored knowledge overseas to nations that were less developed and modernized. Sheinbaum lauded this new focus in international development, which marked a shift from merely giving nations goods to providing the ability for nations to produce goods of their own. The result was that from 1950 to 1955, assistance in terms of just giving money declined from 20% of aid

to less than 1% (Sheinbaum, "Vietnam" 9). Along with other technical assistance programs, MSU professors were helping the Vietnamese and other third-world nations learn how to help themselves.

Moreover, Sheinbaum's role at MSU teaching economics allowed him to put the university's work abroad in an academic perspective. He originally saw the project as "an overseas extension, albeit a somewhat unique one, of the American educational system" (Fishel). As campus coordinator, Sheinbaum had the primary responsibilities of hiring and recruiting professors to work for the MSUG in Saigon, acting as the intermediary between the campus and the overseas branch of the project, and overseeing the participant program (Dreyfuss, Sheinbaum, and Scheer). The participant program fell especially close to Sheinbaum's ideal vision of American assistance. This program focused on postgraduate education for Vietnamese students through exchange programs in the United States, Japan, and other developed countries to expose them to modern techniques in public policy and law enforcement (Ernst 91). Ideally, these students would return to their home country prepared to address pressing political, economic, and security issues. While the program did not always adequately prepare these students in critical programs such as English language learning, it became quite successful in furthering the education of Vietnamese civil servants, something of which Sheinbaum was particularly proud (Ernst 8). All new ventures had their mistakes and inefficiencies, so it was seen as only natural that the MSUG would have a few of its own. Above everything else, Sheinbaum believed democratic development should be accompanied by a good civic education and culturally conscious plans to reduce South Vietnam's inefficiencies. He felt the participant program accomplished this goal, writing in the *Michigan State University Magazine*, "[A] democratic government should serve its people, and ... the people should be made increasingly aware of its activities." To the best of his knowledge, this was exactly what the MSUG was doing in Saigon as well, making the venture "a rewarding and satisfying experience" (Sheinbaum, "Vietnam" 11-12). As a result, Sheinbaum fulfilled his duties in full confidence of the MSUG's efforts.

Sheinbaum soon realized, however, that the MSUG was not living up to its original goals, and he consequently became disillusioned with the group, eventually parting ways with it altogether. Sheinbaum had been running the campus side of the project for

several years when in October of 1957 he decided to visit Saigon to see how the project was coming along (Fox). Once in Saigon, he toured the MSUG facilities and projects. He found that much positive work was being done in agricultural production and civil servant education but also that other divisions, such as police training, were engaging in more questionable activities (Hinckle, Scheer, and Stern). For instance, Sheinbaum was denied entry onto the fifth floor of 137 Pasteur, Saigon, the site of MSUG headquarters, because it contained “classified” operations. In a later interview, Sheinbaum commented, “What was odd about [not being let on that floor] was I couldn’t look at the people I’d hired to talk to them about their work” (Dreyfuss, Sheinbaum, and Scheer; Hinckle, Scheer, and Stern). Upon further investigation, Sheinbaum found out from one of his participant program students that he was denied entry because of the presence of CIA operatives, who were working under the cover of the MSUG (Sheinbaum and Meis 40). This revelation startled him. If CIA operatives were involved with the police training, the university’s degree of autonomy in the project was questionable. Furthermore, it was possible that the federal government was forcing the MSUG to make decisions for the good of the United States at the expense of the South Vietnamese people. Sheinbaum’s fears were later confirmed in the official book on the MSUG, titled *Technical Assistance in Vietnam*: “The approach [of the MSUG in Vietnam] meant that outside groups could impose unsuitable priorities upon the University Group” which included “the CIA unit that had been operating within MSUG” (Scigliano and Fox II, 66). Despite his concerns, Sheinbaum remained with MSU and the MSUG until 1959 to continue his roles as coordinator and economics professor.

Even though he stayed at MSU for two years after his discovery of the CIA presence in the MSUG, Sheinbaum was already changing his views on state building. He questioned the role of academia in executing American foreign policy. He wanted to know how the MSUG was actually being used. Fortunately, as campus coordinator, Sheinbaum was constantly relaying messages between the MSUG chief advisor and MSU President John Hannah and therefore had a unique position from which to gather this information. One letter relayed by Sheinbaum from Wesley R. Fishel, an MSU professor, one-time coordinator, and influential founder of the MSUG, gave the details of his dinner conversation with South Vietnamese Pres-

ident Ngo Dinh Diem:

The President was particularly impressed by the “High caliber” of the faculty, by the remarks on foreign aid made by Governor Williams, and by the cold weather that greeted him in Lansing. He tells me he barely avoided the mistake, when visiting the Ford River Rouge plant, of asking Henry Ford [II] if that was the place where they made Oldsmobiles. Just before the remark would have passed his lips, he turned to an aide and whispered the question and got the obvious reply that Olds was a GM product and he shouldn’t say a thing about it to Mr. Ford. (Sheinbaum)

This message did not necessarily carry much sensitive information, but it highlighted the intimacy between the MSUG and Vietnamese government (GVN) and the strong influence of certain MSUG advisors on Diem. In relaying such messages, Sheinbaum was able to gauge the level of influence of the MSUG on the GVN from East Lansing. But he also sought insights into American overseas involvement from a variety of other sources. He dabbled in the pop literature of the day that discussed the evils of American overseas activities, including Graham Green’s *The Quiet American* as well as Eugene Burdick and William Lederer’s *The Ugly American*. Sheinbaum shared both novels with the dean of the MSU College of Science and Arts, Milton E. Muelder, prompting him to write that the MSUG and the United States in general still had “a long, long way to go” in improving technical assistance methods (Muelder). Muelder, like many other MSU professors, recognized the problems with the MSUG but viewed its overall efforts in a more positive light than Sheinbaum. Thus Sheinbaum became somewhat marginalized among the faculty because of his highly critical views.

Further complicating matters was Hannah’s response to Sheinbaum when he paid Hannah a visit to voice his concerns about the MSUG. Sheinbaum recalled in his memoir that his voicing concern about the CIA’s role in the MSUG prompted Hannah to say, “You know, Mr. Sheinbaum ... [that] is really none of your business,” and that if he could not accept that, Hannah would be fine with accepting his resignation (Sheinbaum and Meis 41). Sheinbaum became exhausted with his work and his attempts to reconcile his own ideals with the realities of the MSUG. He requested four months leave to begin in August of 1959, during which faculty member Stan Gabis would

replace him as campus coordinator (Sheinbaum). While still technically employed by MSU until August 31, 1960, Sheinbaum never returned to MSU after his leave (Termination of Employment Form). His rationale for leaving was largely due to his aforementioned grievances with Hannah and the MSUG but also for being passed over for a pay increase (Ernst 124). Fortunately, Sheinbaum's resignation opened up new opportunities to more actively champion his new views on Vietnam.

Sheinbaum began his critiques of the MSUG and American state building directly after leaving MSU by taking advantage of a unique opportunity on the West Coast. He was invited in 1959 by the former president of the University of Chicago Robert Hutchins to join his new think tank, the Center for the Study of Democratic Institutions in Santa Barbara, California, to provide a perspective on academia's role in government policy (Dreyfuss, Sheinbaum, and Scheer). While at the center, Sheinbaum immersed himself in a great academic atmosphere where thinkers from all over the country congregated to debate current events and their implications on democracy. Here he flourished, writing papers that spurred much insightful debate. One paper in particular, arguing that capitalism did not work the way in which it claimed, led to an especially insightful discussion in regard to economic theory and American aid abroad. During this 1961 discussion, Sheinbaum related his arguments to the situation in Vietnam at the time:

I'd like to give a specific if I may [...] in Vietnam, for instance, where I've had some contact, we've gone in with the insistence of a market principle for the utilization of the funds that go in, and a political resistance on a "capitalistic" kind of economy [... The United States doesn't] recognize the violations we're doing to their principles ... for right or for wrong, the role of the profiteer in that society is a degrading one [...] nobody of consequence wants to assume that role, and yet we force it on them [...] This is a real clash of a value, and the bureaucrat who sits in Saigon doesn't have time to think through the problem. All he knows is that he has a [personal] commitment [...], and he assumes this is his own country's commitment for "capitalism." (Sheinbaum, *Sheinbaum Defends*)

Facilitating these types of discussions allowed Sheinbaum to sharpen his views within a highly critical

setting while also learning to hold his own in conversations with important thinkers, ranging from theologians to physics professors. Through such conversations, Sheinbaum also met people who became important in his personal life. He met his second and lifelong wife, Betty Warner, daughter of Harry Warner of the Warner Brothers film franchise, through his activities at the center (Dreyfuss, Sheinbaum, and Scheer). Betty Warner would become a crucial supporter of Sheinbaum's later activism and political ambitions. With her at his side, Sheinbaum was given more support to follow his principles, even when they were unpopular.

The first chance for Sheinbaum to really follow his principles rather than the status quo came when journalist Robert Scheer asked him to explain his role in the MSUG. While researching in the Berkeley stacks, Scheer had found a donated collection of MSUG papers that contained documents providing evidence that the CIA had tortured Vietnamese nationals while working under the cover of the MSUG (Sharaf). Using a list of MSUG members, Scheer phoned each person to get an explanation, but none would comment—except for Sheinbaum (Sheinbaum and Meis 51). Sheinbaum had been previously unaware of the torture, so this new development prompted him to give Scheer all the help he needed (Sheinbaum and Meis 51). They formed a team in which Sheinbaum provided the eyes of experience and Scheer the ears of an investigative journalist. Using his connections at the center, Scheer's first critique, *How the United States Got Involved in Vietnam*, was published in 1965 (Ernst 124). Scheer alluded to Sheinbaum's predicament while in the MSUG in his critique by writing, "If you are an ordinary [technical assistant] you will be listened to insofar as it sounds right. Otherwise you're considered a deviant. Only if you have high status will a deviant be listened to" (Scheer 37). While this critique did not receive much public attention, it marked only the beginning of Sheinbaum's years of activism.

The big break for Sheinbaum and Scheer came with the publishing of their findings in *Ramparts* magazine. The exposé written by Scheer and *Ramparts'* editor Warren Hinckle in 1966 was titled "University on the Make" and quickly gained national attention with its flashy title, colorful pictures, and harsh language about the MSUG and American state building in Vietnam. Sheinbaum added an introduction to the piece, decrying the failure of professors on the project, including himself, to question the American foreign

policy carried out by the MSUG, instead “hav[ing] only the capacity to be experts and technicians to serve that policy” (Hinckle, Scheer, and Stern 13). While his sentiments were well intentioned, the real controversy of the piece came across in a much simpler phrase: “What the hell is a university doing buying guns, anyway?” (Hinckle, Scheer, and Stern 22). This point caused the American political establishment and academic community to take another look at what the United States was doing in the name of democratic development.

Seeking answers to these questions drove Sheinbaum and Scheer fully into the antiwar movement, but in one of the most unique ways. By around 1966, Sheinbaum became aware of US plans to invade Cambodia under the suspicion that this was where the Ho Chi Minh Trail was located and asked Scheer to accompany him to find out (Sheinbaum and Meis 53). The Ho Chi Minh Trail was the trail by which the North Vietnamese guerillas were entering South Vietnam. Upon their return to the United States with photos of the Cambodian border without any sign of the Ho Chi Minh Trail (but did include the Australian ambassador as proof of their authenticity), the men went to Senator William Fulbright to present their findings. This visit provided the antiwar senator evidence to justify a call to delay the invasion of Cambodia, which did not occur until a few years later (Sheinbaum and Meis 54). Sheinbaum’s accomplishment was unique because he was providing an academic basis for his antiwar agenda. Not only were his findings educated, but they were also supported with thorough evidence rather than emotion. In the long run, Sheinbaum’s more objective methods would prove to be very effective in shifting the views of other influential politicians and public figures on the war, igniting the fuel for the larger public outcry to come.

The escalation of American involvement in Vietnam only caused Sheinbaum to double his efforts in calling for its termination with his best tool: reason. He knew that militancy did not need to be fought with militancy but rather with wit and ingenuity. In other words, Sheinbaum used his understanding of the complexities of the situation to change people’s minds. He traveled all across the country to speak at teachers, such as at the University of Oregon, focusing on how the American public had been misinformed about Vietnam (Dreyfuss, Sheinbaum, and Scheer). He also focused on speaking to unions because these groups were full of families whose children were be-

ing disproportionately drafted. One union leader in particular, Paul Schrade of the United Auto Workers, became a lifelong supporter of Sheinbaum’s social crusades because he gave Schrade an academic basis by which to defend his antiwar convictions and the evidence to convince his union members to do the same (Dreyfuss, Sheinbaum, and Scheer). Even though he was not receiving the same media attention as the more radical antiwar leaders, Sheinbaum’s ideas were no longer being ignored.

Building upon his antiwar agenda, Sheinbaum turned his sights to the political arena. Sheinbaum decided to run for Congress on an antiwar platform in both the 1966 and 1968 elections in Santa Barbara (Ernst 25–26). In this very conservative district, he looked to the unions, finding support in Cesar Chavez’s United Farm Workers (Sheinbaum and Meis 63). With these groups as his foundation, Sheinbaum built a small following. People were beginning to see the benefits of disengagement. To further his own name, Sheinbaum also campaigned for Senator Eugene McCarthy’s 1968 presidential campaign (Dreyfuss, Sheinbaum, and Scheer). This gave him positive publicity but also increased his list of enemies. Back in Santa Barbara, Sheinbaum’s wife Betty received threats and bullets through the front windows of their house (Sheinbaum and Meis 64). These acts of terror, although deplorable, illustrated that the conservatives of the area were concerned that the public was taking notice of Sheinbaum’s criticisms of Vietnam and that his campaign was beginning to succeed. Nevertheless, his one-issue campaign, heavy Brooklyn accent, and wallflower persona were lost on many people, causing him to lose both elections (Sheinbaum and Meis 64, 75). Yet the campaigns were not a complete loss. Sheinbaum had brought publicity to his long-time cause and thus raised public awareness of the call for peace.

Despite the efforts of Sheinbaum and many other antiwar advocates, the United States remained engaged in Vietnam for almost a decade. But that did not mean the antiwar movement had failed. Rather, the movement encouraged Americans from all walks of life to question their government and hold it accountable for its mistakes. Sheinbaum accomplished this better than most because he used reason, not emotion, as the basis of his arguments. He did not stop being an activist at the end of the war. In fact, his entire life, from organizing the defense of Daniel Ellsberg, who had leaked the Pentagon Papers, to dealing with the issues

surrounding the Rodney King beating in Los Angeles in the early 1990s, represented a larger ideal than what encompassed the antiwar movement (Dreyfuss, Sheinbaum, and Scheer). Sheinbaum took countless forms of injustice and corruption and put them on the public radar, forcing Americans to examine the issues that they would ordinarily be too busy to care about. He embodied a unique combination of academic and citizen watchdog who encouraged the public to do its duty by providing the “consent of the governed” that has long been the hallmark of American democracy. All people can follow Sheinbaum’s example by embracing their roles as informed citizens, regaining a keen eye to injustice, and challenging the feelings of apathy and complacency that plague contemporary politics.

References

Carter, James M. *Inventing Vietnam: The United States and State Building, 1954–1968*. New York: Cambridge University Press, 2008.

Dreyfuss, Richard, Stanley K. Sheinbaum, and Robert Scheer. *Citizen Stan*. Documentary. DVD. Directed and produced by Patty Sharaf. Atlanta: John Sharaf Photography, 2004.

Ernst, John, *Forging a Fateful Alliance: Michigan State University and the Vietnam War*. East Lansing: Michigan State University Press, 1998.

Fishel, Wesley R. “The Role of the MSU Group in Vietnam.” Address to the Rotary Club of Saigon, Saigon, Vietnam. Vietnam Project Records, UA2.9.5.5, Box 659, Folder 1, University Archives and Historical Collections, September 12, 1957.

Fox, Guy H. *Final Report Covering Activities of the Michigan State University Vietnam Advisory Group for the Period May 22, 1955–June 30, 1962*. Vietnam Project Records, UA2.9.5.5, Box 658, Folder 6, University Archives and Historical Collections. Saigon: Michigan State University Advisory Group, 1962.

Hinkle, Warren, Robert Scheer, and Sol Stern. “The University on the Make.” *Ramparts*, April 1966, 11–22. *The Sixties: Primary Documents and Personal Narratives, 1960–1974*. Accessed February 27, 2012. <http://asp6new.alexanderstreet.com.proxy1.cl.msu.edu/sixt/sixt.object.details.aspx?id=1003363529&view=du-alview&searchurl=12JAF>.

Levitas, Mitchel. “Vietnam Comes to Oregon U.” *New York Times*, May 9, 1965: SM24, 25. ProQuest His-

torical Newspapers, 1851–2007. Accessed April 3, 2012. <http://search.proquest.com.proxy1.cl.msu.edu/docview/116849825/13D70FDEEF336A1441F/3?accountid=12598>.

Muelder, Milton E. Letter to Stanley K. Sheinbaum. Vietnam Project Records, UA2.9.5.5, Box 632, Folder 11, University Archives and Historical Collections, March 9, 1959.

Scheer, Robert. *How the United States Got Involved in Vietnam*. Santa Barbara, CA: Fund for the Republic, 1965.

Scigliano, Robert and Guy H. Fox. *Technical Assistance in Vietnam: The Michigan State University Experience*. New York: Frederick A. Praeger, 1965.

Sheinbaum, Stanley K. Letter to John Hannah. Vietnam Project Records, UA2.9.5.5, Box 631, Folder 11, University Archives and Historical Collections, June 3, 1957.

Sheinbaum, Stanley K. Letter to Ralph Smuckler. Vietnam Project Records, UA2.9.5.5, Box 632, Folder 15, University Archives and Historical Collections, July 17, 1959.

Sheinbaum, Stanley K. *Sheinbaum Defends His Position That Capitalism Does Not Work the Way It Says It Does*. CD. Vincent Voice Library, Michigan State University Libraries, Voice 5627. Santa Barbara, CA: Center for the Study of Democratic Institutions, 1961.

Sheinbaum, Stanley K. “Vietnam: A Study in Freedom.” *Michigan State University Magazine*, February 1956, 9–12. Vietnam Project Records, UA2.9.9.5, Box 657, Folder 29, University Archives and Historical Collections.

Sheinbaum, Stanley K. and William A. Meis, Jr. *Stanly K. Sheinbaum: A 20th Century Knight’s Quest for Peace, Civil Liberties, and Economic Justice*. Vashon: Fairtree Press, 2011.

Termination of Employment Form for Stanley K. Sheinbaum. Board of Trustees Records, UA1, Box 1914, Folder 21, August 31, 1960.

Corticotropin-Releasing Hormone: Stress, the Brain, and the Gut

Andrew Mecca¹, Nadine El-Ayache^{2,3}, and James Galligan, PhD^{1,2}

¹ Neuroscience Program, Department of Physiology

² Department of Pharmacology and Toxicology

³ College of Osteopathic Medicine

Abstract

The impact of environmental stress on peripheral nervous system function is becoming increasingly recognized. Stress is well known to influence many centrally mediated psychiatric disorders including anxiety and post-traumatic stress disorder, but stress also induces long-term changes in neural function in the periphery. Corticotropin-releasing hormone (CRH) is an important mediator of the neuroendocrine stress response and its activity is altered in many central and peripheral disease states. We studied the expression of CRH at the level of sensory afferent nerves of a serotonin transporter gene knockout (SERT KO) animal model of visceral hypersensitivity; an abdominal pain symptom which has been shown to be influenced by environmental stress. CRH protein expression was visualized in sections of lumbar and sacral dorsal root ganglia (DRG) using immunohistochemistry and fluorescence microscopy techniques. We found that female SERT KO rats display greater CRH protein expression in sensory neurons compared to female wildtypes, and CRH was most strongly expressed in small-diameter afferents that are likely to be involved in the nociceptive pathway connecting the gastrointestinal (GI) tract and brain. Our results support the notion that environmental stress may play a role in visceral hypersensitivity and increased peripheral CRH signaling may present itself as a novel pharmacological target for more effective therapies.

Introduction

Visceral hypersensitivity is a poorly understood symptom characterized by generalized and non-specific pain emanating from thoracic, abdominal and pelvic viscera. Environmental stress is well known to influence the onset and severity of visceral pain, but its role in disorders such as chronic pancreatitis and es-

pecially functional gastrointestinal disorders has yet to be developed. Irritable bowel syndrome (IBS) is a common functional gastrointestinal disorder (FGID) that is characterized by visceral hypersensitivity and altered bowel habits.^{1,29} IBS is a global issue, affecting between 7-21% of the world's population.^{2,29} In the US, IBS presents a significant economic burden with direct and indirect costs summing to \$21 billion annually.² Preexisting therapies have limited clinical benefit; therefore a deeper understanding of the pathophysiology of visceral hypersensitivity is crucial to the development of more effective treatments. Impairment of the brain-gut axis is commonly associated with IBS and may involve both altered neural and behavioral factors.^{3,4} Interestingly, approximately 50% of all IBS patients also suffer from a comorbid psychiatric disorder such as anxiety or depression in which serotonin and corticotropin releasing hormone (CRH) signaling is altered.^{5,27,33} Additionally, IBS is twice as prevalent in females than in males in Western countries, which suggests the potential role of estrogen and/or other female sex hormones in IBS pathogenesis.^{6,29,30}

CRH is both a peptide hormone and local neurotransmitter that plays an important role in mediating the body's neuroendocrine response to environmental stressors.⁷ Abnormal CRH signaling facilitated by dysfunction of the hypothalamic-pituitary-adrenal (HPA) axis is influential to the development of inappropriate sensitivity to somatic and visceral stimuli.^{8,26} In rodents and humans, CRH has also been shown to influence gastrointestinal (GI) function.^{3,28} Peripheral CRH modulates both upper and lower GI motility and plays a role as a signaling molecule in pain-sensing afferent neurons.^{3,9} CRH is an appropriate candidate for studying the contribution of stress to IBS because it provides an observable link between HPA axis activity and visceral hypersensitivity observed in our female SERT KO animal model.^{1,31}

In addition to CRH dysfunction, altered serotonin signaling is observed in human IBS patients.^{1,10} Gene polymorphisms encoding the serotonin transporter (SERT) cause variability in the expression but not function of SERT, and genotypes containing a short (s) allele exhibit comprised SERT expression compared to healthy individuals.¹¹ SERT KO rats serve as an animal model for studying aspects of IBS, particularly the relationship between serotonin and visceral sensitivity.¹ Previous work in our lab has demonstrated that female SERT KO rats display sex-specific increases in visceral sensitivity which is coincidentally indicative of the female-dominated human IBS population. Accordingly, female SERT KO rats have increased colonic extracellular serotonin associated with hypersensitive colon-projecting sensory neurons.¹

CRH expression in sensory neurons has yet to be developed in a SERT-deficient animal model. Our results indicate a sex-specific increase in CRH expression among female SERT KO rats. Highly expressing CRH sensory neurons may therefore play a role as regulatory molecules in the nociceptive pathway connecting the brain and gut.

Methods

SERT KO rats

All animal use protocols were approved by the Institutional Animal Use and Care Committee at Michigan State University. The SERT KO and wildtypes control rats were acquired under license from Genoway, Inc.

Tissue processing, immunohistochemistry, and image analysis

Brain samples and lumbar/sacral dorsal root ganglia (DRG) were harvested from 4-5 month old rats and fixed in 4% paraformaldehyde (0.1 M phosphate buffer, pH, 7.4) for 24 hours. Brains and DRG were washed with phosphate buffer (0.01 M, pH, 7.4) and placed in a 30% sucrose solution overnight. 30 x 10 μ L sections were cut sequentially using a cryostat (Micom HM525 cryostat) to produce a set of 10 slides. Slides were stored at -80 °C.

Five slides were selected from each rat and immunohistochemistry was used to reveal CRH expression. Each slide was washed thoroughly with a 0.4% PBS-Triton solution containing 0.01 M phosphate buffered saline and Triton X-100 (Sigma-Aldrich). Sections were

washed with a 1% goat serum dilution (Sigma-Aldrich G9023-5ML) in 0.4% PBS-Triton twice for 10 minutes. Sections were blocked with a 5% goat serum dilution for 1 hour at 23 °C. Sections were then incubated in rabbit antiserum against α -CRF (1:200 corticotropin releasing factor, H-019-06, Phoenix Pharmaceuticals, Inc.) for 24 hours at 4°C. Primary antibody was diluted in a 1% goat serum dilution. Unbound primary antibody was washed off with 0.01 M PBS twice for 10 minutes. Sections were incubated in secondary antibody (1:300 Fluorescein-conjugated AffiniPure Fragment Goat Anti-Rabbit IgG, 111-096-003, Jackson Laboratories) diluted in 0.01 M PBS for 1 hour. After incubation, slides were washed twice with PBS for 10 minutes. Excess wash was removed, and one drop (-10 μ L) of ProLong Gold antifade reagent (Molecular Probes, Life Technologies) was placed on each tissue section; 24 x 50 mm cover glass was placed on each slide and edges were ringed in a clear fingernail polish.

All images were acquired at either 20X or 40X magnification using a Nikon TE2000-U fluorescence microscope. MetaMorph image analysis software was used to determine the thresholded area of intensity of CRH signal and to measure cell body diameter. Five representative images were taken and area of thresholded intensity was measured for each cell in the image. Data was obtained as a percentage of thresholded area compared to total cell area. Cell body diameter was calculated in microns, μ m, from the acquired cell surface area data. A cell was deemed positive (CRH+) if > 40% of the cell's total surface area was occupied by thresholded CRH signal. Averages were obtained from all five acquired data sets for each animal. Data is expressed as the sum of CRH+ or CRH- neurons from all SERT KO and wildtypes rats studied.

Retrograde labeling of colon projecting sensory neurons

Rats (4-5 months old) were anesthetized with 4% isoflurane gas and placed on a heating pad (-30 C) during the operation. The distal colon was exposed through an abdominal incision. Injections (7 x 1 μ L) of a 0.5% solution (0.1 mol L⁻¹ phosphate buffered saline, pH, 7.2) of cholera toxin- β subunit-Alexa 555 (CT- β -555) conjugate were administered subserosally using a sterile glass syringe (model # 725; Hamilton Company, Reno, NC, USA, 250 μ L) and a 26-gauge hypodermic needle (model # 7806; Hamilton Company). The colon was returned to the peritoneal cavity. The incision was closed using 4-0 sutures. Carprofen (125mg/kg,

s.c.) was administered to reduce postoperative pain. Five days later, rats were euthanized (pentobarbital, 100 mg/kg, i.p.) and lumbar/sacral DRG were harvested for immunohistochemistry and image analysis.

Data Analysis and Statistics

Data were analyzed using student's t-test when comparing two groups and Fischer's exact test was used to analyze contingency tables. $p < 0.05$ was considered statistically significant. Data were analyzed and represented using Prism 5 Graphpad Software (La Jolla, CA, USA).

Results

Increased CRH expression in DRG neurons from female SERT KO, but not male rats

To determine if SERT KO rats exhibit increased CRH expression compared with wildtypes controls, we probed dorsal root ganglia sections with immunohistochemistry (thickness = 10 μm) using an antibody

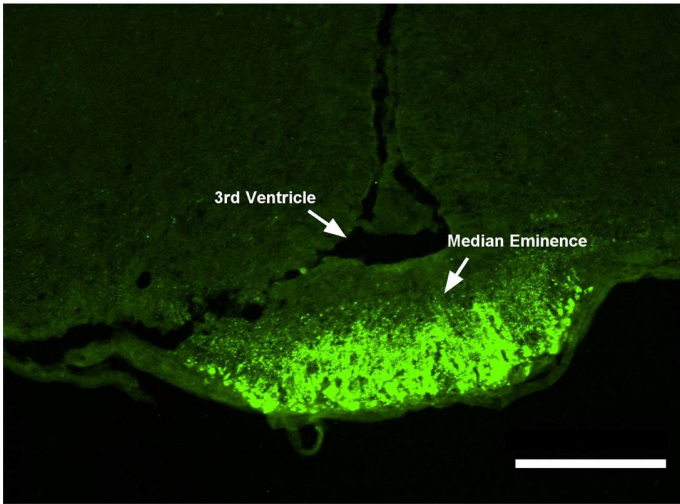


FIGURE 1: Representative coronal brain slice (thickness = 10 μm) from a female SERT KO rat showing CRH expression in the median eminence. Arrows indicate the third ventricle and median eminence, respectively. Intense CRH immunofluorescence in the median eminence confirms anti-CRH antibody specificity. Scale bar = 100 μm .

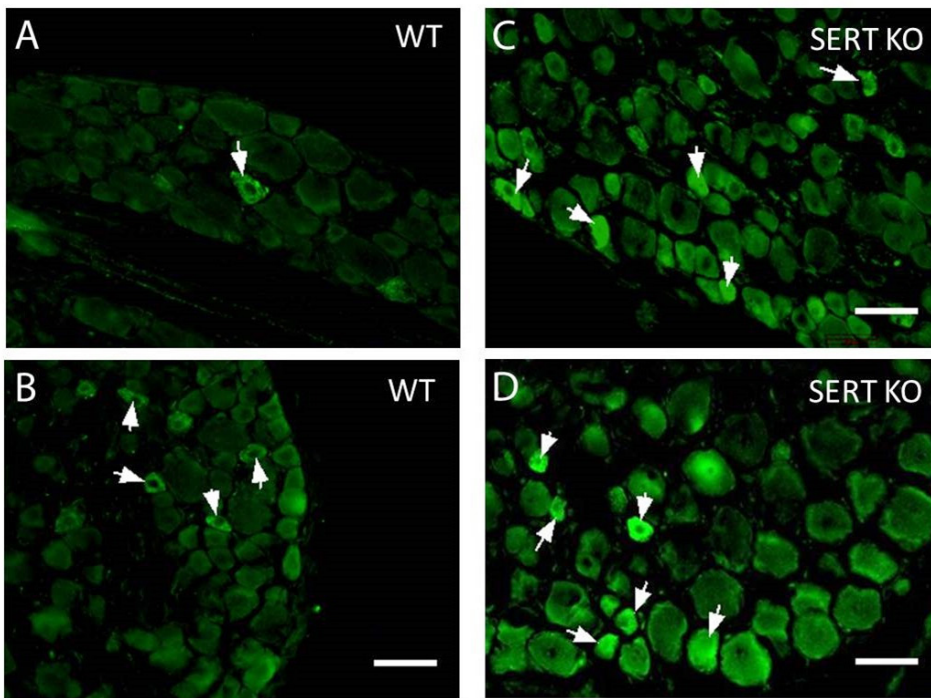
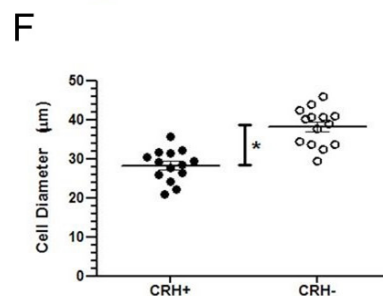
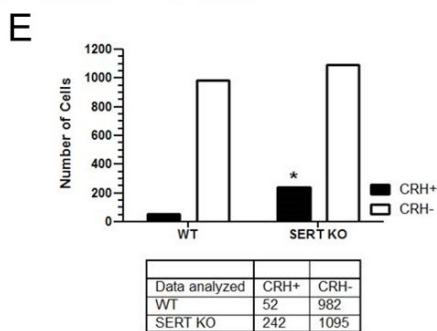


FIGURE 2: CRH protein expression as visualized by immunohistochemistry in 10 μm thick dorsal root ganglia (DRG) sensory neuron sections. Images A-D are representative DRG sections from 4-5 month old female rats at 20X magnification. Arrows indicate CRH+ cells. Scale bar for images A-D = 50 μm . A, B. Representative DRG sections from two different female wildtype rats. C, D. Representative DRG sections from two different female SERT KO rats. E. Sum of CRH+ and CRH- neurons in three different DRG sections from female WT ($n = 7$) and SERT KO ($n = 7$) rats. Number of CRH+ neurons is significantly increased in SERT KO rats (Fisher's exact test, $p < 0.0001$). F. CRH+ neurons have a smaller cell body diameter than CRH- neurons (unpaired t-test, $p < 0.0001$). Each dot represents the average cell body diameter in three different DRG sections from the same rat. CRH+ and CRH- data is expressed as average cell diameter of CRH+ cells from WT ($n = 7$) and SERT KO ($n = 7$) rats. Error bars denote SEM.



directed against CRH and visualized protein expression using fluorescence microscopy. First, to confirm the specificity of our antibody, we probed wildtypes coronal brain sections (thickness = 20 μm) displaying the median eminence and hypothalamus for evidence of CRH immunofluorescence. The median eminence and third ventricle were identified anatomically and intense CRH immunofluorescence was visualized (Figure 1).

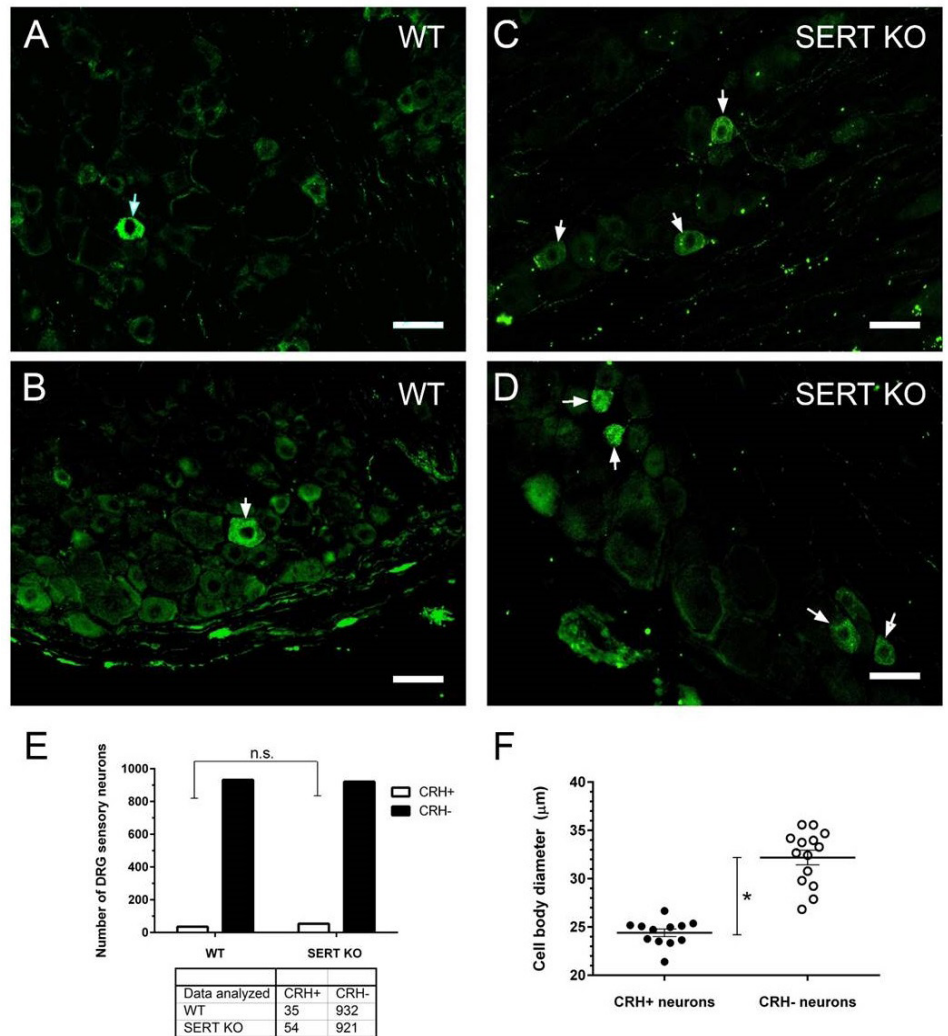
Next, we identified CRH expression in sensory afferent neurons of female wildtypes and SERT KO rats using the same immunohistochemistry technique. Female SERT KO rats displayed increased CRH protein expression in DRG neurons compared to female wildtypes ($p < 0.0001$, Figure 2). On average, neurons that expressed CRH were significantly smaller (28 μm average diameter) compared to non-CRH expressing neurons (33 μm average diameter, $p < 0.0001$). There was no significant difference in average cell body diameter between female SERT KO and wildtype rats.

We then performed the same study in male wildtypes and SERT KO rats. There was no difference in CRH expression in DRG neurons between male SERT KO and wildtypes rats ($p = 0.0504$, Figure 3E). Finally, neurons that expressed CRH were significantly smaller (25 μm average diameter) compared to non-CRH expressing neurons (33 μm average diameter; $p < 0.0001$).

Colon-projecting sensory neurons are likely to express CRH

Next, we used a neuronal retrograde tracer (the beta-subunit of cholera toxin conjugated to a fluorophore, Alexa-555) to determine if CRH+ sensory neurons project to and innervate the distal colon using a dual-label immunohistochemistry technique (From here on cholera toxin will be abbreviated as CTX-b). We used only female SERT KO rats for this study. Female SERT KO animals underwent surgery for cholera-toxin injections into the distal colon and spent 5 days in recovery. On the fifth day, rats were eu-

FIGURE 3: CRH protein expression as visualized by immunohistochemistry in 10 μm thick dorsal root ganglia (DRG) sensory neuron sections. Images A-D are representative DRG sections from 4-5 month old male rats taken at 20X magnification. Arrows indicate CRH+ cells. Scale bar for images A-D = 50 μm . A,B. Representative DRG sections from two different male wildtype rats. C,D. Representative DRG sections from two different male SERT KO rats. E. Sum of CRH+ and CRH- neurons in three different DRG sections from male WT ($n = 7$) and SERT KO ($n = 7$) rats. Number of CRH+ neurons is not different between WT and SERT KO (Fisher's exact test, $p = 0.0504$). F. CRH+ neurons have a smaller cell body diameter than CRH- neurons (unpaired t-test, $p < 0.0001$). Each dot represents the average cell body diameter in three different DRG sections from the same rat. CRH+ data is expressed as average cell body diameter of CRH+ cells from WT ($n = 5$) and SERT KO ($n = 7$) rats. CRH- data is expressed as average cell diameter of CRH- cells from WT ($n = 7$) and SERT KO ($n = 7$) rats. Error bars denote SEM.



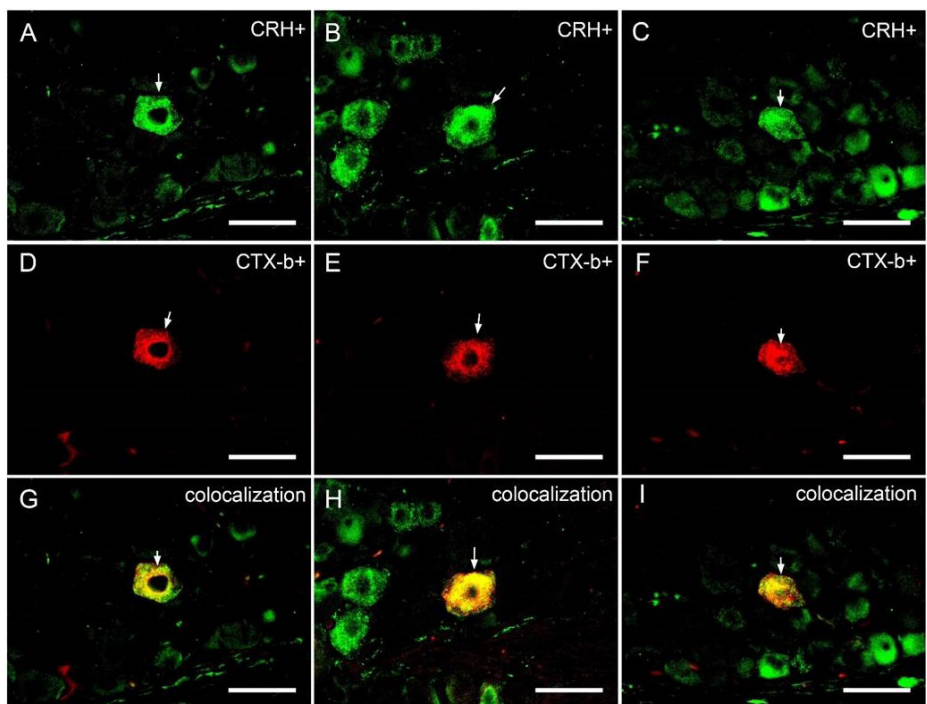


FIGURE 4: Representative CRH and CTX-b immunofluorescence colocalization images from DRG sensory neurons in SERT KO female rats (slice thickness = 10 μ m). Images A-I taken at 40X magnification. Scale bar for images A-I = 50 μ m. A-C. CRH+ immunofluorescence in DRG sensory neurons from three different SERT KO female rats. D-F. CTX-b+ immunofluorescence in DRG sensory neurons from 3 different SERT KO female rats. G-I. Colocalization of CRH+ and CTX-b+ in sensory neurons show that distal colon-projecting neurons are likely to express CRH. J. Percent colocalization of CRH+/CTX-b+ cells summed from female WT (n = 5) and SERT KO (n = 4) rats. There is no difference in percent colocalization between WT and SERT KO (unpaired t-test, p = 0.3893). K. Cell body diameter of CTX-b+ neurons from female WT (n = 5) and SERT KO (n = 3) rats. Each dot indicates the average cell body diameter of CTX-b+ cells from three different DRG sections. Horizontal line indicates a mean diameter of 29.5 μ m. Error bars denote SEM. CTX-b+ neurons are similar in cell body diameter to CRH+ neurons.

thanized and lumbar and sacral DRG were sectioned for anti-CRH staining. We looked for positive staining, which indicates specific cells that have taken up the toxin at nerve endings and has transported it back to the cell body in DRG. We then asked if these colon-projecting neurons (identified by the CTX-b label) were also positive for CRH expression (Figure 4). CTX-b labeled neurons were likely to express CRH (wildtypes n = 5, 66% of CTX-b+ neurons and SERT KO n = 4, 40% of CTX-b+ neurons). CTX-b labeled neurons were either small (<30 μ m diameter) or medium-sized (30-45 μ m diameter), consistent with the size of CRH+ neurons. There was no difference in percent colocalization of CTX-b and CRH between female wildtypes and SERT KO rats (p = 0.3893).

Discussion

CRH Expression in Primary Afferent Neurons

Our data indicates that CRH expression is increased in small-diameter, colon-projecting sensory neurons in female, but not male SERT KO rats. By measuring cell body diameter, we were able to make the inference that small diameter neurons are most likely

c-type nociceptive afferents that are involved in relaying pain information from the periphery to the spinal cord. However, this inference is yet to be confirmed, but will be clarified with future work. We found that small-diameter cells most strongly expressed CRH - this result was observable in all animals studied and neither genotype nor gender had any influence on the types of cells that expressed CRH immunofluorescence. Increased CRH expression may therefore be an indicator of hypersensitive colon-projecting sensory neurons, especially in female SERT KO rats.

Increased expression of CRH may contribute to IBS symptoms.^{2,32} CRH has both central neuroendocrine and peripheral functions; in the central nervous system, CRH mediates homeostatic responses to environmental stress by increasing levels of cortisol, the principle stress hormone in humans (Figure 5).³³ In the periphery, CRH has been shown to affect the gastrointestinal system, as peripheral administration of CRH can cause decreased gastric emptying and increased colonic motility characteristic of IBS.^{4,32} Additionally, both non-specific and specific CRH receptor antagonists have been used experimental-

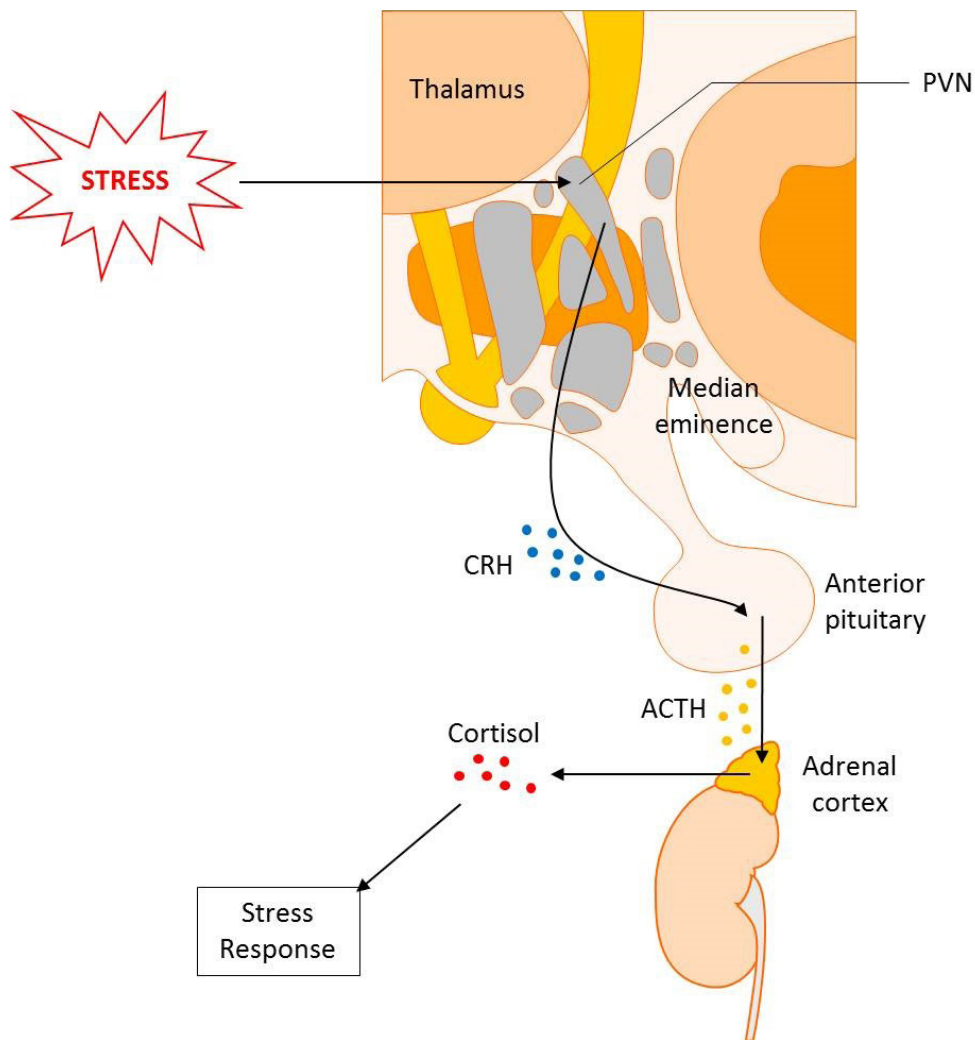


FIGURE 5: In response to environmental stress, corticotropin-releasing hormone is synthesized and released from the paraventricular nucleus of the hypothalamus (PVN), where it travels to the anterior pituitary gland to stimulate production of adrenocorticotrophic hormone (ACTH). ACTH travels via the circulation to the adrenal cortex, where it stimulates production of cortisol which acts on many different tissues to mobilize the whole-body stress response.

ly in the study of IBS.^{3,31} α -helical CRH (α hCRH), a non-selective CRH receptor antagonist was shown to significantly reduce abdominal pain and anxiety after noxious electrical stimulation in human IBS patients.³ In rats, administration of a specific CRH1-receptor (CRH-R1) antagonist inhibited visceral pain in response to colorectal distention.^{3,31}

5-HT Signaling and IBS

Previous work from our lab shows that increased serotonin (5-HT) signaling contributes to visceral hypersensitivity.¹ 5-HT is an important signaling molecule in the gut. Gut 5-HT plays many roles in regulating gastrointestinal function, including regulation of epithelial permeability, gastric motility and pain and discomfort.^{10,11} Enterochromaffin cells in the intestinal mucosa synthesize and store 5-HT which is secreted in response to mechanical distension of the gut wall or chemical stimuli.^{5,23} 5-HT exhibits its many functions by activating a wide range of receptors expressed by intrinsic and extrinsic sensory neurons that extend their processes into the mucosa.^{6,23} Ter-

mination of 5-HT signaling is achieved through SERT, which shares the same family of monoamine transporters as the dopamine transporter (DAT).^{17,23} SERT is expressed by all epithelial cells in the mucosa and is critical in regulating the local availability of 5-HT within the gut.^{18,19} 5-HT signaling is increased in IBS, most likely as a result from decreased SERT function. Many novel pharmacological targets include antagonists of SERT and 5-HT receptors, especially 5-HT₃ and 5-HT₄ receptors.²⁰ In fact, the most common FDA approved treatments for IBS target the serotonergic system.

More recently, psychopharmacological and behavioral therapy have been implicated in the study of FGIDs, as many IBS patients report an improvement in symptoms from a centrally-acting selective serotonin reuptake inhibitor (SSRI).²¹ SSRIs are the most commonly prescribed anti-depressant and anti-anxiety medication in human psychiatric patients worldwide. SSRIs modulate serotonergic signaling by blocking SERT and increasing the amount of ex-

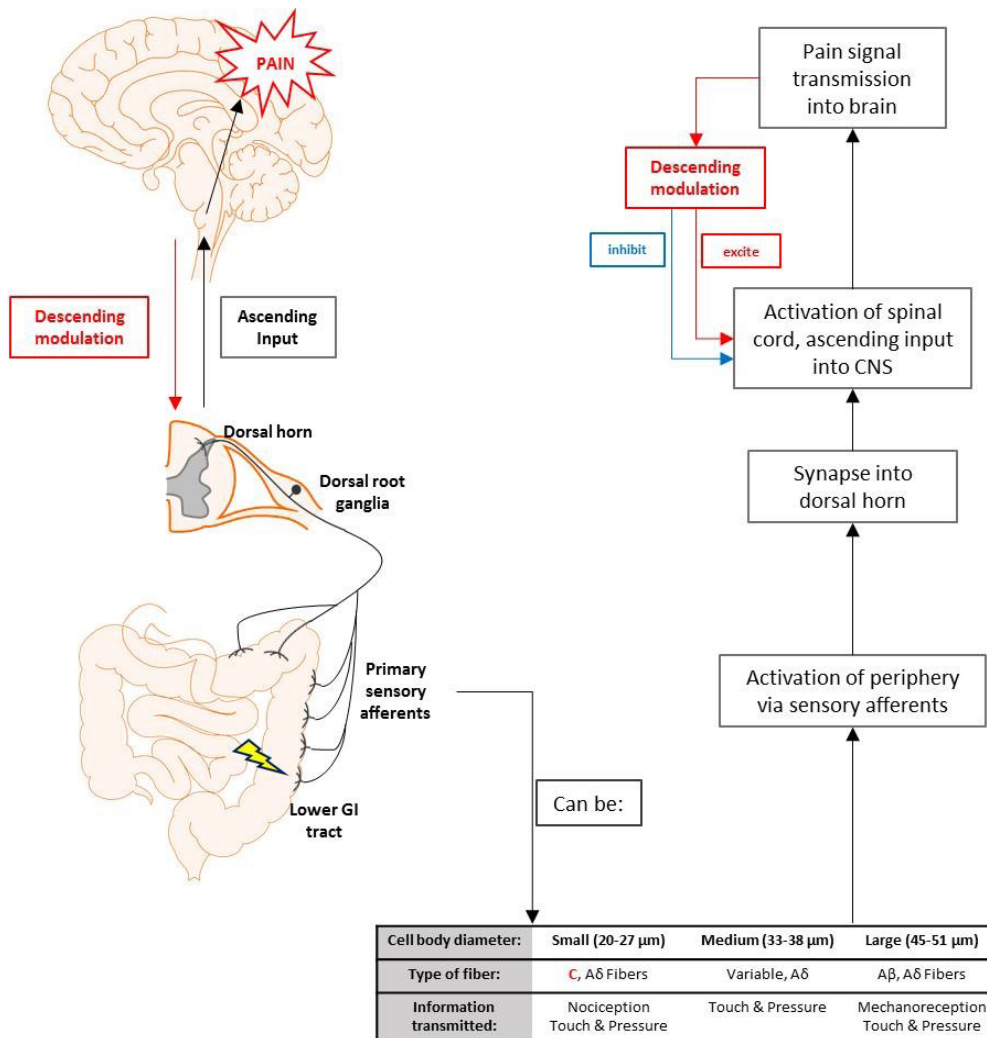


FIGURE 6: Sensory information from the periphery is transmitted centrally via primary afferent neurons, whose cell bodies lie in dorsal root ganglia. These primary afferent neurons make synaptic connections with ascending secondary order neurons in the dorsal horn. The ascending sensory pathway is complex and subject to regulation by different excitatory and inhibitory interneurons which can amplify or suppress sensory signals. Primary afferent are therefore the very first set of neurons that carry sensory information from the periphery to the brain, and their morphology and function have been clearly described. In the gut, 5-HT released from Enterochromaffin cells activates sensory afferents that innervate the mucosa along the length of the GI tract. The brain receives a constant stream of sensory information from the gut via these primary afferents, integrates the signal with environmental stimuli (stress), and directs the appropriate homeostatic response back to specific targets in the GI tract. The brain-gut axis therefore forms a reflexive loop involving the CNS and peripheral efferents, and sensory information coming from the GI tract, mediated by 5-HT, can be modulated by input from the CNS, such as increased CRH activity.

tracellular 5-HT between neurons. The effectiveness of psychopharmacological therapy in IBS patients is exemplary of the fact that FGIDs, especially IBS, may have an important psychosocial component mediated by abnormal 5-HT signaling within centers of the brain that regulate mood and emotion.

Visceral Hypersensitivity: Putting It All Together

Pain is certainly one of the sensory signals that are carried by primary afferent neurons in the gut (Figure 6). Lumbar and sacral DRG neurons innervate viscer-

al tissues, especially gastrointestinal viscera including the small intestine and colon. The brain's perception of nociceptive stimuli is subject to modulation by a number of different cortical circuits that are involved in emotion, stress, memory and arousal.²⁵ In non-IBS healthy individuals, it is thought that interoceptive information from the gut is minimally modulated by these brain circuits and this sensory information is not consciously perceived.²⁵ However, in IBS individuals, it is possible that these same circuits alter sensory perception and reflexive feedback through structur-

al changes in the neuroanatomy of the CNS or gut.²⁵ This is an important point that is often overlooked in the study of IBS. One possible hypothesis is the development of afferent neuron hypersensitivity as a result of long-term neuroplastic changes brought about by CNS modulation such as increased CRH, which may exacerbate pre-existing increases in gut 5-HT.

Conclusion

We found a novel sex-specific increase in CRH expression in the DRG of female SERT KO rats, which suggests that HPA axis dysfunction may contribute to visceral hypersensitivity in both our SERT KO animal model as well as human IBS patients. IBS is a multi-dimensional FGID that is characterized by abdominal pain and altered motility patterns. Serotonin signaling, CRH and sex may all play influential roles in the pathology of IBS. Serotonin signaling is clearly altered in many FGIDs, most commonly as a result of decreased SERT expression and increased mucosal 5-HT. Serotonergic drugs that modulate both CNS and PNS activity may prove to be effective therapies for IBS, and some success has been observed with centrally acting SSRIs and peripheral 5-HT₃ and 5-HT₄ receptor antagonists. CRH may play a role in the sensitization of colon-projecting nociceptive neurons, as a majority of retrograde-labeled cells were colocalized with CRH. Additionally, colocalized cells had an average cell body diameter of 29.6 μm , characteristic of small-diameter C-type nociceptive afferents, indicative that CRH⁺ cells may transmit nociceptive information from the gut to the brain. Sex may be an important determinant of IBS pathology, as female SERT KO animals exhibit sex-specific increases in mucosal 5-HT, visceral hypersensitivity and CRH expression in DRG sensory neurons. A newly revised model of IBS pathophysiology incorporates both aspects of these peripheral and central dysfunctions; our results support the role of both central and peripheral dysfunction and further investigation with CRH receptor antagonists may lead to more effective pharmacological interventions to treat IBS.

References

1. Galligan J., Patel B., Schneider S., Wang H., Zhao H., Novotny M., Bian X., Kabeer R., Fried D., Swain G. (2013). Visceral hypersensitivity in female but not in male serotonin transporter knockout rats. *Neurogastroenterol Motil* 25:373-381.

2. Canavan C., West J., Card T. (2014). The epidemiology of irritable bowel syndrome. *Clin Epidemiol* 6:71-80.
3. Fukudo S. (2007). Role of corticotropin-releasing hormone in irritable bowel syndrome and intestinal inflammation. *J Gastroenterol* 42:48-51.
4. Karling P., Norrback K., Adolfsson R., Danielsson A. (2007). Gastrointestinal symptoms are associated with hypothalamic-pituitary-adrenal axis suppression in healthy individuals. *Scandinavian J. Gastroenterol* 42:1294-1301.
5. Hausteiner-Wiehle C., Henningsen P. (2014). Irritable bowel syndrome: Relations with functional, mental and somatoform disorders. *World J Gastroenterol* 20:6024-6030.
6. Heitkemper M., Jarrett M., Bond E.F., Chang L. (2003). Impact of sex and gender on irritable bowel syndrome. *Biol Res Nurs*. 5:56-65.
7. McKlveen J., Myers B., Herman J. (2015). The medial prefrontal cortex: Coordinator of autonomic, neuroendocrine and behavioral responses to stress. *J Neuroendocrinol* doi: 10.1111/jne.12272. [Epub ahead of print]
8. Gustafsson J., Greenwood-Van Meerveld B. (2011). Amygdala activation by corticosterone alters visceral and somatic pain in cycling female rats. *Am J Physiol Gastrointest Liver Physiol* 300:G1080-1085.
9. Su J., Tanaka Y., Muratsubaki T., Kano M., Kanazawa M., Fukudo S. (2014). Injection of corticotropin-releasing hormone into the amygdala aggravates visceral nociception and induces noradrenaline release in rats. *Neurogastroenterol Motil* 27:30-39.
10. Mawe G., Hoffman J. (2013). Serotonin signalling in the gut - functions, dysfunctions and therapeutic targets. *Nature* 10:473-486.
11. Homberg J., Olivier J., Smits B., Mul J., Mudde J., Verheul M., Nieuwenhuizen O., Cools A., Ronken E., Cremers T., Schoffelmeer A., Ellenbroek B., Cuppen E. (2007). Characterization of the serotonin transporter knockout rat: a selective change in the functioning of the serotonergic system. *Neuroscience* 146:1662-1676.
12. Tache Y., Perdue M. (2004). Role of peripheral CRF signaling pathways in stress-related alterations of gut motility and mucosal function. *Neurogastroenterol Motil* 16:137-142.

13. Gue M., Del Rio Lacheze C., Eutamene H., Theodorou V., Fioramonti J., Bueno L. (1997). Stress-induced visceral hypersensitivity to rectal distension in rats: role of CRF and mast cells. *Neurogastroenterol Mot* 9: 1-9.
14. Willis W., Coggeshall R. (2004). *Sensory mechanisms of the spinal cord*. Ed 3. New York: Kluwer Academic/Plenum.
15. Gershon M., Tamir H. (1981). Release of endogenous 5-hydroxytryptamine from resting and stimulated enteric neurons. *Neuroscience* 6:2277-2286.
16. Mawe G., Branchek T., Gershon M. (1986). Peripheral neural serotonin receptors: identification and characterization with specific antagonists and agonists. *Proc. Natl Acad. Sci. USA* 83:9799-9803.
17. Bertrand P., Hu X., Mach J., Bertrand R. (2008). *Am J Physiol Gastrointest Liver Physiol*. 295:G1228-1236.
20. Grover M., Drossman D. (2011). Centrally acting therapies for irritable bowel syndrome. *Gastroenterol Clin N Am* 40:183-206.
21. Clouse R., Lustman P. (2005). Depression in diabetic patients: the relationship between mood and glycemic control. *J Diabetes Complications* 19:113-122.
22. Scroggs R., Fox A. (1992). Calcium current variation between acutely isolated adult rat dorsal root ganglion neurons of different size. *J Physiol* 445:639-658.
23. Brookes S., Spencer N., Costa M., Zagorodnyuk V. (2013). Extrinsic primary afferent signalling in the gut. *Nature* 10:286-296.
24. Mayer E., Tilisch K. (2011). The brain-gut axis in abdominal pain syndromes. *Annu. Rev. Med.* 62:381-396.
25. Wilder-Smith C. (2011). The balancing act: endogenous modulation of pain in functional gastrointestinal disorders. *Gut* 60:1589-1599.
26. Tache et al. (2005). Role of corticotropin-releasing factor pathways in stress-related alterations of colonic motor function and viscerosensitivity in female rodents. *Gender Med* 2:146-154.
27. Laryea G., Arnett M., Muglia L. (2012). Behavioral studies and genetic alterations in corticotropin-releasing hormone (CRH) neurocircuitry: insights into human psychiatric disorders. *Behav Sci* 2:135-171.
28. Vanuytsel T., Van Wanrooy S., Vanheel H., Vanormelingen C., Verschuere S., Houben E., Rasoel S., Toth J., Holvoet L., Farre R., Van Oudenhove L., Boeckxstaens G., Verbeke K., Tack J. (2013). Psychological stress and corticotropin-releasing hormone increase intestinal permeability in humans by a mast cell-dependent mechanism. *Gut* 63:1293-9.
29. Chey W., Kurlander J., Eswaran S. (2015). Irritable bowel syndrome: a clinical review. *JAMA* 313:949-58.
30. Bharadwaj S., Barber M., Graff L., Shen B. (2015). Symptomatology of irritable bowel syndrome and inflammatory bowel disease during the menstrual cycle. *Gastroenterol Rep (Oxf)*. pii: gov010 [Epub ahead of print]
31. Saito-Nakaya K., Hasegawa R., Nagura Y., Ito H., Fukudo S. (2008). Corticotropin-releasing hormone receptor 1 antagonist blocks colonic hypersensitivity induced by a combination of inflammation and repetitive colorectal distension. *Neurogastroenterol Motil* 10:1147-56.
32. La J., Sung T., Kim H., Kim T., Kang T., Yang I. (2008). Peripheral corticotropin releasing hormone mediates post-inflammatory visceral hypersensitivity in rats. *World J Gastroenterol* 14:731-6.
33. Naughton M., Dinan T., Scott L. (2014). Corticotropin-releasing hormone and the hypothalamic-pituitary-adrenal axis in psychiatric disease. *Handb Clin Neurol* 124:69-91.

The Effects of Prolonged Intense Exercise on Blood Glucose Metabolism in Healthy Individuals

Brad Riedinger, Roy Small, and Erica Wehrwein

Department of Physiology

Abstract

Moderate exercise is known to increase insulin sensitivity and thus decrease plasma glucose concentration. We hypothesized that intense exercise (90% of maximum heart rate; max HR) would cause a decrease in plasma glucose concentrations due to depleted muscle glycogen levels. Five healthy male individuals between the ages of 20 and 22 were subject to our intense exercise protocol where subjects maintained 70 revolutions per minute (RPM) on a stationary bike while resistance was increased 10 watts every two minutes. Data did not support our hypothesis, as overall blood glucose concentration increased rather than decreased after recovering from intense aerobic work. Blood glucose concentrations increased during baseline to 65% of maximum HR, decreased during 65% to 90% of maximum HR, and then increased during recovery. While participating in intense aerobic exercise, both hypoglycemic and hyperglycemic conditions were observed. The final blood glucose levels were in the hyperglycemic range during recovery.

Introduction

Glucose homeostasis in the human body is a well-regulated physiological system in healthy individuals that can be affected by multiple hormones in the body. Insulin is the primary hormone that lowers plasma glucose levels; it does this by recruiting additional facilitated glucose transporters on peripheral tissues, like skeletal muscle, that help eliminate excess glucose from plasma. The most common glucose transporter in skeletal muscle is the glucose transporter type 4 or GLUT4. Approximately 80% of glucose uptake is by insulin signaling in skeletal muscle (Bell-Wilson, 2004). Insulin signaling allows for additional glucose to be stored, mainly in muscles and the liver, in

the form of glycogen that can be used to raise blood glucose levels during hypoglycemic states. Many hormones can cause an increase in glucose plasma levels, such as glucagon, norepinephrine, epinephrine, growth hormone, and cortisol. Glucagon, the primary hormone to increase blood glucose concentration, binds to receptors on the liver causing the breakdown of liver glycogen stores into the usable monomer glucose, a process called glycogenolysis.

Exercise and glucose homeostasis have been studied in humans, with a large number of studies focusing on diabetic patients and a few studies done on healthy individuals during high intensity aerobic work. Exercise has been shown to immediately improve glucose tolerance and insulin sensitivity in the body during moderate and intense aerobic exercise (Bonen, 1998). Researchers have investigated to what extent insulin sensitivity increases for high intensity cycling compared to moderate intensity cycling. Subjects completed a 4-week cycling protocol of either high-intensity cycling (three minutes at 80% maximum watts and two minutes at 40% maximum watts) or low-intensity cycling (three minutes at 40% maximum watts and two minutes at 20% maximum watts) for one hour each, totaling 19 sessions. Based on this study, insulin sensitivity improved significantly for high intensity training compared with low intensity training.

Research has also shown that intense aerobic exercise can produce mechanical and oxidative damage in skeletal muscle which impairs insulin action and glucose tolerance (Wright, 2001). Glucose homeostasis is maintained by a balance of glycogen breakdown in the liver and skeletal muscle with the glucose uptake from the blood. During intense exercise, glucose released from the liver exceeds peripheral glucose uptake, creating excess glucose concentrations in

blood plasma (Kjaer, 1998). An increase in glucose concentration is expected in the initial stages of the exercise protocol, but plasma glucose concentrations will decrease once glycogen stores diminish. It is unclear, based on current research, how a single bout of intense exercise to 90% of maximum heart rate (max HR) performed in a fasted state will affect plasma glucose concentrations in young, healthy male subjects. It is our hypothesis that glucose concentration in blood plasma will increase initially then decrease below baseline levels throughout the remainder of the test due to the depletion of hepatic and skeletal muscle glycogen stores.

Methods

Subjects: Five healthy males were selected from Michigan State University and used as participants in this study. Each participant knew the risks and that their participation could cease at their choosing. Subjects with similar body type and amount of regular physical activity were used in order to eliminate any variance in glucose tolerance (BMI < 25, physical activity = 3x per week). All subjects were asked to refrain from hard exercise and caffeine for 24 hours prior to the study. The subjects were also asked to fast overnight and skip breakfast before participating in the study (minimum of 8 hours). Only subjects with blood glucose in the normal range prior to the study were accepted (70mg/dL-100mg/dL). The height and weight of the subjects were recorded prior to the study in a digital spreadsheet.

Procedure: After the height and weight of the subjects were obtained, a baseline blood glucose measurement was taken using a glucometer and recorded. The glucometer process was thoroughly explained to the subject. The subjects were asked to exercise on an exercise bike (Lode Bike System) until 90% of their maximal heart rate was achieved. Maximum heart rate was calculated using the formula Maximum Heart Rate = 220 minus the age of subject. Storer's VO₂ maximum exercise bicycle test procedure was used to provide standardized intense exercise for the subjects. The subjects began pedaling at a resistance of 50 watts that was increased by 10 watts every two minutes. The subjects were asked to maintain a pedaling speed of 70 RPM throughout the exercise. The subjects were told to stop at any time they felt uncomfortable, or had exercised to exhaustion. Blood glucose was measured at four points throughout the study: baseline, 65% of maximum heart rate, 90% of

maximum heart rate, and recovery (HR < 100 beat per minute). Sixty-five percent and 90% maximum heart rates were arbitrary time points within the categories of sub-maximal and maximal exercise heart rates respectively (Robergs, 2002). The glucose measurements were taken from the finger by the researchers while subjects were still biking. Blood samples were obtained using a retractable lancet (Surgilance Safety Lancet, Medipurpose) and were analyzed for glucose using a single drop of blood loaded into a test strip (Contour Blood Glucose Test Strips, Bayer) in a handheld glucose meter (Contour USB device, Bayer). Blood glucose measurements were collected immediately at the precise moment individuals reached the heart rate checkpoints, and were recorded in a spreadsheet on a personal computer. The RPMs were not allowed to drop below 60 RPM during the measurement. Heart rate was monitored using a Polar T31 Coded Heart Rate Transmitter Belt wirelessly connected to Parvo-Medics TrueOne Metabolic System (OUSW v4.3.4) to monitor heart rate in real time. The recovery stage was defined as when the subjects' heart rate dropped below 100 BPM after the conclusion of the intense exercise protocol. Participants were asked to remain on the bike and not to cycle until the targeted recovery heart rate was observed lower than 100 BPM. At the precise moment 100 BPM was observed the final blood glucose measurement was taken. Subjects were not to drink water during the exercise, but were provided with water after the conclusion of the experiment.

Analysis: The variables measured included blood glucose levels at four points: baseline, 65% max HR, 90% max HR, and recovery (HR < 100BPM). The data from the four points were compared to see if any statistically significant increase or decrease in blood glucose levels had occurred in response to the intense exercise. The data was analyzed using one-way repeated measures analysis of variance (ANOVA) with Tukey's post hoc test (n = 5; p < 0.05 for significance).

Results

Our hypothesis was not supported by our data; there was an overall increase in plasma glucose concentration as opposed to a decrease that was predicted. Baseline glucose concentration was 92.4 ± 2.4 mg/dL (mean ± SEM); at 65% maximum heart rate glucose concentration was 103.6 ± 6.6 mg/dL; at 90% maximum heart rate was 88.4 ± 7.0 mg/dL; and the recovery glucose concentration was 103.0 ± 5.8 mg/dL. Significance (p < 0.05) was shown between baseline and

recovery (Figure 1: %), between recovery and 90% maximum heart rate (Figure 1: #), and between 65% and 90% of maximum heart rate (Figure 1). There was no significant difference between baseline and 65% of maximum heart rate ($p = 0.08$). However, as predicted, a slight increase in glucose concentration at the 65% maximum heart rate was observed. All subjects were in a hyperglycemic state ($> 100\text{mg/dL}$) for both 65% maximum heart rate and recovery heart rate. Inversely at 90% maximum heart rate one subject was in a hypoglycemic state ($< 70\text{mg/dL}$); however, all other subjects were well in a normoglycemic state ($70\text{--}100\text{ mg/dL}$).

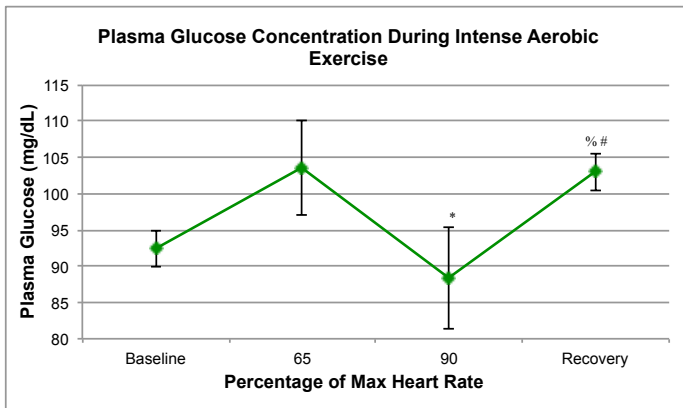


FIGURE 1: Plasma glucose concentrations at baseline, 65% max HR, 90% max HR, and recovery intervals for five subjects. Significance was shown using a one-way repeated measures ANOVA with Tukey's post hoc test, between baseline and recovery (%), between 90% max HR and recovery (#), and between 65% and 90% max HR.

Discussion

Glucose homeostasis was not maintained throughout the exercise protocol. A significant increase in glucose concentration from baseline to recovery and a slight increase from baseline to 65% maximum heart rate was observed. It is likely that muscle glycogen stores were depleted because all participants had the perception of fatigue by the end of the test—a common sign of muscle glycogen store depletion (Hermansen et al., 1965). This increased glucose concentration during recovery is likely due to gluconeogenesis which is the generation of glucose from other fuel sources in the liver, such as pyruvate, lactate, glycerol, amino acids, and fatty acids, while the increase at 65% maximum heart rate is likely due to hepatic and muscle glycogen stores not depleted in the fasting stage. During intense exercise, gluconeogenesis dominates energy production compared to glycogenolysis because gly-

cogen stores are being depleted, hence the increase during the recovery phase. While counter-regulatory mechanisms have a stimulating effect on the liver to raise glucose production during hypoglycemia, the effect in humans from sympathetic nervous activity, norepinephrine, growth hormone, and cortisol is minimal. As important as glucagon is to stimulate hepatic glucose production, a decrease in insulin is also important for raising plasma glucose concentrations to normoglycemic levels. This study helped demonstrate hypoglycemic conditions were less likely than hyperglycemic conditions, which is due to the summation of the counter regulatory hormones that stimulate gluconeogenesis.

A longer fasting time or a longer exercise protocol could have made a difference in recovery glucose concentrations. However, fasting also increases fat utilization and lowers the rate of muscle glycogen depletion during exercise (Dohm et al., 1986). This glycogen saving effect would mean that a longer fasting or longer exercise would be needed to show the effects of depleted muscle and hepatic glycogen stores. A decrease in plasma glucose concentrations would more likely be seen after a 24-hour fast since that is one of many published values for hepatic glycogen stores to be depleted. Bell-Wilson found that it took about 60 minutes of intense exercise to get statistically similar plasma glucose concentrations and 90 minutes to have no further decrease in plasma glucose concentrations (Bell-Wilson, 2004). Bell-Wilson's participants did consume glucose before the bout of intense exercise, which kept plasma glucose concentrations higher for a longer duration and did not allow for glucose concentrations to fall below baseline levels. In healthy individuals, a potentially serious hypoglycemic state would only be obtainable if they have fasted for longer than 24 hours or participated in a longer bout of intense exercise at 90% maximum heart rate; suggesting gluconeogenesis could not sustain skeletal muscle demand for glucose. The fact that one subject was slightly hypoglycemic suggests that the glucose was used faster than counter regulatory effects could raise blood glucose, creating a temporary hypoglycemic state. This state is more likely to have persisted if a longer duration fasting protocol was implemented to reduce other fuel sources used during gluconeogenesis. In conclusion, intermediate fasting before intense aerobic exercise will most likely not result in any dangerous plasma glucose levels in healthy individuals. However, during periods of in-

tense exercise, plasma glucose levels may vary outside the norm range.

Future experiments should focus on plasma concentrations of free fatty acids and glycerol during a fasted state and during a fed state of exercise while comparing that with plasma glucose concentrations. It would be expected that free fatty acids and glycerol levels would increase as glycogen stores deplete, and the body needs alternative fuels to function at normal levels. Different lengths of fasting could be tested to find optimal fat utilization which could be a desired effect for some individuals.

Acknowledgement

The authors would like to thank the Michigan State University Department of Physiology for the support of this study and for use of the necessary supplies and equipment to make this study a success. We acknowledge the help of James Poteracki and would also like to thank our research subjects for their voluntary participation in this research.

References

Bell-Wilson, J. (2004). Oral glucose tolerance after an acute bout of continuous exercise versus multiple exhaustive bouts. Order No. 3144066. Albuquerque: The University of New Mexico.

Bonen, A., Ball-Burnett, M., & Russel, C. (1998). Glucose tolerance is improved after low- and high-intensity exercise in middle-age men and women. *Canadian Journal of Applied Physiology*, 23, 583–593.

Dohm, G. L., Beeker, R.T., Israel, R.G., & Tapscott, E.B. (1986). Metabolic responses to exercise after fasting. *Journal of Applied Physiology*, 61, 1363–1368.

Hermansen, L., Hultman, E., & Saltin, B. (1965). Muscle glycogen during prolonged severe exercise. *Acta Physiologica Scandinavica*, 71, 334–346.

Kjaer, M. (1998). Hepatic glucose production during exercise. *Advances in Experimental Medicine and Biology*, 441, 117–127.

Robergs, R. A., & Landwehr, R. (2002). The surprising history of the “HRmax=220-age” equation. *Journal of Exercise Physiology*, 5(2). Retrieved 23 Feb. 2015 from <https://www.asep.org/asep/asep/Robergs2.pdf>

Wright, D. C., & Swan, Pamela D. (2001). Optimal exercise intensity for individuals with impaired glucose

tolerance. *Diabetes Spectrum*, 14(2). Retrieved 4 Nov. 2013 from <http://spectrum.diabetesjournals.org/content/14/2/93.full>



Highlights of Undergraduate Research

Adidharma, W., Attenuated orexinergic signaling in a diurnal rodent model of SAD, Society for Neuroscience Annual Meeting, 9-13 November 2013.

Apland, A., Food insecurity, folate intake, and the moderating effect of coping strategy among Ariaal mothers in Kenya, American Association of Physical Anthropology, 9-12 April 2014.

Bates, E., EEG Time Series Analysis and Functional Connectivity Network Measures of TD and ASD Youths, The Networked Brain, 7-8 November 2013.

Busch, A., Assessing DSM-5 traits with the Personality Assessment Inventory, North American Society for the Study of Personality Disorders, 4-6 April 2014.

Buschman, J., Relative Rotations of Pelvis and Ribcage in Seated and Standing Postures, American Society of Biomechanics, 4-7 September 2013.

Buskirk, S., Survival Processing Advantage and Memory, Midwestern Psychological Association, 1-2 May 2014.

Christy, D., Theatre Engine Fashmob, Margetts Theatre, 24-28 March 2015.

Cox, C., Probing the neural bases of beat perception using transcranial magnetic stimulation, Society for Neuroscience Annual Meeting, 9-13 November 2013.

Creed, E. & Kearsley, D., Informing Policymakers: The Influence of Institutions on State Legislators' Use of Information Sources Across the Policy Process, Midwest Political Science Association, 3-6 April 2014.

Dell, K., Use and Non-Use of the Post 9/11 GI Bill, Midwest Political Science Association, 3-6 April 2014.

Drost, J., Blood Flow Characterization in Multiple Anatomical Locations during Normal and Shear Loading, American Society of Biomechanics, 4-7 September 2013.

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Beef, Cowboys, and Republicans: The Rugged Aaron Copland?

Sarah Tomlinson | College of Music

Abstract

The music of Aaron Copland (1900–1990) shares strong associations with bucolic landscapes, Wild Western themes, and American nationalism. Indeed, much of Copland’s music, both in its original performance contexts and commercial appropriations, is programmed, performed, and paired with these themes. However, many aspects of Copland’s identity—that he was Jewish, European-educated, a communist sympathizer, and homosexual—do not fit with the constructs of American identity that his music has been appropriated to project. This paper examines two commercial appropriations of Copland’s music, Spike Lee’s 1998 film *He Got Game* and one of Texas Governor Rick Perry’s 2012 presidential campaign advertisements. Both appropriations extend the pastoral idioms and frontier figures of Copland’s music into the rugged, righteous, and unquestionably masculine cowboy. Through comparison between Copland’s identity, the original performance contexts of Copland’s music, and the more contemporary appropriations, this paper discusses multi-dimensional constructions of American identity, the cowboy hero, and masculine ideals.

Copland Onstage and In Print

At a 2013 orchestral performance of Aaron Copland’s *Billy the Kid Suite*, the conductor prefaced the piece with a performance of his own.¹ He sucked in his gut, gave the audience a mischievous smirk, raised his eyebrows as if to say “Howdy, y’all!” and acted in an elaborate impersonation of the composer. The conductor’s entertaining Copland caricature narrated the ballet synopsis while speaking with the Wild Western twang of a hard-weathered, yet lighthearted cowboy. While it was a charming preface, the characterization of Copland himself as a cowboy, indicated through the conductor’s accent and mannerisms, was entirely fictional. Copland was a Jewish musician from Brooklyn, not a lasso-swinging hero from Oklahoma. The conductor, surely aware of the historical

Copland, chose instead to appeal to the Wild Western theme of the 1938 ballet, *Billy of the Kid*, in which cowboy-clad characters dance and duel on the open range. Although the conflation of Copland and idealized cowboy is ahistorical, it is not uncommon or without precedence. Indeed, much of Copland’s music, both in its original performance contexts and commercial appropriations, is programmed, performed, and paired with cowboy characters and frontier landscapes. Considering the cowboy as the iconic, distinctly American hero and the Western landscape’s romantic promise of manifest destiny, Copland and his music are similarly remembered as essentially American.

Listeners, scholars, critics, and collaborators have long referred to Copland as “The Dean of American Music,” often commenting that his music showcases a quintessentially American sound. Copland’s colleagues in the short-lived Young Composers’ Group first coined the moniker in 1932 when Copland was thirty-two years old (Pollack). Furthermore, his 1990 *New York Times* obituary, written by John Rockwell, was titled, “Copland, Dean of American Music, Dies at 90,” and remembered Copland as “America’s best-known composer of classical music.” Rockwell recalled the impact of Copland’s well-remembered works:

In ballet scores like “Billy the Kid” (1938), “Rodeo” (1942) and above all “Appalachian Spring” (1944), and in concert pieces like “El Salon Mexico” (1937), “Fanfare for the Common Man” (1942) and “Lincoln Portrait” (1942), Mr. Copland touched a chord in the American psyche reached by no other classical musician this country has produced. (See, also, Mellers.)

Justifications for how and why Copland’s music touches “a chord in the American psyche” use both musical analysis and iconographic associations. English critic W.H. Mellers noted in 1943 that Copland’s music demonstrated “the American idiom” more remarkably than any other composer:

I refer to a feeling of vastness, enormous airiness and emptiness of space which probably derives from America's physical immensity and which is communicated through the music partly by the dominance of fourths and natural sevenths in the line which produce an effect at once aspiring and curiously hollow. (370–71)

Many others have heard Copland's music as representing an American landscape of open space, including his collaborator Agnes de Mille. De Mille choreographed *Rodeo* (1942), the second "cowboy ballet" for which Copland composed the music. In a 1973 video recording released by the American Ballet Theatre about *Rodeo*, de Mille commented, "America has to do with great space, great landmasses And there is this in the music. Aaron Copland wasn't using authentic tonalities. This has become the American sound because he struck certain cold rather penetrating and evocative intervals that suggest space to us" ("Rodeo American"). Musicologist Neil Lerner has written about listeners' fascination with Copland's open, pastoral sound, arguing that musical characteristics such as "homophonic texture, disjunct melodies set against conjunct bass lines, [and] . . . a fondness for fourths and fifths" create the pastoral "longing for a place that is no more, perhaps the music of utopian desire" (483). While many have been able to articulate *what* Copland's music sounds like—open, spacious, pastoral, American—it is more difficult to define *who* Copland's music represents. Whose utopian desire does his music connote? Who is included or excluded from the American identity constructed in accordance with his music?

The Man and the Cowboy Myth

Considering a mainstream vision of cowboyesque American identity—a white, heterosexual, Christian man from a rural background of dirty bootstraps and calloused hands—many aspects contradict Copland's own identity. Copland was born in 1900 to Jewish parents, whose families had emigrated to the US from Russia in the last few decades of the nineteenth century. In the early 1920s, Copland was a part of the famous generation of Americans in Paris, where he studied with composition teacher Nadia Boulanger (Fauser). He was a communist sympathizer and, as musicologist Elizabeth Crist writes, "clearly participated in the cultural work of the left-wing social movement known as the Popular Front" (9). Copland was also homosexual, and, though he did not dis-

cuss his sexuality openly, frequently traveled with his partner Victor Kraft (Pollack). As a Brooklyn-bred, European-educated, communist sympathizer, and homosexual son of Russian-Jewish immigrants, Copland was far from the rugged American cowboy. Nevertheless, Copland (1939) was "anxious to write a work that would immediately be recognized as American in character," and, as noted, "many have been convinced that he successfully achieved that goal" (549). In *The Queer Composition of America's Sound: Gay Modernists, American Music, and National Identity*, Nadine Hubbs points out that Copland at least had some factors working in his favor: "Being visibly male and, at least sometimes, invisibly homosexual was an identity combination that, although stigmatized and thus limiting, afforded certain possibilities unavailable to persons plainly marked as, for example, female or black" (8; see, also, Levy). Even so, Copland's choice to write Western-themed music could have been dangerous; it is clear that Copland's identity was far from that of the lionized cowboy. Beth Levy, however, posits how the Western setting could work for Copland rather than against him: "The aggressive heroes and rugged landscapes of the west helped balance (veiled) allusions to his homosexual preferences, deflecting interest away from his Jewish, cosmopolitan background and focusing it on an Anglo, western mythology that was rapidly becoming a favorite arena for representations of American identity in the mass media" (294).

Although Copland's identity may contradict a mainstream vision of American cowboy identity, Copland himself is still championed as "The Dean of American Music." In *Struggling to Define a Nation: American Music and the Twentieth Century*, Charles Hiroshi Garrett studies disparate musical constructions of American identity, not to posit a unified vision of America, but rather to uncover the cultural implications that these struggles for identity reveal. Following Garrett's study, this essay finds both similarities and differences in constructions of American identity promoted through commercial appropriations of Copland's musical works. Specifically, Lee's 1998 film *He Got Game* and one of Perry's 2012 presidential campaign advertisements both use Copland's music to evoke the cowboy and characterize American identity. Through comparisons of the original performance contexts of the ballets *Rodeo* and *Appalachian Spring*, to later appropriations by Lee and Perry, respectively, this essay argues that while these Western-themed ballets do indeed promote American nostalgia for the West and

include certain cowboy characters and themes, the film and political advertisement extend the pastoral idioms and frontier figures in favor of a different ideal: the rugged, righteous, and unquestionably masculine cowboy. Yet while Lee's film and Perry's ad similarly employ the masculine cowboy as an icon of American identity, the characteristics of their cowboys and their visions of America diverge. Lee's cowboy creates a more, although not entirely, inclusive vision of American identity, while Perry's cowboy aims to return to a utopian past of conservatism and exclusivity.

“Hoedown” in *He Got Game*

Lee featured Copland's music in his 1998 film, *He Got Game*, which follows Brooklynite Jesus Shuttlesworth, the nation's number one ranked high school basketball player, through his final days of deciding which college to attend. In explaining why he specifically chose Copland's music, Lee recognized Copland's nationalist appeal: “When I listen to his music, I hear America, and basketball is America” (quoted in Pollock 528). Not surprisingly, Lee chose to program Copland's well-known Western-themed works, such as *Appalachian Spring*, *Rodeo*, and *Billy the Kid*, as well as more overtly nationalist works, such as *Fanfare for the Common Man* and *Lincoln Portrait*.² Many of these compositions would have been widely recognizable. For example, the CBS Sport Spectacular's 1979 theme song was an art-rock arrangement of *Fanfare for the Common Man*. Here, “the common man” became associated with the American athlete, an especially vigorous, masculine, and idyllic role. Also contemporary to the film were the long-running Beef Industry Council and Beef Board commercials, which made the “Hoedown” movement of the 1942 Western-themed ballet, *Rodeo*, instantly recognizable not only to classical music listeners, but also to general audiences. These commercials, which began airing in 1992, made *Rodeo*'s “Hoedown” synonymous with the campaign slogan “Beef. It's What's for Dinner.”³ The association of Copland's already Western-themed music with the muscular athlete and the rugged, virile, and domestic imagery of freshly killed beef, seasoned and cooked on the homestead, meant that Lee's choice of Copland's music implied an American ideal that was specifically masculine.

The masculinization of *Rodeo* is especially striking in comparison to the ballet's original story. The protagonist of the frontier-set ballet is the Cowgirl, “a young tomboy . . . who wants to ride and rope with the boys”

(Crist 132).⁴ The Cowgirl struggles as she neither fits in with the conventionally feminine prairie girls, nor the virile cowboys. The final scene depicts a Western hoedown, where the characters dance to compete with one another. Compared to alternative modes of entertainment and competition in the fictionalized West, such as drunken saloon brawls, high-stakes gambling, and cold-blooded gun battles, a community dance competition is a healthy and wholesome way to gain respect and power. The Cowgirl displays her skill and attracts the Roper, one of the two male lead dancers. The Roper dances with the Cowgirl in her style, and the ballet ends with their passionate kiss. While the kiss symbolizes her acceptance into society, it does not imply conformity. The Roper's masculine authority may seem to devalue her independence, but it is significant that he reveals his attraction by dancing in the same style as the Cowgirl. The Cowgirl also contributes to the compromise by wearing a dress to the dance, yet she is still able to maintain her core identity. Both the Cowgirl and the Roper negotiate, and their union creates a more accepting and egalitarian community (Crist 32–45).

Similar to the ballet's hoedown scene, the analogous scene in *He Got Game* offers basketball as a wholesome form of competitive, communal entertainment and promotes a more inclusive vision of American identity than is typically offered by the mainstream. Early in the film, the camera zooms in on Jesus and his friends meeting at a brightly lit basketball court in Brooklyn for a nighttime game. The action begins with the sudden eruption of *Rodeo*'s “Hoedown” movement. Like the ballet's hoedown, the high-energy basketball game attracts a large crowd, offering entertainment to the community as well as status and respect to the individual players. Furthermore, both the original context of *Rodeo*'s “Hoedown” and Lee's use of it in this scene offer a sense of belonging to marginalized groups. The ballet offers an American identity that includes women, and the film offers a vision of African American inclusion. Contrary to the original context that celebrated a young woman, however, is the misogyny in Lee's film. The few female characters fit one of three categories: manipulative sexual temptresses, obedient domesticated wives, or helpless damsels in distress. While Lee uses Copland to promote racial inclusion, he also uses the music to promote a singularly masculine ideal. He likens the African American basketball star to the Western cowboy hero. This transformation in the film contributes to the associa-

tion of Copland's music with a rugged, righteous, and masculine ideal.

Strategically utilized by Lee and others, the gap is narrow between Western nostalgia and the idyllic cowboy hero. Both are part of the Western myth, which began when the real frontier disappeared in the late nineteenth century. In this myth, says Elizabeth Crist, "The West, the prairie, the pioneer, and the cowboy—all were cemented icons of American progress" (113). So solidified have these associations become that they would be difficult to break apart. Thus, making connections between Copland and the idealized Western cowboy seems inevitable even though Copland never collapsed the West into an idealization of rustic manhood. Instead, the merging happens in moments of appropriation as in Lee's use of Copland's music to transform Jesus from an African American high school student to a cowboy.

The Conservative Cowboy

Years later, the idealization of the cowboy would return to alleviate our sense of helplessness after 9/11. Susan Faludi's *The Terror Dream: Fear and Fantasy in Post-9/11 America* illustrates that 9/11 "triggered a search for a guardian of the homestead, a manly man, to be sure, but one particularly suited to protecting and providing for the isolated American family" (148). At this time, the cowboy was revived to protect America, rather than extending American identity to previously excluded groups. Perry staked his 2012 Republican presidential nomination campaign on this kind of imagery. Like the post-9/11 cowboy, Perry wanted to protect our borders against alien threats and what he felt were immoral agendas.

Ambling through a verdant countryside, dressed in a leather jacket and Texas-sized belt buckle, Perry stood ready to protect Christian America from the threat of homosexuality. "There's something wrong in this country when gays can serve openly in the military but our kids can't openly celebrate Christmas or pray in school," proclaims Perry in his political campaign advertisement titled "Strong." Perry becomes the hero that must conquer the gay villain to protect the damsel-in-distress: America. In his final words of the commercial, he says, "Faith made America strong. It can make *her* strong again" (emphasis mine). America is the defenseless woman, faith is her redemption, and Perry is both her protector and her agent of redemption. Accompanying the pasto-

ral scene are delicate open-interval chords played by flutes, clarinets, strings, and bell chimes. The diatonic chords move seamlessly and momentarily to invoke expansionism, nostalgia, and hope. The music, while not a direct quotation, imitates Copland's beloved *Appalachian Spring*.⁵

Appalachian Spring, like *Rodeo*, places a woman, the Bride, at the center of the ballet. *Appalachian Spring* follows the growth of the Bride from self-doubt and fear to agency and strength.⁶ The ballet, which has been allegorized to a Biblical story and wartime struggles, essentially demonstrates the passing of traditions, power, and resilience between two characters of feminine strength: from Pioneer Woman to Bride, from mother to daughter, from older generation to younger, and from woman to woman (for more analysis of *Appalachian Spring*, see Pollack 388–406 and Crist 165–76). The men of the ballet are crucial to the story, but their relationships with the women are harmonious and democratic rather than dominating or self-righteous. The presence of *Appalachian Spring* in "Strong" juxtaposes a female-centric ballet to an advertisement that capitalizes on the rugged masculinity of the cowboy.

However, the commercial is not only incongruous with its music's original context but also with Copland's personal identity. As a Jewish, gay, communist sympathizer, Copland's identity was in many ways contradictory to the American identity that Perry was promoting. It is possible that by rearranging *Appalachian Spring* rather than directly quoting the music, Perry and his advertisement producers could deny the link to the ballet and Copland's identity. However, there is no doubt that they were trying to arouse the warm-hearted American nationalism and pastoral nostalgia that the sounds of Copland's music, and especially *Appalachian Spring*, evoke.

Identities, Conclusions, and Questions

Yet in comparison to *He Got Game*, as white men, Perry and Copland both align with a privileged white identity not afforded to Lee and the film's lead characters as African Americans. However, as African American music has long been appropriated, repurposed, and repossessed by white musicians, repeatedly exploiting black creativity for white financial gain, Lee turns the tables by appropriating a white composer's music for his own purposes (see, also, Mahon). While this understanding of Copland's music in *He Got Game* may

place identities at the opposite extreme of a racial binary, Copland, like the film's main character, grew up in Brooklyn. In terms of place, Copland and Jesus were aligned. In contrast to Perry's pastoral setting, Copland's urban roots further add distance between their identities. However, the pastoral associations of Copland's music align well with Perry's representation of place. The multi-dimensionality of identity construction creates a push and pull of distance and similarity between characters, creators, sounds, and interpreters, questioning who is more aligned: Perry and Copland, Copland and Jesus, or Copland's music and Copland himself.

It is also important to contrast the similarities and differences between the ways that Lee and Perry use Copland's music. Both film and campaign advertisement *transform* Copland's music to represent the hyper-masculinized cowboy. Because the cowboy was already a strong icon of quintessential American identity, they use the cowboy as a source of masculine potency and as validation that their characters have claim to "true" American identity. However, the works differ in why they need to assert their masculine and American identities. As an African American, Jesus risks that his masculinity will be understood not as strength, but aggression. African American men have repeatedly been portrayed as violent, aggressive, and threatening in numerous media sources (see also Brackett 392–94, 406–13; Johnson and Cloonan 95–122; Chang 7–19, 381–405). However, by casting Jesus as the basketball-playing cowboy, Lee uses Copland's music to transform Jesus' strength into something positive, wholesome, and desirable both to his Brooklyn surroundings and to American society at large. Perry, on the other hand, risks being another emasculated white-collared businessman. In a time when the most powerful men are those answering the call of their smart phones, Perry the cowboy is a man who still answers the call of the wild. Besides muscle-decaying office jobs and mind-sucking technology, tolerance of homosexuals poses another threat. Perry proposes a return to the past, a return to the days when faith was still strong—when the white, heterosexual males were still dominant.

The cowboy is idyllic, but he is also flexible in his ability to bolster complicated forms of masculinity and conflicting visions of America. Along with using the cowboy character to advocate two separate and specific kinds of masculinity, both commercial appropriations advocate two different kinds of American

identity. Lee uses Copland's music to create a new vision for America, one that accepts African Americans into the mainstream, that idealizes athletes as the modern-day cowboys, and that makes basketball an accessible path to the American Dream. Perry's commercial uses Copland's music to opposite ends. He wants to return America to a utopian past, when American identity was exclusive. In this respect, the cowboy can either create a new vision of America or defend a preexisting, conventional vision. Therefore, it is remarkable that Copland's music is as flexible as the cowboy, especially considering the identity factors that might seem to hinder Copland's own acceptance into mainstream America. Nevertheless, cowboy associations are attached to Copland's music and also attached to Copland himself. As such, not only is Copland's music often appropriated to evoke the cowboy in popular culture, but Copland as the cowboy himself is still a pervasive image on the concert stage.

Notes

¹ Aaron Copland, *Billy the Kid Suite*, performed by the Michigan State University Symphony Orchestra, conducted by Kevin Noe, Cobb Great Hall, Wharton Center for Performing Arts, East Lansing, MI, 8 February 2013.

² For a full list, see Aaron Copland, *He Got Game: Spike Lee presents the music of Aaron Copland*, performed by the London Symphony Orchestra, the New York Philharmonic, and the New Philharmonia Orchestra, conducted by Leonard Bernstein and Aaron Copland, Sony Classical SK 60593, 1998, compact disc.

³ In email correspondence with the Beef Industry Council and Beef Board, I learned that the advertisements featuring *Rodeo* began in 1992. While the television ads ended around 2005, there are still current radio and online advertisements.

⁴ The only DVD/video recordings of a full length ballet production of *Rodeo* are available at the Library of Congress, New York Public Library, and Syracuse University. In this paper, I present an analysis that paraphrases Crist's work on *Rodeo*.

⁵ I first read about the commercial's use of *Appalachian Spring* in Alex Ross's weblog: Alex Ross, "Copland and the Republicans," *Alex Ross: The Rest is Noise: Books, Articles, and a blog by the music critic of The New Yorker*, last modified 10 December 2011, <http://www.therestis->

noise.com/2011/12/copland-and-the-republicans.html

⁶ A full production of the ballet, with Martha Graham performing at the Bride, is on YouTube. “Martha Graham’s Appalachian Spring Part 1/4,” video clip, accessed 25 November 2013, YouTube, <http://www.youtube.com/watch?v=XmgaKGSxQVw>; “Martha Graham’s Appalachian Spring Part 2/4,” video clip, accessed 25 November 2013, YouTube, <http://www.youtube.com/watch?v=PTdyDOWtE2Q>; “Martha Graham’s Appalachian Spring Part 3/4,” video clip, accessed 25 November 2013, YouTube, <http://www.youtube.com/watch?v=9Iy-NEdTj-g>; “Martha Graham’s Appalachian Spring Part 4/4,” video clip, accessed 25 November 2013, YouTube, <http://www.youtube.com/watch?v=6KIn6xHbSZg>

References

“Beef It’s What’s For Dinner – Circa 1993.” Video clip. Accessed 25 November 2013. YouTube. [www.youtube.com, http://www.youtube.com/watch?v=tvijAIS9c_U](http://www.youtube.com/watch?v=tvijAIS9c_U).

Brackett, David. *The Pop Rock and Soul Reader: Histories and Debates*. New York: Oxford University Press, 2005.

“CBS Sports Spectacular Theme 1979.” Video clip. Accessed 25 November 2013. YouTube. [www.youtube.com, http://www.youtube.com/watch?v=T_2-O9N-QvPE](http://www.youtube.com/watch?v=T_2-O9N-QvPE).

Chang, Jeff. *Can’t Stop, Won’t Stop: A History of the Hip-Hop Generation*. Introduction by DJ Kool Herc. New York: St. Martin’s Press, 2005.

Copland, Aaron. *Billy the Kid Suite*. Performed by the Michigan State University Symphony Orchestra. Conducted by Kevin Noe. Cobb Great Hall, Wharton Center for Performing Arts, East Lansing, MI, 8 February 2013.

Copland, Aaron. “Composer from Brooklyn.” *Magazine of Art* 32 no. 9 (1939): 522-23, 548-50.

Copland, Aaron. *He Got Game: Spike Lee presents the music of Aaron Copland*. Performed by the London Symphony Orchestra, the New York Philharmonic, and the New Philharmonia Orchestra. Conducted by Leonard Bernstein and Aaron Copland. Sony Classical SK 60593, 1998. Compact Disc.

Crist, Elizabeth B. *Music for the Common Man: Aaron Copland during the Depression and War*. Oxford: Oxford University Press, 2005.

Faludi, Susan. *The Terror Dream: Fear and Fantasy in Post-9/11 America*. New York: Metropolitan Books, 2007.

Fausner, Annegret. “Aaron Copland, Nadia Boulanger, and the Making of an ‘American’ Composer.” *The Musical Quarterly* 89 no. 4 (2006): 524-54.

Garrett, Charles Hiroshi. *Struggling to Define a Nation: American Music and the Twentieth Century*. Oakland: University of California Press, 2008.

He Got Game. Directed by Spike Lee. Burbank, CA: Touchstone Home Video, 1998. DVD.

Hubbs, Nadine. *The Queer Composition of America’s Sound: Gay Modernists, American Music, and National Identity*. Berkeley: University of California Press, 2004.

Johnson, Bruce and Martin Cloonan. *The Dark Side of the Tune: Popular Music and Violence*. Burlington: Ashgate, 2008.

Lee, Spike. “Why Aaron Copland?” Liner notes to *Spike Lee Presents: The Music of Aaron Copland*. Sony SK 605930.

Lerner, Neil. “Copland’s Music of Wide Open Spaces: Surveying the Pastoral Trope in Hollywood.” *The Musical Quarterly* 85, no. 3 (2001): 477-515.

Levy, Beth. *Frontier Figures: American Music and the Mythology of the American West*. Berkeley: University of California Press, 2012.

Mahon, Maureen. *Right to Rock: The Black Rock Coalition and the Cultural Politics of Race*. Durham: Duke University Press, 2004.

“Martha Graham’s Appalachian Spring Part 1/4.” Video clip. Accessed 25 November 2013. YouTube. [www.youtube.com, http://www.youtube.com/watch?v=XmgaKGSxQVw](http://www.youtube.com/watch?v=XmgaKGSxQVw).

“Martha Graham’s Appalachian Spring Part 2/4.” Video clip. Accessed 25 November 2013, YouTube. [www.youtube.com, http://www.youtube.com/watch?v=PTdyDOWtE2Q](http://www.youtube.com/watch?v=PTdyDOWtE2Q).

“Martha Graham’s Appalachian Spring Part 3/4.” Video clip. Accessed 25 November 2013. YouTube. [www.youtube.com, http://www.youtube.com/watch?v=9Iy-NEdTj-g](http://www.youtube.com/watch?v=9Iy-NEdTj-g).

“Martha Graham’s Appalachian Spring Part 4/4.” Video clip. Accessed 25 November 2013, YouTube. [www.youtube.com, http://www.youtube.com/watch?v=6KIn6xHbSZg](http://www.youtube.com/watch?v=6KIn6xHbSZg).

Mellers, W.H. "American Music (An English Perspective)." *The Kenyon Review* 5, no. 3 (1943): 357-75.

Pollack, Howard. *Aaron Copland: The Life and Work of an Uncommon Man*. New York: Henry Holt, 1999.

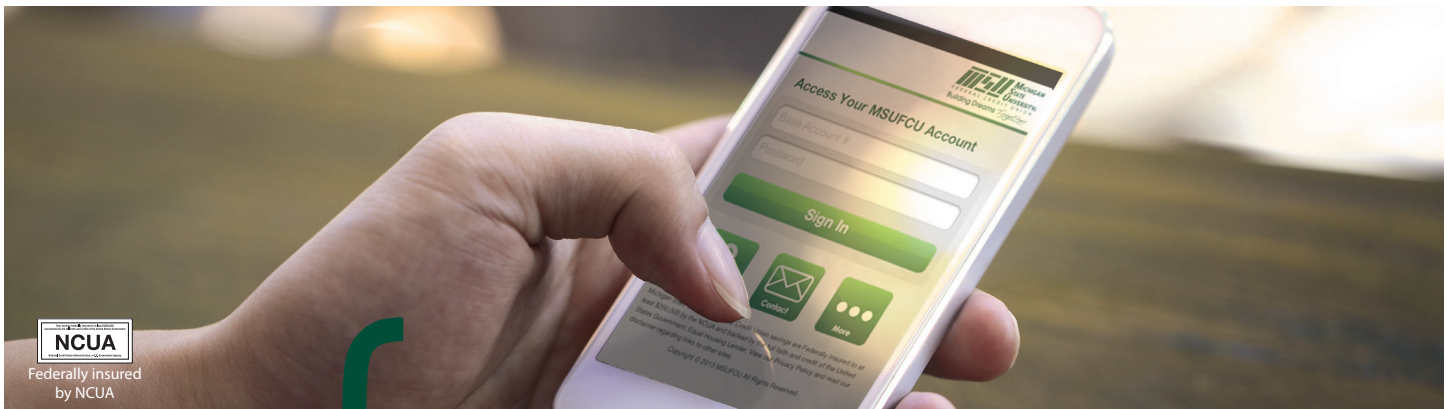
Rockwell, John. "Copland, Dean of American Music, Dies at 90." *New York Times*, December 3, 1990. Accessed February 26, 2015. <http://www.nytimes.com/books/99/03/14/specials/copland-obit.html>.

"Rodeo American Ballet Theatre 1973." Video clip. Accessed 25 February 2015. YouTube. www.youtube.com, <https://www.youtube.com/watch?v=8PGkKjp-KlyU>.

Ross, Alex. "Copland and the Republicans." *Alex Ross: The Rest is Noise: Books, Articles, and a blog by the music critic of The New Yorker*. Last Modified 10 December 2011. <http://www.therestisnoise.com/2011/12/copland-and-the-republicans.html>.

Smith, Julia. *Aaron Copland: His Work and Contribution to American Music*. New York: E.P. Dutton, 1955.

"Strong." Video clip. Accessed 25 November 2013. YouTube. www.youtube.com, <http://www.youtube.com/watch?v=0PAJNntoRgA>.



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2014 National and International Fellowship and Scholarship Recipients

Each year, MSU undergraduates and alumni are awarded highly competitive national and international fellowships and scholarships. In this issue of ReCUR, recent recipients of these prestigious awards are profiled.

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Kent Dell is an Iraq War veteran and recent graduate of Michigan State University accepted into the Presidential Fellows Program.

Dell is MSU's 8th Presidential Fellows Program winner. He graduated in 2014 with a bachelor's degree in public policy and in 2015 with a master's degree in public policy through the Department of Political Science within the College of Social Science. He was in the Honors College.

"My area of research would involve exploring the decision calculus of the modern President when deciding whether or not to use military force," Dell said. "As a veteran of the Iraq War, a Parachute Infantryman who served a total of 17 months in country, this unique role of the President is of great interest to me."

Dell worked as a research assistant to MSU Honors College Dean Cynthia Jackson-Elmoore, most recently on a project examining the influence of institutions and demographics on legislator's use of information sources when making policy decisions.

A recipient of the Purple Heart, Dell has also served as instructor for the U.S. Army Reserves.



Mykala Ford is an Honors College senior majoring in international relations in James Madison College and Arabic in the College of Arts & Letters. She was a 2014 recipient of the Boren Scholarship.

Ford used the scholarship to study Arabic in Morocco. She wants to be a Foreign Service officer for the federal government after graduation.



Christopher Murphy is a senior majoring in Chinese and French in the College of Arts & Letters. He was a recipient of the Boren Scholarship.

Murphy studied Mandarin in China with the scholarship. He wants to be a political officer in the Foreign Service branch of the federal government.



Craig Pearson is MSU's 16th Marshall Scholar and was also admitted into the National Institutes of Health Oxford-Cambridge Scholars program.

Pearson began his doctorate in clinical neurosciences at the University of Cambridge funded by the Marshall Scholarship in fall 2014. His final two years will be spent working with a co-mentor at the National Institutes of Health in Bethesda, Maryland.

"It's a fantastic opportunity to build new relationships between laboratories in the U.S. and the U.K., and I'm thrilled to have the chance to work with two mentors and in two labs, while maintaining a cohesive focus on a single PhD project," Pearson said.

Pearson graduated from MSU with degrees in neuroscience, biochemistry and molecular biology from the College of Natural Science and English from the College of Arts & Letters. He was a member of the Honors College.

He entered MSU as an Alumni Distinguished Scholarship recipient and served as an undergraduate research assistant in the MSU Department of Small Animal Clinical Sciences and an undergraduate lab manager and lead undergraduate researcher for the MSU Digital Humanities and Literary Cognition Lab.

He served as a clinical volunteer at the MSU Department of Neurology and Ophthalmology. Pearson was the student managing editor for ReCUR, the Red Cedar Undergraduate Research Journal, in 2014 and founded *Exceptions* journal.



Alexis Pierce is an Honors College senior majoring in international relations, and comparative cultures and politics in James Madison College.

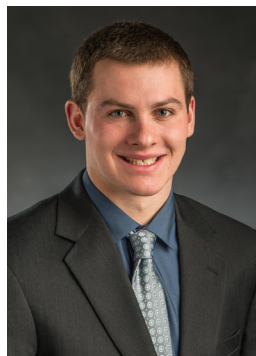
Pierce studied Korean in South Korea as a 2014 Boren Scholar. She wants to work for the Central Intelligence Agency or U.S. Department of State.



John Suddard-Bangsund was named a Goldwater Scholar. He graduated in 2015 with a bachelor's degree in materials science and engineering from the College of Engineering. He was a member of the Honors College.

Suddard-Bangsund was a research assistant in the Molecular Organic Excitronics Lab. Suddard-Bangsund was an Honors Times Two mentor, fundraising chair for Engineers Without Borders, and participated in the Michigan State Solar Car team. Suddard-Bangsund was also a recipient of the MSU Alumni Distinguished Scholarship. He plans to pursue a doctoral degree in materials science and engineering, conducting research on solar energy materials and teaching at the university level.

"I'm honored to be recognized as a Goldwater Scholar but I couldn't have gotten to this point without the mentorship I've received," Suddard-Bangsund said. "I've had the opportunity to work with people who are really excited and passionate about their work, and their energy has been contagious. I look forward to continuing my research and seeing where it takes me."



David Zoltowski graduated in 2015 with a bachelor's degree in electrical engineering from the College of Engineering. He was in the Honors College.

He was a research assistant to Professor Selin Aviyente in the Communications and Signal Processing Lab, a member of MSU's Student-Athlete Advisory Council, Tau Beta Pi, Eta Kappa Nu and an Honors Times Two mentor. In addition, he was captain of the MSU Men's Swimming and Diving Team.

"I am very excited to be a Goldwater Scholar," Zoltowski said. "It feels great to be recognized for my hard work and I am motivated to live up to the standards of past Goldwater Scholars. The award is a testament to the quality of Michigan State University's College of Engineering, Honors College, and Student-Athlete Support Services."

Editor's note: Elizabeth Dunham also was awarded a Boren Scholarship, but ultimately declined it.

Novel Alkaline Hydrogen Peroxide Pretreatment Enhances the Enzymatic Digestibility of Woody Biomass Substrates under Ambient Condition

Charles H. Chen^{1,2}, Zhenglun Li^{1,2}, Eric L. Hegg^{2,3}, and David B. Hodge, PhD^{1,2,4}

¹ Department of Chemical Engineering and Materials Science

² U.S. Department of Energy Great Lakes Bioenergy Research Center

³ Department of Biochemistry and Molecular Biology

⁴ Department of Biosystems and Agricultural Engineering

Abstract

Copper(II) 2,2'-bipyridine catalyzed alkaline hydrogen peroxide pretreatment (Cu^{II}(bpy)-AHP) is a new method to enhance the yield of fermentable sugars from hardwood and softwood biomass. The pretreatment results in significant improvement in enzymatic sugar yields from woody biomass under mild reaction for 10 minutes, and consumes small amounts of chemicals and energy. The removal lignin enhances the enzyme accessibility of polysaccharides, and the lignin degradation products have broad applications as precursors for biofuel and biomaterial. As a superior biorefinery approach, Cu^{II}(bpy)-AHP is an effective biomass conversion process, which liberates the lignin without causing loss of the polysaccharides.

Introduction

Petroleum consumption has rapidly increased and caused global environmental issues in recent years.¹ Therefore, research on alternative fuel to reduce the carbon dioxide emission has become necessary. Ethanol produced from lignocellulosic biomass is a candidate as renewable biofuel and has been used as a partial gasoline replacement as E10 (10% volume ethanol and 90% volume gasoline) and E85. Production of lignocellulosic ethanol involves hydrolysis of polysaccharides to fermentable reducing sugars, and the fermentation of sugars to alcohol.² In lignocellulosic biomass, lignin is a complex polyphenolic polymer in

the secondary cell walls of plants, and it impacts negatively on enzymatic hydrolysis in biofuel production. Pretreatment is an important process for increasing the accessibility of enzyme to polysaccharides and improving the yield of fermentable sugars using plant cell wall deconstruction. Pretreatment can modify the structure of lignocellulosic biomass and enhance the enzymatic accessibility by mechanical, physico-chemical, chemical, or biological alterations of plant cell wall. Furthermore, pretreatment has great potential in fractionating the polysaccharides, lignin, and other valuable compounds in industrial processes for different purposes and applications.³

Alkaline hydrogen peroxide (AHP) pretreatment is an effective method to improve the enzymatic hydrolysis using hydrogen peroxide at alkaline pH. AHP pretreatment performed at ambient conditions (room temperature and atmosphere pressure) liberates the hemicellulose (e.g., arabinoxylan) and lignin complexes, and enhances the enzymatic accessibility to polysaccharides in glucan/xylan hydrolysis.^{4,5} However, the slow reaction rate of hydrogen peroxide decomposition and the difficulty in achieving high glucan/xylan conversion in hydrolysis are major issues to this process. Copper(II) 2,2'-bipyridine (Cu^{II}(bpy)) catalyzed AHP pretreatment was developed to use catalyzed oxidation to deconstruct the plant cell wall and enhance the yield of sugars during enzymatic hydrolysis. The catalyzed oxidation has similar mechanisms as laccase, which is an oxidoreductase,

containing coordinated copper in the activity center that has been found in many plants, fungi, and microorganisms.^{6,7} The metal catalysts require electron acceptors as hydrogen peroxide to perform oxidation reaction, in which hydrogen peroxide is activated by the catalysts and produces oxygen radicals. The radicals then do homolytic or heterolytic cleavage of the side chains (C α -C β , alkyl-phenyl) and aromatic rings on lignin, yielding degradation products, which have a smaller degree of polymerization and greater solubility.⁸ Degradation of lignin enhances the accessibility of polysaccharides to cellulase and xylanase enzymes, and more reducing sugars are recovered after the saccharification.

Methods

Biomass

Debarked hardwood from 18-year-old hybrid poplar (*Populus nigra* var. *charkoviensis* x *caudina* cv. NE-19) was grown at the University of Wisconsin Arlington Agricultural Research Station and provided through the Great Lakes Bioenergy Research Center (GLBRC). The hardwood was hammer-milled to pass through a 5 mm screen. Silver birch (*Betula pendula*) wood chips were obtained from Smurfit Kappa Kraftliner AB (Piteå, Sweden), and the chips were cut to the size of about 45 mm × 8 mm × 2 mm.

Chemical composition analysis of lignocellulosic biomass

The compositions of structural carbohydrates and acid-insoluble lignin (Klason lignin) in lignocellulosic biomass were quantified using a modified method based on NREL two-stage acidolysis.^{6,9}

Catalytic AHP pretreatment

Copper(II) 2,2'-bipyridine complexes were prepared in situ in an aqueous stock solution. 40 mM cupric sulfate pentahydrate (EMD Chemicals, Billerica, MA) was mixed with 2,2'-bipyridine (Sigma-Aldrich, St. Louis, MO) at a ligand:metal molarity ratio (L:M) of 5:1. Hybrid poplar hardwood (0.500 g dry basis; 3.0% moisture) was added to a total of 2.5 mL aqueous solution (20% w/w solid loading) with 2.0 mM Cu^{II}(bpy) complexes and 75 μ L of 30% (w/w) hydrogen peroxide solution. At the same time, the pH was adjusted to 11.5 \pm 0.2 by concentrated NaOH solution. After appropriate mixing of the biomass and aqueous liquid, the slurry was incubated in an orbital shaker

at 180 rpm under 30°C. After pretreatment, 20 μ L of 72% (w/w) H₂SO₄ was added to the pretreated slurry and drop the pH to 5.0.

Enzymatic hydrolysis

500 μ L of 1 M citric acid buffer (pH 5.0) was added to the pretreated slurry to maintain the pH at 5.0, which is the desirable condition for enzymatic hydrolysis. 40 μ L of 10 mM tetracycline (Sigma-Aldrich) stock solution was added to inhibit microbial growth. Then, 30 mg protein/g glucan of both enzyme CTec2 and HTec2 cocktail (Novozymes A/S, Bagsværd, Denmark) were mixed with the slurry, and the solid loading of slurry was adjusted to 5% (w/v) using deionized water. The total protein contents of enzyme cocktails were determined by the Bradford assay (Sigma-Aldrich). The samples were incubated at 50°C with orbital shaking at 180 rpm. After enzymatic hydrolysis, the solid and liquid phases were separated by centrifugation, and the water-soluble sugars were quantified using HPLC. (For HPLC analysis, Agilent 1100 Series equipped with an Aminex HPX-87H column was operated at 65°C. A mobile phase of 0.05 M H₂SO₄ was used at a flow rate of 0.6 mL/min, and the detection of sugars was performed by a refractive index detector.)^{6,10}

Carboxylate Measurement

Whatman filter paper no. 1 was cut into ~3 mm squares and processed with uncatalyzed and Cu(bpy)-catalyzed AHP pretreatment at 10% w/w H₂O₂ loading at 10% w/w solids loading as described previously. After pretreatment, the reaction mixture was centrifuged, washed with large volume of water, and air-dried. The carboxylate content in pretreated filter paper was determined in triplicates via potentiometric titration (716 DMS Titrino; Metrohm AG, Herisau, Switzerland).^{11,12}

Results and Discussion

Our results showed that the Cu^{II}(bpy)-AHP-treated poplar hardwood with 20% (w/w) solid loading was nearly complete in 10 minutes, as reflected by the improvement in enzymatic digestibility (62.9% glucan conversion and 64.4% xylan conversion after 72 hours of enzymatic hydrolysis). The sugar yields of biomass treated with higher solids loading of Cu^{II}(bpy)-AHP resulted in almost one-fold higher than 10% (w/w) solid loading of Cu^{II}(bpy)-AHP-treated poplar hardwood (Figures 1A and B). The extension of pretreatment time to 24 hours enhanced the monomeric

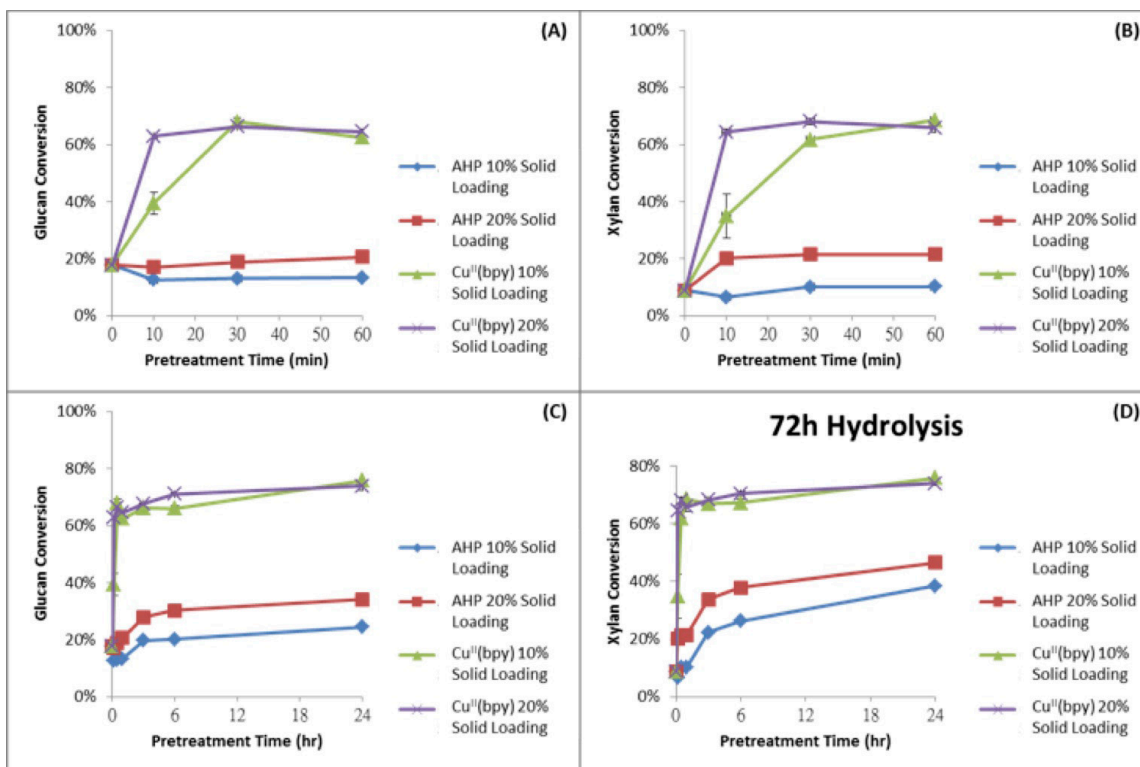


FIGURE 1. Cu^{II}(bpy)-AHP-treated (10% H₂O₂ loading) poplar heartwood with pretreatment time (0–24 hour) and solid loading (10% weight and 20% weight biomass/volume total liquid) showing (A) enzymatic glucose yield and (B) enzymatic xylose yield in 0–60 minute pretreatment, and (C) enzymatic glucose yield and (D) enzymatic xylose yield in 0–24 hour pretreatment. Enzymatic hydrolysis was performed with 30:30 (mg CTec/g glucan : mg HTec/g glucan) enzyme loading for 72 hours.

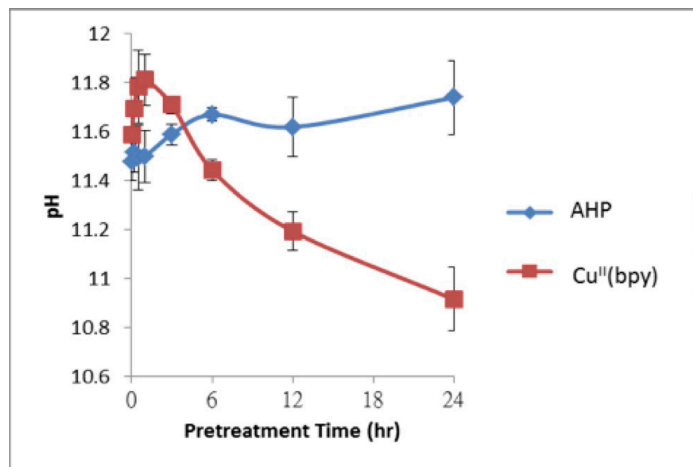


FIGURE 2. pH trajectory in pretreatment of poplar heartwood was measured by pH meter, and the measurements were done in quadruplicates.

sugars yield to 73.9% of glucan and 34.1% of xylan conversion (Figures 1C and D). Interestingly, the trajectory of pH during pretreatment showed that the pH of Cu^{II}(bpy)-AHP-treated poplar hardwood slurry rapidly increased from 11.50 to 11.81 in an hour and gradually dropped to 10.90 after 24 hours. However, the pH of AHP increased linearly from 11.5 to 11.74 after 24 hours (Figure 2). The reason of this pH effect still

remains unknown, and it may be revealed by further mechanistic studies on lignin and cellulose models. On the other hand, the structural compositions of the plant cell wall had been studied using the modified two-stage acidolysis and carboxylate content methods. Compared to untreated poplar hardwood, Cu^{II}(bpy)-AHP-pretreated poplar hardwood has lower content Klason lignin and more carboxylate group than AHP (Figures 3 and 4). The higher carboxylate content enhances the hydrophilicity of the lignin and carbohydrates; hence, it causes the lignin to become more soluble in the water and decreases the degree of polymerization of cellulose.⁶ These results confirmed that the oxidation reaction of Cu^{II}(bpy)-AHP is more effective than AHP. However, more studies are required to have a better understanding of the oxidation reaction during Cu^{II}(bpy)-AHP.

The consumption of chemicals is an important issue in the cost of the process, and it is related to parameters including biomass solid loading, enzyme loading, hydrogen peroxide loading, catalysts concentration, and ratio of metal to ligand. As we have discussed, increasing biomass solid loading may result in higher sugar conversion in 1 hour pretreatment, but there is no sig-

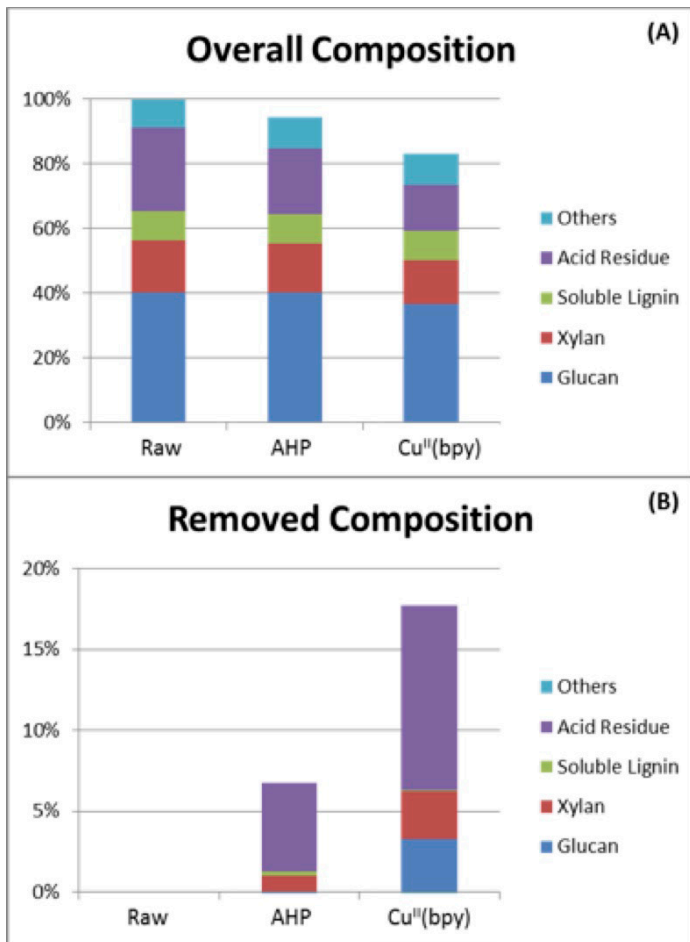


FIGURE 3. Biomass composition analysis of $\text{Cu}^{\text{II}}(\text{bpy})$ -AHP-treated (10% solid loading, 10% H_2O_2 loading and 1 hour pretreatment time) poplar hardwood for (A) overall composition in solid phase and (B) removed composition in liquid phase.

nificant difference between 10% and 20% (w/w) solid loading when the pretreatment time is extended to more than 24 hour (Figure 1). After enzymatic hydro-

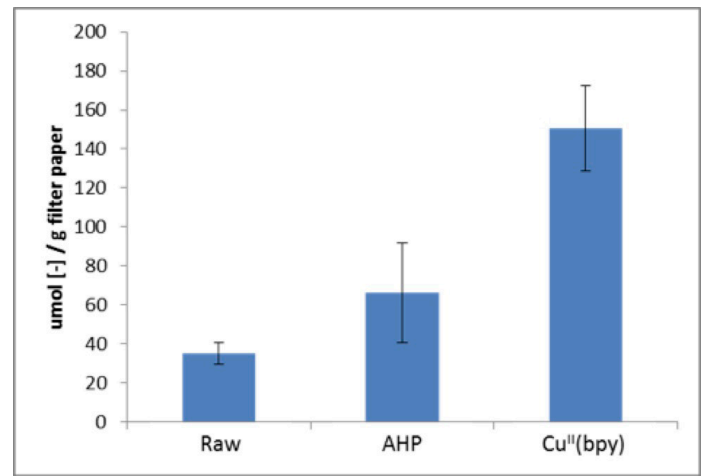
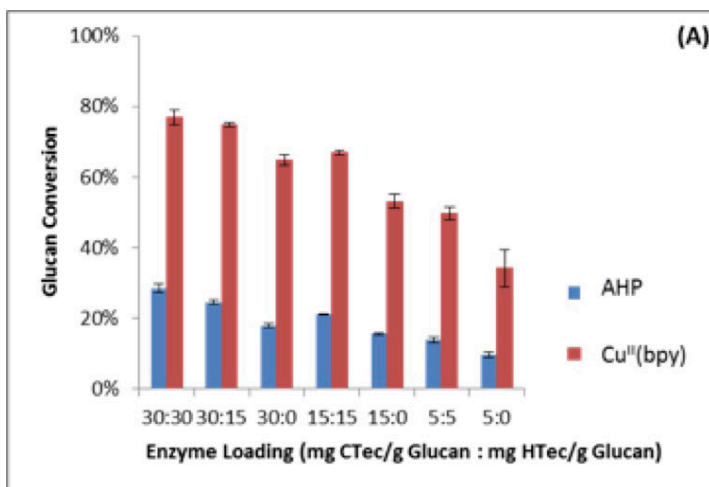


FIGURE 4. Pretreatment of Whatman filter paper with either AHP or $\text{Cu}^{\text{II}}(\text{bpy})$ -AHP showing the quantity of carboxyl groups to cellulose.

lysis of $\text{Cu}^{\text{II}}(\text{bpy})$ -AHP-treated poplar hardwood, the effects of enzyme loading on monosaccharide yields indicating 30:0 and 15:15 enzyme loading (“x:y” defines as “x mg C-Tec II/g glucan and y mg H-Tec II/g glucan during enzymatic hydrolysis”) had similar results for $64.7 \pm 1.5\%$ and $67.0 \pm 0.6\%$ glucan conversion, but the yield of glucose was 10.0–12.3% glucose lower than 30:30 enzyme loading. On the other hand, 5:5 enzyme loading of $\text{Cu}^{\text{II}}(\text{bpy})$ -AHP-treated poplar hardwood still had 49.7% glucan and 56.5% xylan conversion (Figure 5). Reducing hydrogen peroxide loading and catalysts loading is another effective approach to reduce the process cost. Our results showed that 72 hour enzymatic hydrolysis of $\text{Cu}^{\text{II}}(\text{bpy})$ -AHP-treated poplar hardwood using 5% and 10% hydrogen peroxide loading during $\text{Cu}^{\text{II}}(\text{bpy})$ -AHP converts 76.9–80.5% of the glucan, and merely 2.5% hydrogen peroxide loading, $64.0 \pm 0.2\%$, which is still one-fold higher than the

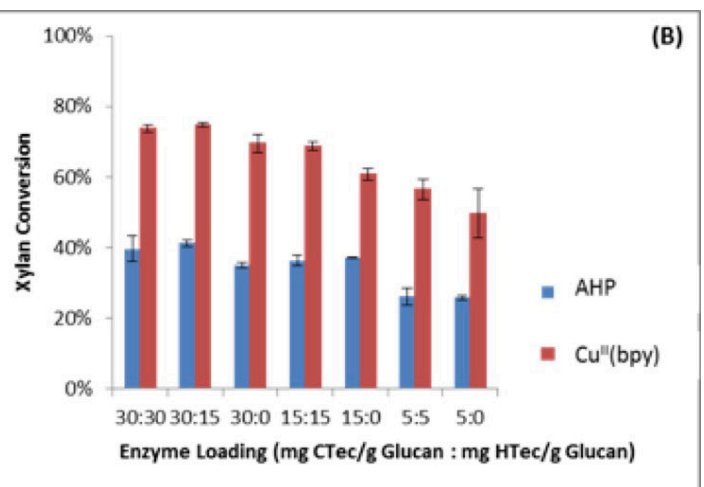


FIGURE 5. $\text{Cu}^{\text{II}}(\text{bpy})$ -AHP-treated poplar hardwood with 10% solid loading, 10% H_2O_2 loading, and 10% solid loading for 24 hour pretreatment time showing (A) enzymatic glucose yield and (B) enzymatic xylose yield. Enzymatic hydrolysis was performed with screening ratio of C-Tec II and H-Tec II loading for 72 hours.

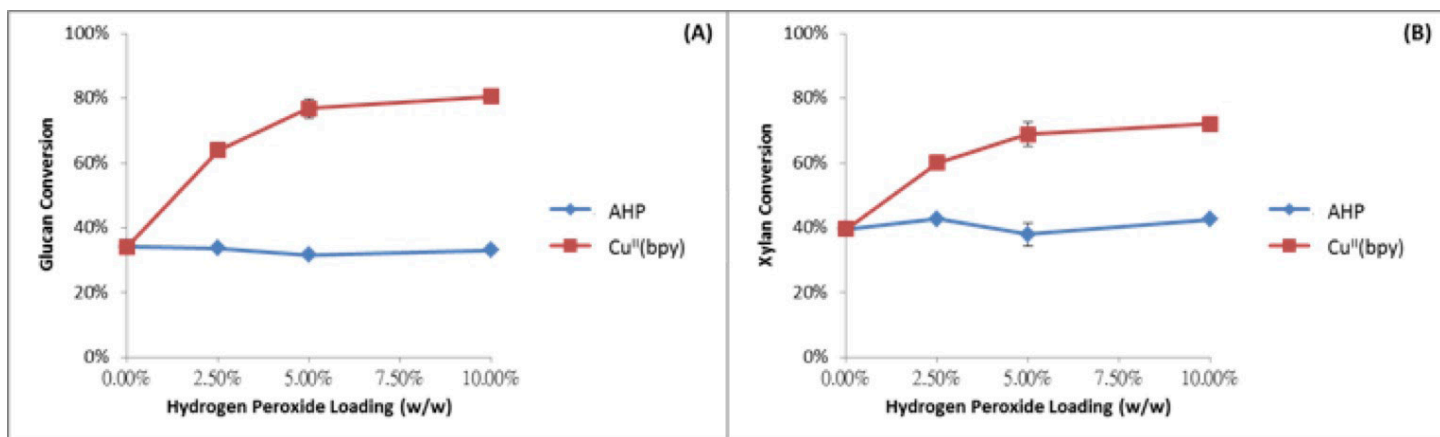


FIGURE 6. Enzymatic hydrolysis with 30:30 (mg CTec/g glucan : mg HTec/g glucan) enzyme loading for 72 hours results showing (A) enzymatic glucose yield and (B) enzymatic xylose yield for Cu^{II}(bpy)-AHP with 0-10% (w/w biomass) H₂O₂ loading. Pretreatment was performed for 24 hours at 10% solid loading with 2 mM Cu^{II}(bpy) catalysts.

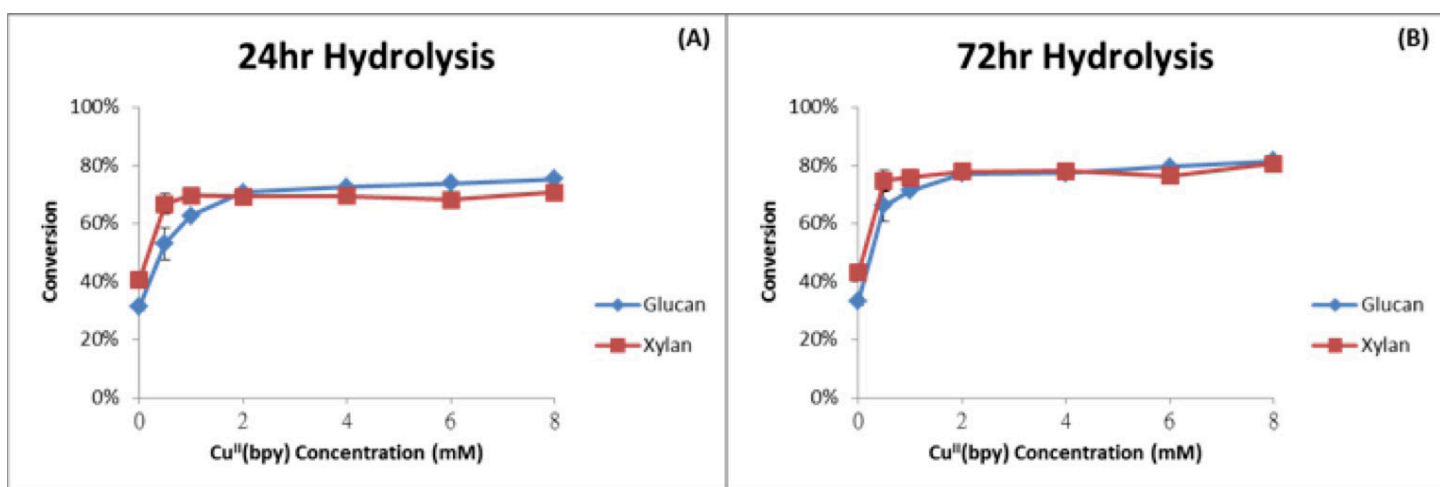


FIGURE 7. Effect of catalysts concentration (0-8 mM) of 24 hr Cu_{II}(bpy)-AHP-treated (10% H₂O₂ loading) poplar hardwood showing the sugars yield of enzymatic hydrolysis with 30:30 (mg CTec/g glucan : mg HTec/g glucan) enzyme loading for (A) 24 hours enzymatic hydrolysis and (B) 72 hours hydrolysis time.

glucan conversion for the control condition, which is Cu^{II}(bpy) treatment without hydrogen peroxide (Figure 6). Alternative oxidants (e.g., oxygen) have the potential to reduce cost and improve the oxidation reaction. The catalysts loading may be dropped to 2 mM as the glucan and xylan conversion are saturated at this catalyst concentration. The Cu^{II}(bpy) concentration during pretreatment can further drop from 2 to 0.5 mM, resulted in 6.0±3.5% lower glucan conversion in enzymatic hydrolysis (Figure 7). This result strongly inspired us to further reduce the catalysts concentration to less than 0.5 mM in order to lower the cost of chemicals. Overall, we report some critical parameters for Cu^{II}(bpy)-AHP process and show how these factors affected the glucose and xylose yields. Economic analysis and scale-up of Cu^{II}(bpy)-AHP process will be the focus of the future work.

Conclusions

Cu^{II}(bpy)-AHP reduced reaction time to 10 minutes, significantly enhanced glucose and xylose yields (62.9±0.6% glucan and 73.9±1.6% xylan conversion in 10 minutes and 24 hours pretreatment time), and processed under ambient conditions (at 30°C and 1 atm). Instead of treating the small particle size of poplar hardwood, we also performed the Cu^{II}(bpy)-AHP to pretreat birch wood chips (about 45 mm × 8 mm × 2 mm). The results showed that Cu^{II}(bpy)-AHP is applicable with different woody biomass and larger particle size (Figure 8). The cost of transition metal catalysts, the solubility of catalysts, and process scale-up are the issues to be resolved in future applications. Better understanding of Cu^{II}(bpy)-AHP and metal-catalysts screening among more candidates is hereby required. The goal of Cu^{II}(bpy)-AHP is to

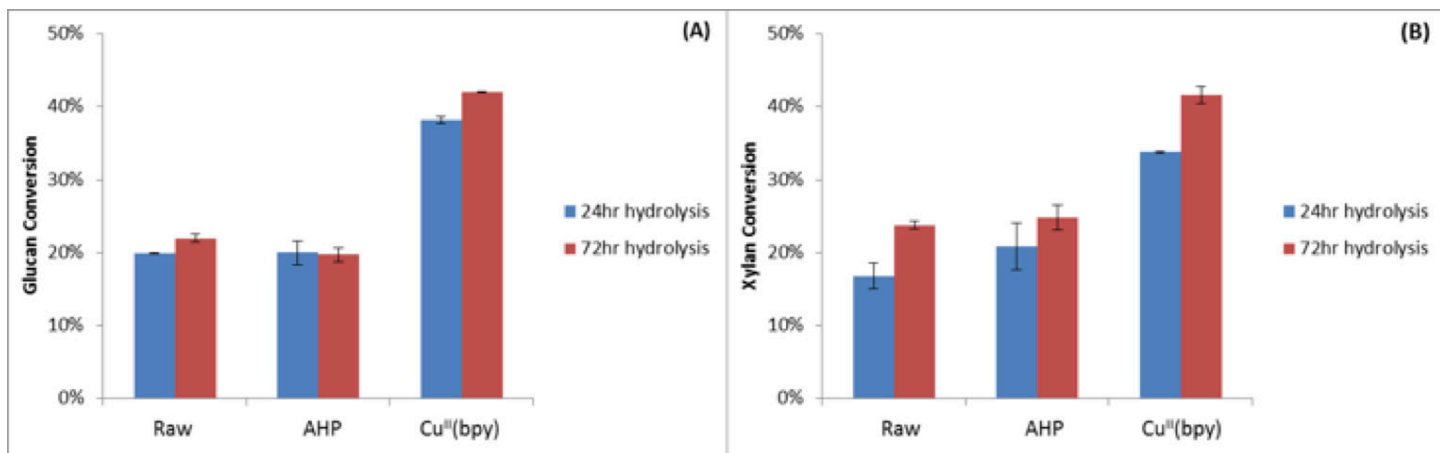


FIGURE 8. Cu_{II}(bpy)-AHP-treated birch wood chips (about 45 mm × 8 mm × 2 mm) with 20% solid loading and 10% H₂O₂ loading for 24 hours pretreatment time showing (A) enzymatic glucose yield and (B) enzymatic xylose yield. Enzymatic hydrolysis with 30:30 (mg CTec/g glucan : mg HTec/g glucan) enzyme loading for 72 hours.

further enhance the glucose and xylose yields after enzymatic hydrolysis, and to optimize the ethanol productivity in fermentation. Both the cellulose and hemicelluloses are abundant sources of reducing sugars for alcohol fermentation, but many pretreatments (e.g., dilute acid pretreatment) remove hemicellulose, which sacrifices the xylose to increase the cellulose accessible for enzymatic hydrolysis.¹³ In our study, Cu^{II}(bpy)-AHP introduced more carboxylate content of the biomass that increased the lignin and xylan solubilization, and reduced the degree of polymerization of cellulose, which possibly resulted in structural modification of the plant cell wall. Cu^{II}(bpy)-AHP is a rapid and effective oxidative pretreatment to separate the polysaccharides and lignin-polymer complexes, and produces fermentable sugars and lignin byproducts.¹⁴

Acknowledgment

This work was funded by the U.S. Department of Energy Great Lakes Bioenergy Research Center (DOE BER Office of Science DE-FC02-07ER64494).

References

- Hoffert, M, et al. Advanced technology paths to global climate stability: energy for a greenhouse planet. *Science* 2002;298:981–7.
- Sun Y, Cheng J. Hydrolysis of lignocellulosic materials for ethanol production: a review. *Bioresource Technology* 2002;83:1–11.
- Hendriks ATWM, Zeeman G. Pretreatments to enhance the digestibility of lignocellulosic biomass. *Bioresource Technology* 2009;100:10–8.

- Doner LW, Kevin BH. Isolation of hemicellulose from corn fiber by alkaline hydrogen peroxide extraction. *Cereal Chemistry* 1997;74:176–81.
- Banerjee G, Car S, Scott-Craig JS, Hodge DB, Walton JD. Alkaline peroxide pretreatment of corn stover: effects of biomass, peroxide, and enzyme loading and composition on yields of glucose and xylose. *Biotechnology for Biofuels* 2011;4:16.
- Li Z, Chen CH, Liu T, Mathrubootham V, Hegg EL, Hodge DB. Catalysis with Cu^{II}(bpy) improves alkaline hydrogen peroxide pretreatment. *Biotechnology and Bioengineering* 2013;110:1078–86.
- Bourbonnais R, Paice MG, Reid ID, Lanthier P, Yaguchi M. Lignin oxidation by laccase isozymes from *trametes versicolor* and role of the mediator 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulfonate) in kraft lignin depolymerization. *Applied and Environmental Microbiology* 1995;61(5):1876–80.
- Bouchard J, Wang J, Berry R. The role of hydroxyl and oxyl anion radicals in selectivity of oxygen delignification. *Holzforschung* 2010;64:153–9.
- Sluiter A, Hames B, Ruiz R, Scarlata C, Sluiter J, Templeton D, Crocker D. Determination of structural carbohydrates and lignin in biomass. Technical Report NREL/TP 2011;10:42618.
- Li Z, Chen CH, Hegg EL, Hodge DB. Rapid and effective oxidative pretreatment of woody biomass at mild reaction conditions and low oxidant loadings. *Biotechnology for Biofuels* 2013;6:119.
- Banerjee G, Car S, Liu T, Williams DL, Meza SL, Walton JD, Hodge DB. Scale-up and integration of alkaline hydrogen peroxide pretreatment, enzymatic

hydrolysis, and ethanolic fermentation. *Biotechnology and Bioengineering* 2012;109(4):922–31.

12. Coseri S, Nistor G, Fras L, Strnad S, Harabagiu V, Simionescu BC. Mild and selective oxidation of cellulose fibers in the presence of *n*-hydroxyphthalimide. *Biomacromolecules* 2009;10:2294–9.

13. Kumar P, Barrett DM, Delwiche MJ, Stroeve P. Methods for pretreatment of lignocellulosic biomass for efficient hydrolysis and biofuel production. *Ind Eng Chem Res* 2009;48:3713–29.

14. Kim YS, Kadla JF. Preparation of a thermoresponsive lignin-based biomaterial through atom transfer radical polymerization. *Biomacromolecules* 2010;11:981–8.



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Highlights of Undergraduate Research

Ellis, J., Increasing Negative Emotions in Psychopathic Undergraduates: An Electrophysiological Investigation, Association for Psychological Science, 22-25 May 2014.

Farkas, H., Parents as Teachers: Reading and Teaching Beliefs and Practices at Home Predict Children's Language Skill Growth, Society for Research in Child Development Biennial Meeting, 19-21 March 2015.

Fleck, C., Griffin, N., The Effect of Expertise and Trust on False Memory in Twitter Feeds, Midwestern Psychological Association, 1-3 May 2014.

Fleck, C., More than just the medium: Factors affecting false memory from Twitter, Psychonomic Society Meeting, 20-23 November 2014.

Griffin, N., The Effects of Social Media on False Memory, Annual Meeting of the Psychonomic Society, 14-17 November 2013.

Hahn, S., Association of bloody fatty acids and growth in Tanzanian children 2-6 years of age, Experimental Biology, Experimental Biology Conference, 28-31 March 2015.

Hirzel, M., Taking Baths with Duck-Ducks: Exploring Children's Understanding of Contrastive Reduplication, TULCON Toronto Undergraduate linguistics Conference, 7-9 March 2014.

Kneibel, J., Realistic Multi-ion Absorption Spectra from Simulations of the Intergalactic Medium, AAS 225th Meeting, 4-8 January 2015.

Lakey, B., You Are What You Eat: Horizontal Gene Transfer in Euglenoids, International Society of Evolutionary Protistology Meeting, 3-9 August 2014.

Liter, A., Inclusive plural interpretations depend on grammaticalized number: an argument from artificial

language learning, Workshop on the Acquisition of Quantification, 4-5 October 2013.

Martin, N., Geochemistry of lavas from the Kaiapo tuff cone, Taupo Volcanic Zone, New Zealand: lava heterogeneity within a single edifice, Goldschmidt California Conference 2014, 8-13 June 2014.

Morel, V., Self-regulation in land plant and global climate interactions, American Geophysical Union Fall Meeting, 9-13 December 2013.

Nicoli, C., Survey of Student Mental Health Resource Utilization, NASPA Mental Health Conference, 16-18 January 2014.

Pastoria, S., I can't tell you, but I can show you: Preverbal children's understanding and representation of emotions through gesture, 14th annual WAIMH World Congress, 14-18 June 2014.

Steil, T., Comparison of Compressed Sensing Techniques, Joint Mathematics Meeting, 15-18 January 2014.

Sylvester, J., The Miller and the Brook: distinctions between Man and Feminized nature in Schubert's Song, Midwest Popular Culture Conference, 3-5 October 2014.

Tomlinson, S., Aaron Copland: An American in Paris of The Lone Ranger?, Mid-Atlantic Popular and American Culture Association, 7-9 November 2013.

Tomlinson, S., Minnie, The Girl Who Lived: Why Cowgirls Make Better Role Models than Angels, 2014. National Conference on Undergraduate Research, 3-5 April 2014.

Zdziarska, P., Mapping the Time Course of Confidence Judgments in Facial Recognition, Annual Meeting of the Psychonomic Society, 14-18 November 2013.

Animism, Animals, and Agriculture: Animal Husbandry in Nineteenth Century Shaker Religious Practice

Julia Johnson | Department of Religious Studies

Abstract

The topic of religion and animals in the American Shaker settlement has been overlooked by scholars of religion and ecology, despite the fact that use of animals for food, clothing, labor, and transportation was central to their way of life. Distinguished from outside of their community, several Shakers broached the idea of an animistic universe: that all life, including plants and animals, were sentient beings. Manuscripts, poetry, and even a table monitor served as ongoing reminders of how animals should be treated according to Christian ethical norms. A central figure in developing the Shakers' view of animals was Elder Frederick Evans (1808-1893), a radical member of the community who promoted a vegetarian diet based on biblical reasoning. This paper examines the Shaker views of animals, and also analyzes Evans' use of biblical texts to implement a vegetarian diet and promote animal advocacy for over a decade within the Shaker community.

Introduction

Evans (1808-1893), an Englishman who arrived in the Shaker community in 1830, was a progressive member of the Mount Lebanon society, and, like many Shakers broached the idea of an animistic universe, in which all life, including plants and animals, were sentient beings. This essay is a window into my examination of Evans' sensitivity towards God's creation and how it influenced his views on vegetarianism. This profound sensitivity developed into the conviction that all living things, even trees, were capable of cognitive emotion. Evans' belief took extreme form in his dietary practices, leading him to experience guilt and believe that meat consumption equaled murder. His conviction of equality among species (human, plant, and animal) led him to abstain from eating meat. While Evans felt that there was an equal energy throughout all of creation, which traditionally can be described as

a soul, it is uncertain if he believed in the idea of animal salvation or the afterlife. Nevertheless, he viewed animals as physical equals that could reason, understand and feel emotion. This essay attempts to show how Evans' dietary practices and spiritual devotion to animals were formed through biblical precedence, millennial understanding, and moral conviction at Mount Lebanon, the Shaker community commonly referred to as Mount Zion.

Discussion

In 1932, Edward Deming Andrews writes of an encounter between Evans and Shaker sympathizer William Hempworth Dixon, stating that the following passage "illuminates [Evans'] attitude of spiritual devotion to husbandry."¹ Dixon documents his encounter as follows:

This morning I have spent an hour with Frederick in the new orchard, listening to the story of how he planted it, as to a tale by some Arabian poet. "A tree has its wants and wishes," said the Elder; "and a man should study them as a teacher watches a child, to see what he can do.... I don't know if a tree ever comes to know you; and I think it may; but I am sure it feels when you care for it and tend it; as a child does, as a woman does."²

Hands to Work, Hearts to God

Important to this essay is a brief understanding of Shaker spiritual beliefs and farm practices, which will be helpful in developing Evans' opinion on food animals. The Shakers began in England in the late eighteenth century with founder Mother Ann Lee, who later migrated to America. Being a post-millennial community, their actions were for bettering the Earth for final judgment. Mount Lebanon, a settlement founded in New York in 1787, was home to many progressive thinkers, including Evans and Eldress Anna

White of the North Family. With the work ethic of “Hands to Work, Hearts to God,” the Shakers were focused on bringing “Heaven to Earth,” thus, striving for perfectionism in their work was essential. Andrews writes that the Shakers viewed their work as glorifying God in a ritualistic, sacramental manner, tending the soil as “something to be redeemed from [its] ‘rugged barrenness into smiling fertility and beauty,’” demonstrating a spiritual essence in agriculture.³

The Shaker, a newspaper written and circulated by and for Shakers, published in 1871 and primarily edited by Evans, contained an Eden-like notion of agriculture, and demonstrated the moral obligation of taking care of the Earth. It stated, “Then let us study the most feasible and effectual means to ‘multiply’ vegetation and ‘replenish’ the worn-out Earth with renewed vigor and ‘subdue’ its spontaneous productions to comfort, convenience and use.”⁴ This idea of replenishing a worn-out Earth was important to Evans, as he relied on scripture in his book *Autobiography of a Shaker*, in a chapter on “Bible Farming.” Evans applied Mosaic laws to understand agricultural practices and attitudes. In his book, he referenced Exodus 23, describing the law to allow the land to rest on the seventh Sabbatical year, not only for soil renewal but also so that wild animals could eat from the land.⁵ While it is uncertain that Evans and the Shakers allowed their land this lengthy period of “rest,” it was something Evans aspired to in his reflection. In his book, *Shakers Compendium of the Origin, History, Principles, Rules, and Regulations, and Government and Doctrines of the United Society of Believers in Christ’s Second Appearing*, Evans paraphrases Moses on his rule of stewardship as a benchmark in moral farming. He makes it clear that the Shakers do not own the land, rather the land is a gift from God and they are there as caregivers. In Chapter Ten, he lists the importance of stewardship: “In Canaan, *the land is mine*, saith the Lord; ye are stewards.”⁶ The use of words such as “redeeming the soil” and “stewardship,” suggest an obligation towards the Earth, treating it as an altar to worship God.

Millenni-animal

In 1838, Nathan Williams, a member of the Mount Lebanon Shaker society, received a vision from Lee.⁷ Although the Shaker community believed that it was their duty to provide care and comfort for their animals, it seems Lee’s testimony was a timely and much needed apparition against cruelty. This vision may have been inspired by Williams’ conscience, as

perhaps he witnessed cruelty, either in himself or in the community at large. Williams stated, “In this vision, Mother Ann is described as saying, ‘I have come to teach you how to deal with poor, dumb creatures... that were made for the use of man and put into his care and mercy.’”⁸ She then commanded Williams to erase abuse in the communities.

In this colorful vision, Williams describes Lee as pointing to animals, claiming that they “do not belong to the children of this world,” but rather are under her care.⁹ This notion of stewardship equates with the Shaker farming practice of caregiving, not ownership, which is derived from Genesis 1:26. Controversial interpretations of Genesis 1:26 have pervaded many religious traditions, inferring that humankind has dominion over the animal world. The Shakers interpreted this verse differently, believing this injunction referred to stewardship rather than ownership of these beasts.¹⁰ According to Williams, Lee warned him in an omniscient fashion that her “eye is upon them and [she knows] when [animals] are abused and suffer cruelty.”¹¹ Her authority to elicit punishment on Judgment Day on members of Williams’ community was based on the Shakers’ belief that Christ’s second coming was realized in her.¹²

While this vision has an urgent apocalyptic tone, laws against cruelty to animals were already in place. In the Shakers’ *Millennial Laws*, specific guidelines concerning animals stated, “No beasts belonging to the people of God, may be left to suffer with hunger, thirst or cold, in consequence of neglect, on the part of those who have the care of them. But all should be kept in their proper places, and properly attended according to their [needs].”¹³ While this does not seem out of the ordinary in nineteenth century animal husbandry, the final rule supports Evans’ idea of animal emotion: “No beasts or any living thing, may be wantonly pained, injured, or tortured. And no living thing may be chastened or corrected in a passion.”¹⁴

Words such as “torture” documented in rules and regulations led Evans and others like him in the North Family, such as Anna White, to advocate outside of the Shaker community for humane treatment of animals. Their involvement included one of the sisters acting “as Local Secretary for several different societies, improving every opportunity to win advocates to anti-vivisection¹⁵ and animal protection.”¹⁶ Surely Evans was influenced by animal advocacy, especially the North Family’s vegetarian lifestyle. Evans’ belief

that animals can feel, suffer, reason, and deduce led him to determine that animals must have divine intelligence. This “intelligence” can be likened to a spiritual essence in creation, suggesting that there is more than just the physical appearance created by God. Job 12:7-9 supports this notion that even animals have an understanding of their Creator and their place on the Earth. Evans writes:

The *animal kingdom*...[is] governed by laws, called *instinct*, far more enduring and unchangeable than the “laws of the *Medes and Persians*,” and which lead them... to do, in all respects, that which is for their best present good and future welfare. “This also cometh forth from the Lord of hosts, who is wonderful in counsel, and excellent in working (Isa. Xxviii. 29).”¹⁷

Poetry and a table monitor served as ongoing reminders of how animals should be treated according to Christian ethical norms. *A Table Monitor Poem*, written around the year 1830, was hung in every Shaker dwelling; it speaks of not wasting and abusing all food resources. The poem depicts the importance of this memory-like tool to continually foster a contemplative approach, not only to eating but also to the care and keeping of animals. Evans, like other Shakers, was reminded daily of not wasting portions of food in visual reminders like the *Millennial Laws* and banners such as *The Table Monitor Poem*. In addition, poems such as *A Man of Kindness, to his Beast is Kind*, hung in barns throughout the Shaker community,¹⁸ demonstrating that actions towards animals and belief in God were linked. The poem encompasses judgment to those who displayed brutality towards animals. This will play an important role in the Shakers’ dietary change, starting at Mount Lebanon.

Mount Zion

Evans wrote about the link between vegetarianism and moral behavior, an important notion in establishing a peaceable kingdom here on Earth. Evans stated, “Our lands are held in common... it is very easy to be ‘peaceable.’ We are temperance people; the most of us are vegetarians.”¹⁹ This link between his dietary habits and kind actions are a taste of Evans’ thoughts on vegetarianism.

A typical meal at the North dwelling with family members—Evans, Daniel Fraser and other progressive spirits—was proudly described by White as follows: “No meat has fouled the air of kitchen and pantry, or fed the cannibalism of appetite in the old North

Home, the ‘Gate’ to the Shaker temple.”²⁰ White’s fervent description of the dwelling house as a temple was well versed by those at Mount Lebanon who viewed their community as Mount Zion.²¹ White states that the consumption of meat would deface what she considered holy ground, referring to appetite as cannibalistic, likening the eating of animals to eating human flesh. The use of the term cannibalism suggests that eating meat is equated to murder. The perception by White and others regarding animals slaughtered may be drawn from Isaiah 66:3, which reads, “He who slaughters an ox is like one who kills a man.”²² The idea of murder relates to the action of taking of “life,” more specifically “blood,” as Shakers like Evans and White found it difficult to distinguish between an animal’s life force and the very blood responsible for that life. Many Shakers believed in a bloodless diet; however, Shakers like Evans believed that life is not just in the blood but that the animal’s breath was the true source of life.

Health concerns about vegetarianism were quickly addressed. Evans agreed with White that vegetarianism was important to rid the home of noxious greasy viands, not only to clean the spiritual temple (physically cleanse the body), but also to have spiritual clarity. Evans writes of *Christian Physiology*, stating, “Purity of mind and body is necessary to Shakerism,”²³ and concurs with White on the practice of vegetarianism “that the body will not lack strength and vigor, and [that] serious sickness is not an issue, with fevers virtually nonexistent.” In regards to stamina, White is adamant how “few meat eaters could keep up in energetic, active work with the vegetarian sisters and brothers of [the] industrious Shaker workers.”²⁴ Charles Nordhoff, in 1875, a writer visiting the Shaker society in Alfred, Maine, stated that abstinence from meat has “almost extirpated fevers [and] formally cancer was a frequent disease among them,” but because of the vegetarian diet, “this has disappeared.”²⁵

But it wasn’t just physical health for Evans. In an interview with the *Brooklyn Eagle*, he is recorded discussing his reasons for his vegetarian diet. He stated, “It is not the fact of eating meat that I object to so much as it is the murder. All animals have a right to their lives.”²⁶ This reveals how Evans viewed animals and their consumption, comparing their slaughter to murder. His idea that they have a right to their lives also shows that animals have a sort of status in Evans’ eyes, elevating them to the place of not wanting animals to be murdered.

Evans believed that the abundance of varied vegetables, fruits, and grains has satisfied every physiological need, and stated that not eating meat has had “the satisfaction of mind and conscience on the other,”²⁷ showing that there is no guilt in the food, and is therefore linked to spiritual cleanliness.

With no meat being consumed, Evans described his meals as “perfect,” with fresh food being “exquisitely cooked and served with care and intelligence.” In reading the North Family’s writings on his meals, one can find an opinion of superiority. White, author of *Vegetarianism among Shakers*, writes, “The more one becomes accustomed to plain food, the finer grows the sense of taste; rich, greasy viands become alike obnoxious to sight, palate and stomach.”²⁸ While White is referring to animal foods as obnoxious, there are records of egg and dairy products being used throughout recipes and accompanying a meal, even though food should never be fried in animal fats.^{29 30}

The animal that posed the most problem for residents at Mount Lebanon was the pig. Well before the Shaker communities converted to vegetarianism, the first change in their dietary habits was abstaining from pork. Russell Anderson writes in a powerful journal entry describing a divine revelation on the consumption of pork:

Hogs were an important part of the livestock at Mount Lebanon until 1845, when this community decided to renounce the use of pork. As their record quaintly puts it, “Now by this power & by divine oracle now & then that has been given, it is concluded, settled, declared & sworn to be obeyed that Hog shall never again be brought onto Holy Zion’s ground.”³¹

This quote demonstrates that their change in dietary habits was in preparation for the Messiah’s arrival to their ‘Holy Zion,’ or Mount Lebanon. Nordhoff describes Shaker dining as follows:

Their diet is simple but sufficient. Pork is never eaten, and only a part of the Shaker people eat any meat at all. Many use no food produced by animals, denying themselves even milk, butter, and eggs. At Mount Lebanon, and in some of the other societies, two tables are set, one with, the other without meat. They consume much fruit, eating it at every meal.³²

Evans and like-minded Shakers believed their Holy Mount of Mount Lebanon would somehow be dis-

graced by the presence of pork. It appears that the members adhered to the Judaic idea of pork consumption, found in Leviticus 11:3-8. Despite the fact that all foods were deemed ‘clean’ in the New Testament,³³ it seems that the Shakers were turning to the literal definition of the New Jerusalem with the upcoming millennium by adhering to Judaic Law. These ritualistic laws served Evans’ cause for vegetarianism in good stead.

The process of the Shaker community converting to a vegetarian diet followed this chronology. By 1845, the North Family at Mount Lebanon became completely vegetarian, which led the rest of the communities to follow this model. Evans writes in 1871, “It is now some ten years since the eighteen societies discontinued the use of swine as food.”³⁴ This dietary change of abstaining from pork was unanimous throughout these communities by 1861, maybe even earlier. However, Evans and the North Family were different from the rest of the Shaker communities, with this dietary change based on the moral implications of eating another sentient being.

Another source of evidence for when Mount Lebanon abstained from eating pork is found in White’s *Vegetarianism among Shakers*, written in 1895. She writes, “The bloodless diet would seem a natural outcome of the simplicity, purity and kindness of the Shaker faith and practice, and in one group at least, the North Family at Mount Lebanon, New York, the practice of vegetarianism has been adhered to for over fifty years.”³⁵ It is important to note that the opinions about animals were changing in the year 1845, with the last revision of the Shaker *Millennial Laws*, as well as Mount Lebanon abstaining from eating meat.

Conclusion

Evans remained true to the idea of physical strength and spiritual clarity being the result of a vegetarian diet. With the assistance of the North Family, eighteen Shaker communities abjured from eating pork, and only a few members continued to eat meat. Through this examination of Evans’ dietary practices, it is clear that his spiritual devotion to the Earth and animals were formed through moral conviction, millennial understanding, and biblical precedence. His experience throughout the Shaker communities in regards to animal treatment, as demonstrated through poetry as reminders, eventually led the entire Shaker community to abstain from eating meat. Evans was

ahead of his time with his health concerns and animal advocacy. One wonders today what he would think of the food industry, in regards to cruelty and waste. It seems that we are still very distant from the Utopia he had imagined, as stated in Isaiah 65:25, where the “wolf and the lamb shall feed together, and the lion shall eat straw.”³⁶

Acknowledgments

I would like to thank the College of Arts & Letters. I would also like to thank the Department of Religious Studies, including the faculty that advised, proofread, and previewed my paper and my presentation for the Midwest American Academy of Religion, as well as the MSU Department of Religious Studies' Undergraduate Research Conference. These individuals are Dr. Arthur Versluis, Dr. Chris Frilingos, Dr. Gretel Van Wieren, and Dr. Amy DeRogatis. This research could not have been completed without the help from staff members Todd Burdick, Michelle Richard, Laura Field, Magda Gabor-Hotchkiss, and Jerry Grant at both the Hancock Shaker Village in Pittsfield, Massachusetts and the Mount Lebanon Shaker Settlement in Lebanon, New York. I would like to acknowledge Michigan State's Digital Humanities and American History Librarian Bobby Smiley who was essential in revealing the library's resources to make this project possible. Without these individuals, this project would not be where it is today.

Notes

1. Edward Deming Andrews, *The Community Industries of the Shakers* (Albany: University of the State of New York, 1932), 61-62.
2. Ibid.
3. Edward Deming Andrews, *The Community Industries of the Shakers* (Albany: University of the State of New York, 1932), 61. These farm practices were atypical of regular farm life because with their faith being at the core of their work, they were able to subsist on an economic level. Russell Anderson writes about livestock production at Mount Lebanon being used to meet the food and clothing needs of members, but at times there was a surplus for sale.
4. *The Shaker*, 1871.
5. “I will not drive them out from before thee in one year; lest the land become desolate, and the beast of the field multiply against thee.” Exodus 23:29. The Holy Bible. King James Version, 1611.
6. Frederick W. Evans and Ann Lee [electronic Resource]: *A Biography with Memoirs of William Lee, James Whittaker, J. Hocknall, J. Meacham, and Lucy Wright; Also a Compendium of the Origin, History, Principles, Rules, and Regulations, and Government and Doctrines of the United Society of Believers in Christ's Second Appearing* (London: J. Burns, 1871), 94-95.
7. Anna White and Leila S. Taylor, *Shakerism: Its Meaning and Message* (Columbus: Press of F.J. Heer, 1905) 243-244.
8. Ibid.
9. Ibid.
10. There are many interpretations of Genesis 1:26-28, especially in regards to the term *dominion*. What did God mean when He instructed man to have dominion over all creation? The Shakers interpreted this as understanding animals' roles in the community, specifically labor, meat, or products, but also treating them with respect and treating them humanely (kind treatment, proper bedding, shelter, etc. See *Shaker Millennial Laws*).
11. White and Taylor, *Shakerism*, 243-244.
12. In Christianity, Jesus' Second Coming, or the Parousia, is prophesized in the Book of Daniel and the Book of Revelation. The Shakers were Millennialists and believed that Christ's Second Coming was personified in Mother Ann Lee. In final preparation of Judgment Day, they began efforts to restore Heaven on Earth (postmillennialism).
13. White and Taylor, *Shakerism*, 243-244.
14. Ibid.
15. Vivisection is “the practice of subjecting living animals to cutting operations, especially in order to advance physiological and pathological knowledge” (Dictionary.com). This is used to study the central nervous system and organs.
16. White and Taylor, *Shakerism*, 217.
17. Frederick W. Evans, *Autobiography of a Shaker: And Revelation of the Apocalypse* (New York: American News Co, 1869), 137.
18. Andrews, *The People Called Shakers*, 120.
19. Evans. *Autobiography of a Shaker*, 222.

20. Anna White and J P. MacLean, *Vegetarianism among Shakers: Republished from "the Counsellor"* (Mount Lebanon, N.Y: North Family, 1895), 3.

21. This reference to Anna White's Holy Zion is the Holy Temple in Jerusalem. This reference to Holy Zion, which in Judaism is the Hebrew name for the Temple Mount in Jerusalem, which is the holiest place in the world, seen as the connection between God and humanity, shows how the Shakers viewed their land as being sacred, and in doing so, began resorting back to Judaic dietary laws, or Kashrut. At Zion, Jews were recorded as praying three times a day for the restoration of the Holy Temple, the redemption of the world, and for the coming of the Messiah.

22. Isaiah 66:3, *The Holy Bible, King James Version*, 1611.

23. Frederick W. Evans. *Autobiography of a Shaker*, 269.

24. White and MacLean. *Vegetarianism among Shakers*, 11.

25. Charles Nordhoff. "The Communistic Societies of the United States; [electronic Resource] from Personal Visit and Observation: Including Detailed Account of the Economists, Zoarites, Shakers, the Amana, Oneida, Bethel, Aurora, Icarian and Other Existing Societies; Their Religious Creeds, Social Practices, Numbers, Industries and Present Conditions." Vii.9, (New York, Hillary House, 1875), 180.

26. Skinner, Brooklyn Eagle, repr. In Manifesto March/April, Copy at Hancock Shaker Village, Pittsfield, MA. (Mount Lebanon, New York, 1886).

27. White and Taylor, *Shakerism*, 216.

28. White MacLean, *Vegetarianism among Shakers*, 7.

29. Ibid. 8.

30. "It shall be a perpetual statute for your generations throughout all your dwellings, that ye eat neither fat nor blood." Leviticus 3:17 KJV.

31. Russell H. Anderson. "Agriculture among the Shakers, Chiefly at Mount Lebanon." (*Agricultural History* 24.3, 1950), 116.

32. Nordhoff, "The Communistic Societies of the United States," 141.

33. Acts 10:9-16 states that all food is created by God, and is therefore clean.

34. Evans and Ann Lee, *A Biography with Memoirs of William Lee*, 40.

35. White and MacLean, *Vegetarianism among Shakers*, 3.

36. "The wolf and the lamb shall feed together, and the lion shall eat straw like the bullock: and dust shall be the serpent's meat. They shall not hurt nor destroy in all my holy mountain, saith the LORD." Isaiah 65:25, KJV.

References

Anderson, Russell H. "Agriculture among the Shakers, Chiefly at Mount Lebanon." *Agricultural History* 24.3 (1950): 113-20. JSTOR. 7 Jan. 2014. <<http://www.jstor.org/stable/3741026>>.

Andrews, Edward Deming. *The Community Industries of the Shakers*. Albany: University of the State of New York, 1932.

Carson, Gerald. *Men, Beasts, and Gods: A History of Cruelty and Kindness to Animals*. New York: Scribner, 1972.

Evans, F. W. 1808-1893. *Shaker Communism, Or, Tests of Divine Inspiration: the Second Christian Or Gentile Pentecostal Church, As Exemplified by Seventy Communities of Shakers In America*. London: Published by J. Burns, 1871.

Evans, Frederick W. Ann Lee (the Founder of the Shakers) [electronic Resource]: A Biography with Memoirs of William Lee, James Whittaker, J. Hocknall, J. Meacham, and Lucy Wright; Also a Compendium of the Origin, History, Principles, Rules, and Regulations, and Government and Doctrines of the United Society of Believers in Christ's Second Appearing. 4th ed. London: J. Burns, 1871.

Evans, Frederick W. *Autobiography of a Shaker: And Revelation of the Apocalypse*. with an Appendix. New York: American News Co, 1869.

Evans, F W. *The Shaker*. Mt. Lebanon, N.Y: United Society, 1871.

The Holy Bible. King James Version. N.p., 1611. King James Version Online. <<http://www.kingjamesbibleonline.org/>>.

"Mount Zion." *Wikipedia*. Wikimedia Foundation, n.d. 17 Mar. 2014.

Nordoff, Charles. "The Communistic Societies of the United States; [electronic Resource] from Personal Visit and Observation: Including Detailed Account of the Economists, Zoarites, Shakers, the Amana, Onei-

da, Bethel, Aurora, Icarian and Other Existing Societies; Their Religious Creeds, Social Practices, Numbers, Industries and Present Conditions." Vii.9 (1875): n. p. New York, Hillary House.

Pidgeon, Daniel. *Old-World Questions and New-World Answers*. London: K. Paul, Trench & Co, 1885.

"The Shakers." Shaker Historical Society. N.p., n.d. 04 Mar. 2014.

Skinner, Brooklyn Eagle, repr. In *Manifesto March/April*, Copy at Hancock Shaker Village, Pittsfield, MA. Mount Lebanon, New York, 1886.

"Sylvester Graham." *Wikipedia*. Wikimedia Foundation, 15 Mar. 2014. 17 Mar. 2014.

Table Monitor. Framed copy found in the attic of the trustees house, Hancock Church Family, in November 1971. By Jon Ott and Jim Tobin. Hancock Shaker Village Archives, 9789.C7 Br. 1830.

"Vivisection." *Dictionary.com*. Dictionary.com, n.d. 17 Mar. 2014.

Wenger, Tisa J. "Female Christ and Feminist Foremother: The Many Lives of Ann Lee." *Journal of Feminist Studies in Religion* 18.2 (2002): 5-32. JSTOR. 7 Jan. 2014. <<http://www.jstor.org/stable/25002436>>.

White, Anna, and J P. MacLean. *Vegetarianism among Shakers: Republished from "the Counsellor"*. Mount Lebanon, N.Y: North Family, 1895.

White, Anna, and Leila S. Taylor. *Shakerism: Its Meaning and Message*. Columbus: Press of F.J. Heer, 1905.



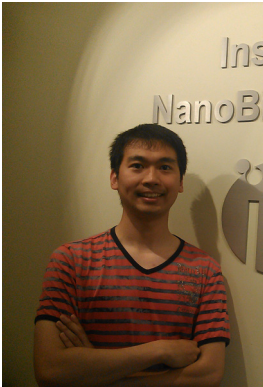
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About the Contributors

Charles Chen



Charles Chen received his BS in chemical engineering from Michigan State University in May 2013. As a chemical engineer, Chen wondered how to apply this knowledge to his major, and entered David Hodge's lab in the Department of Chemical Engineering and Materials Science. Chen is currently a 2nd-year Ph.D. student in Materials Science and Engineering at Johns Hopkins University. He works with Martin Ulmschneider and his research focuses on understanding membrane active-peptides, which have been proposed as a powerful source of new antibiotics.

Julia Johnson



Julia Johnson graduated from Michigan State University in Spring 2015 with a BA in religious studies and a concentration in non-profit leadership, as well as a specialization in science, technology, environment, and public policy. She was a research assistant for three professors during her time at Michigan State, as well as a teaching assistant for the chair of the Department of Religious Studies. Johnson was also a research intern for the MSU Animal Behavior and Welfare Group, where she evaluated food animal and livestock behavior. An internship at the Hancock Shaker Village in Pittsfield, Massachusetts prompted her first publication. Johnson was the recipient of both the Nick Rashford and Jake Folio Award for Religious Studies excellence and non-profit outreach, as well as the Religious Studies Engaged Scholar Award, holding the highest grade point average among undergraduates in the department. In the fall of 2015, Johnson is attending Yale Divinity School to pursue a master's in divinity, as well as a diploma in Anglican Studies from Berkeley Divinity School.

Andrew Mecca



Andrew Mecca is a senior at MSU dual majoring in neuroscience and physiology in the College of Natural Science. Andrew spent the last two years working with James Galligan in the Neuroscience Program and Department of Pharmacology and Toxicology, where his work has focused on characterizing the role of serotonin and corticotropin-releasing hormone in pain-sensing neurons of the gastrointestinal tract. Mecca has received scholarship from the College of Natural Science for his research work and has presented his findings at the annual Experimental Biology conference in Boston in April 2015. He is a current student in the undergraduate physician-scientist education and research training program (SUPER 2015) in the MSU College of Osteopathic Medicine where he will continue his work in Galligan's lab.

Bradley Riedinger



Bradley Riedinger graduated from Michigan State University in May 2014 with a BS in physiology. Riedinger's research interest focused on muscle physiology where he spent two years working with Jill Slade in the MSU Department of Radiology and with Erica Wehrwein in the Department of Physiology. His research experience as an undergraduate has led this Michigan native to pursue a career in medicine, where he plans on attending Michigan State University's College of Osteopathic Medicine.

Roy Small



Roy Small graduated from Lyman Briggs College at Michigan State University in May 2014 with a BS in physiology. He worked as a calculus learning assistant for three years at MSU. Small's undergraduate research on blood glucose regulation was part of a physiology capstone project and was sparked from a particular interest in the

physiology of diabetes, particularly its relation to exercise. Small is currently pursuing a doctorate of osteopathic medicine at Michigan State University College of Osteopathic Medicine. Small plans to pursue a surgical subspecialty after graduation.

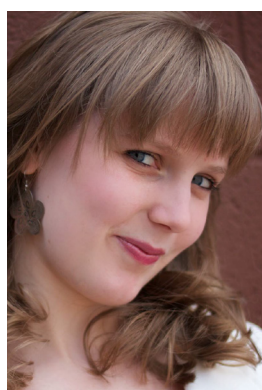
J. Andrew Stables



J. Andrew Stables graduated from Michigan State University in May 2015 with a BA in international relations at James Madison College with minors in economics and geographic information science (GIS). He was a member of the Honors College and Phi Beta Kappa and conducted research on a variety of topics, including the interac-

tion between local and international interests such as the MSU Vietnam Project, comparative environmental policies between the United Kingdom and the United States, and the macroeconomic impacts of highway funding in the United States. Additionally, Stables worked throughout the summer of 2014 contributing to the data used in the 2015 report titled Energy Baseline Study: Mid-Michigan and the Michigan Avenue/Grand River Avenue Corridor that was published by the local Nonprofit Michigan Energy Options as part of a multi-million dollar U.S. Department of Housing and Urban Development Sustainable Communities Grant called the Mid-Michigan Program for Greater Sustainability. Stables hopes to pursue graduate studies in urban planning over the next several years and gain practical experience in GIS.

Sarah Tomlinson



Sarah Tomlinson graduated from Michigan State University in May 2014 with a BM in music education and a BA in music, earning both degrees with high honors. She has long enjoyed the music of Aaron Copland, and she began her musicological research on the composer during a 2013 independent study with Assistant Professor of Musicology,

Marcie Ray. Ray's expertise on the relationships between music, gender, and sexuality has been influential to Tomlinson's growth and scholarly interests. The independent study course led Tomlinson to pursue other research projects in twentieth-century American music, identity construction, and gender and sexuality studies. She is currently a graduate assistant earning her MA and PhD in musicology at the University of North Carolina-Chapel Hill.

Feature: One Book, One Community

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Michigan State University and the city of East Lansing host the annual One Book, One Community program in the fall.

The program encourages the city-university community to experience the same works and discuss them in a variety of settings.

For 2014, three influential voices on the continuing struggle for racial equality were highlighted. It was the first time in the program's 13-year history in which more than one selection was chosen and a non-written piece was featured: Graphic novel "March Book One" by U.S. Rep. John Lewis, Andrew Aydin and Nate Powell; the film "Fruitvale Station" directed by Ryan Coogler; and the memoir "The Grace of Silence" by award-winning journalist and National Public Radio contributor Michele Norris.

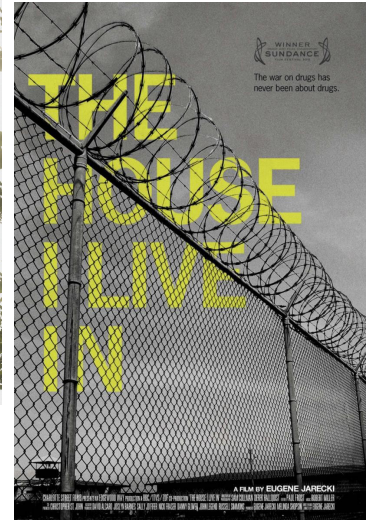
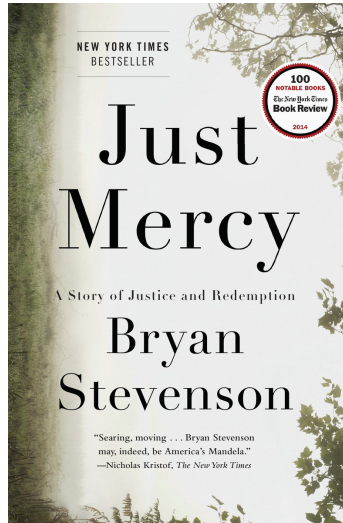
The 2014 OBOC program was coordinated in conjunction with MSU's Project 60/50, which commemorated the 60th anniversary of Brown v. Board of Education Supreme Court decision and the 50th anniversary of the 1964 Civil Rights Act.

"The issues surrounding the Civil Rights movement, and the continuing issues of race in this country, are very complex," said Ginny Haas, director of community relations at MSU. "This year the One Book, One Community committee, working with Project 60/50, decided to recognize that complexity by selecting a variety of works which span multiple decades and show a variety of perspectives.

"This also allows students and community members to engage in a way they feel most comfortable, and still be part of the discussions about this important issue."

For 2015, the program features the works of two extraordinary champions of human rights. The selections include "Just Mercy: A Story of Justice and Redemption," a *New York Times* bestselling book by attorney and author Bryan Stevenson; and "The House I Live In," a documentary film by Eugene Jarecki that won the Sundance Film Festival Grand Jury Prize in 2012.

The selections embody the 2015 theme: "A Community Conversation on Justice, Human Rights and



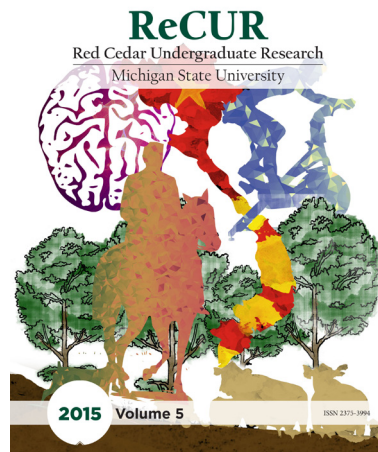
Compassion." The selections have been instrumental in raising the nation's consciousness of how institutionalized bias and punitive legislation have denied the rights of many Americans and tarnished human rights in the United States.

"MSU students, community members and faculty are encouraged to engage in thoughtful conversations around the themes explored in both the book and film," said MSU Provost June Youatt. "These issues are important and timely, as public awareness of bias and injustice across the country has recently increased."

Stevenson will kick off the month-long OBOC program with a talk at 7 p.m. Aug. 30 at the East Lansing Hannah Community Center. He will discuss his experiences and sign books. Stevenson will also address MSU's incoming class at the Academic Welcome at 9 a.m. Aug. 31 in the Jack Breslin Student Events Center. Both events are free to the community.

On Sept. 16, filmmaker Eugene Jarecki will speak about his documentary at 7 p.m. at the Wharton Center for Performing Arts. OBOC and the World View Lecture Series jointly sponsor this program. The event is ticketed.

For more information on OBOC programming, visit www.onebookeastlansing.com.



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