CURIOSITAS

Journal of Undergraduate Research at Montana State University

Spring 2025

Cover Photo by Madison Anderson
see more on page 1-2

Dear MSU Community,

We are proud to share with you this year's edition of *Curiositas*, Montana State University's undergraduate research journal. This publication celebrates the breadth and depth of original research conducted by MSU undergraduates across an array of academic disciplines.

Curiositas is the result of cross-campus collaboration. As part of the Undergraduate Research Council, the journal embodies MSU's commitment to shared governance by expanding access to research publication and ensuring the long-term sustainability of this platform for future scholars.

We would like to thank the dedicated students and faculty mentors whose passion and dedication has made this journal possible. We would also like to thank the National Science Foundation's ART program as well as the Undergraduate Scholars Program and Doug Downs for their contributions and support!

We hope you find inspiration and insight in the pages of this year's journal.

Warmly,
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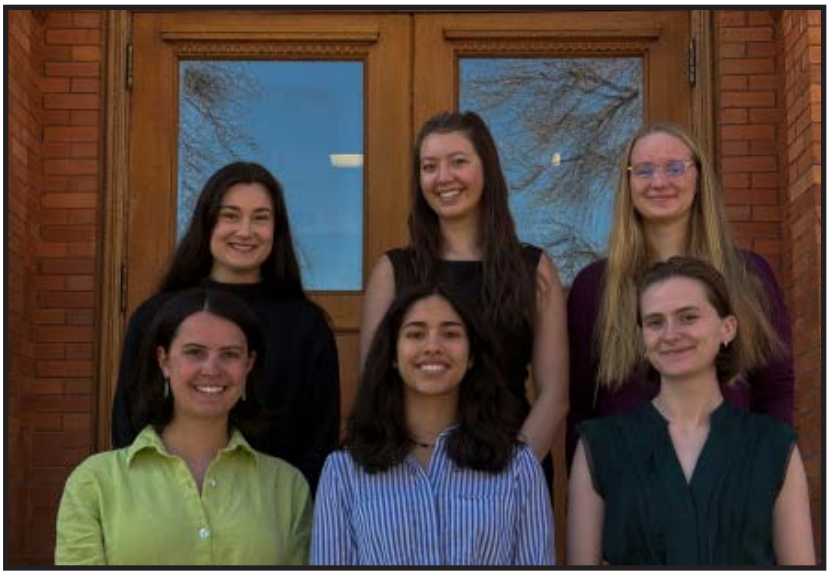

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Spring 2025

We extend our sincere thanks to all who contributed their time, expertise, and support in bringing this publication to life. Your efforts are deeply appreciated.

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FEATURED WORKS

Ghosts of the High Country: Photographing Mountain Goats in the Bridger Range of Montana

Madison Anderson

Not only do mountain goats live at the top of the world, but they have also adapted to incredibly harsh climates where few other species are found. After spending time with and observing this particular herd, I've learned so much about their mannerisms and personalities. The group dynamic is incredibly complex and operates similarly to how humans participate in these dynamics. Every encounter I have with these special animals gives me a deeper awe and appreciation for how capable and resilient they really are. This herd lives in a harsh, rocky, alpine environment that yields little water and lots of temperamental weather. Despite the adverse conditions these animals face, they are able to live up to between fourteen and eighteen years of age. Their adaptations such as guard hairs, leather-like hoof soles, and salty, high-fiber diets allow them to navigate and thrive in an extremely unforgiving environment. These photographs are unique and special to me because of the relationship I've been able to cultivate with this herd, and this goat specifically. I am incredibly grateful to have captured this moment and be able to share it with everyone. The storytelling aspect of my photography is a huge part of my mission to share the beautiful places and creatures I find on my adventures to help protect them. Awareness and admiration will hopefully lead to the conservation and preservation of not only these wonderful creatures, but also the environments that they know as home.

About the Author

Madi is a landscape and adventure photographer from Bozeman, Montana majoring in Microbiology with a minor in Hispanic Studies. Her passion is photographing the world through her lens and sharing her unique perspective of the incredible places and stories she gets to explore. Through her interests, she accesses many remote locations and captures them with her distinct style through backcountry skiing, biking, and surfing. She strives to inspire others to appreciate and cultivate connection with the natural world in order to protect our beautiful home.

To see the published photos at their highest resolution please see Scholarworks

Laundry Room Jungle

Kylie Mills

"Laundry Room Jungle" is a fun poem about the difficulties of doing laundry in a college dorm. At face value, it is a good laugh and an easy read. Looking deeper into the writing, readers will see themes of human nature and selfish individualism. I wanted this poem to represent what it feels like going to college as a freshman, surrounded by people who are already familiar with the campus and so engrossed in their day-to-day lives that they have no time to entertain newcomers.

There is something strange about the laundry room.
Drying clothes vanish without a trace.
Wash loads are prematurely ripped from their mother's womb,
leaving them heavy with no hope of getting dry.
Washers overflow with abuse,
spreading spiteful floods throughout the basement.

The laundry room twists and warps people,
bringing out animalistic qualities they didn't know they had.
The moment they step into the room,
they shift and morph into something … else.
They prowl the laundry room,
inspecting each machine and marking their next victim.
They stake their claim without empathy for those around them.
Territory is well guarded and cunningly bartered.
There are no friends in the laundry room-
only allies and enemies.

There is no one to help you,
no guide to tell you what to do.
You must quickly learn how to handle yourself,
to read the environment and blend in.
Standing out gets you hurt.
Newcomers are nothing but fresh meat-
so watch your back, or you will feel their teeth.

I see this happen far too many times.
I want to help-
I really do.
But I hunch my back,
Stake my claim,
And guard my territory.
Welcome to the laundry room jungle.

About the Author

Kylie Mills is a first-year student at Montana State University, Bozeman. She is pursuing an undergraduate degree in Fish and Wildlife Ecology and Management with a minor in Geographic Information Sciences (G.I.S.). She is a presidential scholar in the Honors College at MSU, where she is developing her passion for writing poetry. In the future, she hopes to earn her master's degree and work as a terrestrial biologist for the United States National Park Service. She is honored that you are reading her work and hopes you enjoy her writing.

Amelia Lasky | Salt Lake City, Utah

"God rules my life more than fear and anxiety, so whatever is coming, my kids will be prepared in some way."

Portraits of a Planet in Crisis

A project by Amelia DiGiano

The climate crisis makes my future, and the future of humanity, feel alarmingly precarious. I started to develop this series as a way of documenting this sensation, the chronic fear associated with climate change. But as I began approaching people to include in the project, it became clear that we do not all conceptualize climate change in the same way. To some it feels existential, but to others it feels fabricated and to many, it feels entirely beyond human control. Portraits of a Planet in Crisis explores and documents this broad spectrum of human stories that transpire within stories of environmental devastation.

Amelia DiGiano is graduating in May with a B.F.A. in Integrated Lens Based Media. She completed this project with help from the Undergraduate Scholars Program research grant. To see her completed project, visit the QR code below.

To see the full series of published photos please see Scholarworks

Kylan Skinner | Hobuck Beach, Washington
"Climate change is causing major loss of fish and loss of wildlife. I want him to grow up to understand what I saw when I was a child. But I'm sure it's going to be different for him. I want to know more information, but it's so sad to me."

Abram and Ashley Misiluti | Bozeman, Montana
"We don't have kids yet but we're expecting. Climate change is something we've talked about, like is everything going to be on fire? And will there be enough drinking water? But we also have the mindset that if we're educated, then hopefully we can bring up educated people to help with our world. But it is scary."

Tyler Nelson & Sons | Cortez, Colorado
"I think we should take care of the earth. I don't like litter. But what's the opposite of eco-anxiety? I'm like, eco-chill. Drive diesel pick-ups, roll the coal."

Joe Bryant | Swannanoa, North Carolina
"I've heard a whole lot about climate change and I don't know a lot about it. I'm ready to learn about anything right now. I'm tired of damn sleeping on the ground."

Malia, Jordin, Katherine, Elijah | Neah Bay, Washington
"It's not something we stress about because it's not that bad down here." - Malia

Stenzin Dawa | Leh, Ladakh
"If the Ladakhi people die, they will die for lack of water. The fields will go dry, the animals won't be able to drink, all of the springs will dry up. And we're already seeing this happen."

The Paradox of Language: An Exploration of Abjection and Language in Play it as it Lays

Josiah Durrell

Mentor: Dr. Alex Harmon (Department of English)

In *Play It as It Lays* by Joan Didion, we are presented with a character in the midst of a crisis of identity. Maria, a failed actress in Hollywood, is beset by many of the problems commonly associated with a rising star in the industry. A reliance on drugs, a commodification of the self, and a deteriorating sense of who she is all play into her downward spiral. Yet when we examine the reason that Maria lacks an actualized sense of self, the reader is presented with a paradox. If we take the words of French psychoanalyst Jacques Lacan to be true, then language serves to create a filter through which a subject is distanced from the true nature of the world. They are placed into the symbolic order, a realm of socially constructed understanding that shapes the way we interact with the outside world. Our identity is tied to a sense of self that exists within the outside world, separate and unique from others. Yet we see that Maria is driven away from the symbolic order and toward a state of collapse, as the boundaries of her identity are dissolved through language.

In Play It as It Lays by Joan Didion, we are presented with a character in the midst of a crisis of identity. Maria, a failed actress in Hollywood, is beset by many of the problems commonly associated with a rising star in the industry. A reliance on drugs, a commodification of the self, and a deteriorating sense of who she is all play into her downward spiral. Yet when we examine the reason that Maria lacks an actualized sense of self, the reader is presented with a paradox. If we take the words of French psychoanalyst Jacques Lacan to be true, then language serves to create a filter through which a subject is distanced from the true nature of the world They are placed into the symbolic order; a realm of socially constructed understanding that shapes the way we interact with the outside world. Our identity is tied to a sense of self that exists within the outside world, separate and unique from others. Yet we see that Maria is driven away from the symbolic order and toward a state of collapse, as the boundaries of her identity are dissolved *through* language.

This idea that our sense of sense is both intrinsically tied to the outside world while being confined by the boundaries of our identity is one that Lisa Blackman touches on in her book *Immaterial Bodies.* She writes, "We extend into our environments and yet paradoxically are required to live this extension as interiority" (Blackman, 151). This raises the question of agency. One has to wonder if this extension can be a conscious choice, and if one can choose the environments that we reach into as a way of shaping the self. In some ways, we have no choice but to interact with the world around us and thus "extend" into these environments. But this requires a knowledge of what consists within, otherwise, there would be no boundary to "extend" past. As a subject, we have a sense of what our identity consists of, whether it is realized or not. This is the "interiority" that Blackman discusses. It is self-contained and while influenced by the surrounding world, is felt only by the individual. The filter of language that Lacan refers to is essential to the process of maintaining a solid boundary of "self." Without this boundary, one would lose their sense of self and be entirely exposed to the outside environment.

This idea of extension envisions a piece of the self reaching out, bare to be shaped by the surrounding forces, vulnerable and malleable. In an ideal world, these forces expand one's sense of self, growing the individual's interiority in a healthy way. We take on the challenges of the environment and overcome them in a triumphant manner, growing as a person and becoming more resilient. But what happens when these environments do not expand the "self" but shrink it? Or when they destroy the sense of self altogether? With no boundaries to separate the "self from "other," the conscious these forces expand one's sense of self, growing the individual's interiority in a healthy way. We take on the challenges of the environment and overcome them in a triumphant manner, growing as a person and becoming more resilient. But what happens when these environments do not expand the "self" but

Or when they destroy the sense of self altogether? With no boundaries to separate the "self from "other," the conscious either expands to include everything or shrinks to include nothing. Maria experiences both ends of this, dissolving into the world and being left with a sense of emptiness.

Maria's grasp on her own interiority deteriorates to the extent that she no longer can tell where her own body ends and her environment begins. On her vacation to Las Vegas, her boundaries dissolve and she begins to envelop her surroundings. "She was thinking constantly about where her body stopped and the air began, about the exact point in space and time that was the difference between Maria and other . . . She could feel smoke against her skin. She could feel voice waves. She was beginning to feel color, light intensities" (Didion, 138). We see here a breakdown of the boundaries that separate Maria's body from the outside world, and as they begin to coalesce in her mind she grows less certain of what constitutes her own existence. Her experience with color, light, and sound is born out of crisis. It is a crisis born out of a lack of stasis with her own body. Her inability to conceptualize where her identity ends and where the world begins leads to this breakdown, opening up her "interiority" to the surrounding world.

As Lacan says, it is through language that we enter the symbolic order and distance ourselves from the real. But this depiction of Maria shows her progressing away from a constructed reality and toward a more unfiltered existence. Our constructed sense of self is what allows for the boundaries between self and other, and is necessary to maintain a rational existence. Without a firm understanding of where our identity lies and where the world begins, one experiences an abjection of self where meaning begins to collapse in itself Maria is experiencing the deterioration of her filter that separates her sense of the symbolic order from the real.

Yet contrary to Lacan, it is the very same process of language that causes the boundaries between "self" and "other" to deteriorate. This is manifested in the dehumanizing manner in which her abusive husband Carter speaks to her and treats her. In a moment of confrontation, he tells her e fights with her "to find out if [she's] alive" (Didion, 158). Coupled with the threat of physical violence and a constant degradation of her agency, this dehumanizing language begins to strip away Maria's identity.

This culminates not in her crisis at the Hoover Dam, but in the period of emptiness after that. When asked what matters by BZ, Maria says, "Nothing" (Didion, 164). The "interiority" that Blackman talks about has been reduced to nothing. The words used by her husband and BZ take away from her validity as a person with meaning. By asking if she is alive, he puts her at odds with her own existence. He implies that her identity lacks substance to the point that it no longer exists. This is powerful, affective language that serves to tear down and destroy. This is not the language that Lacan talks about when referring to the symbolic order. That language is one that builds and creates, embedding the subject further into an understanding of the social creation. Instead, Maria's identity is deconstructed and dissolved.

We see Maria wrestle with the effects of what is being done to her, attempting to use language to reclaim some agency for herself. She describes herself as "a radical surgeon of my own life. Never discuss. Cut. In that way I resemble the only man in Los Angeles County who does clean work" (Didion, 165). These words speak to a power that she claims to have. Even in its self-destructive nature, these words would imply that Maria at least has some agency in her own deconstruction. That she is the one cutting away these parts of herself, not the language of her husband or her friends. But this attempt to identify some part of herself that is able to make a choice falls short. She is still left with her crisis of identity and a life devoid of any meaning. Her boundaries of self have already been stripped away by language, in the same way that her baby was stripped away from her. These actions were forced upon her, no matter how hard she tries to rationalize her own control over them. Her attempt to use language to reclaim a part of herself fails, and she is left with an undefined and dissolved identity.

This leaves the reader with a paradox of influence. We see through the work of Lacan how language filters our perception of the world and places us into a symbolic . . . order that is socially constructed. But we also see how language can be used to tear down and strip away the identity of another person, blurring the boundaries of "self" and bringing them closer to the real. This destructive power tears away all agency from Maria, leaving her a blank slate for which nothing matters. Yet when she attempts to use language to wrestle

fails to be enough, leaving her no better off. We are presented with a depiction that contrasts and defies, giving no straight answer to the reader. We are left to wonder at the affective power of language and how it might be used to build others up or utterly destroy them.

About the Author

Josiah Durrell is an undergraduate at Montana State University, currently pursuing a degree in English Literature and Philosophy. After graduation, Josiah plans to get his masters and teach at the high school level in Colorado.

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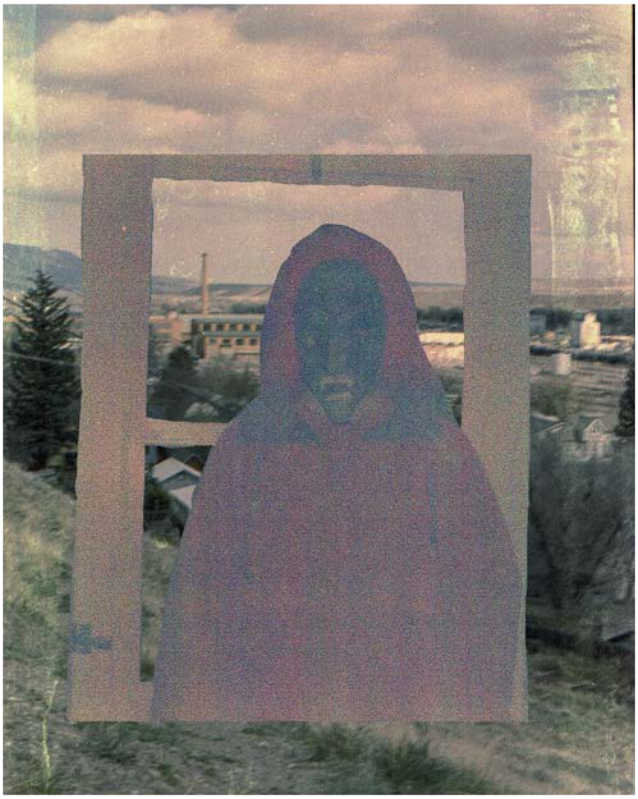
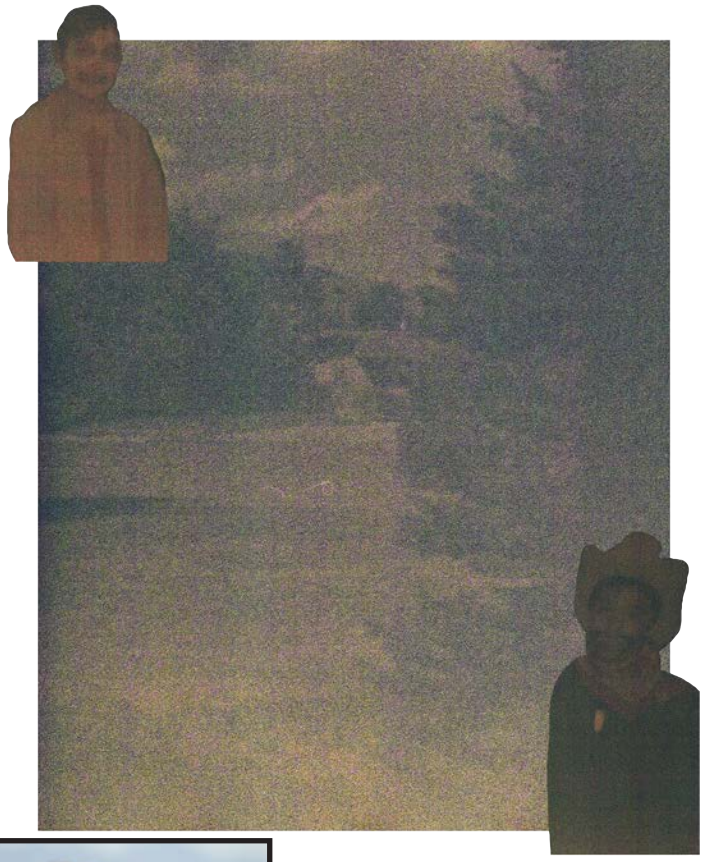
Ghosts of the Landscapes

Sierrah Paul

Having recently inherited a set of cameras and film from a great uncle, Ray Wilmot (1923–1993), this work, Ghosts of the Landscapes, works to explore more about the life of a family member that I was unable to meet, having been born 11 years after his death. Ray Wilmot was an avid photographer, who pursued photography throughout his adult life until he was diagnosed with Multiple sclerosis (MS) about 10 years before his death. This led him to leave his cameras and film sitting for the rest of his life, along with them sitting for 30 years beyond his death. I embarked on the journey of developing the film Ray had never been able to see and after studying them I chose to visit Livingston, Montana and photograph the landscapes my great uncle once photographed. The landscapes of Livingston were photographed on expired film that once belonged to my great uncle using his cameras. By collaging the prints from the found film and the new landscapes and using the equipment he had used, I have worked to combine the past and present, allowing myself to build a stronger





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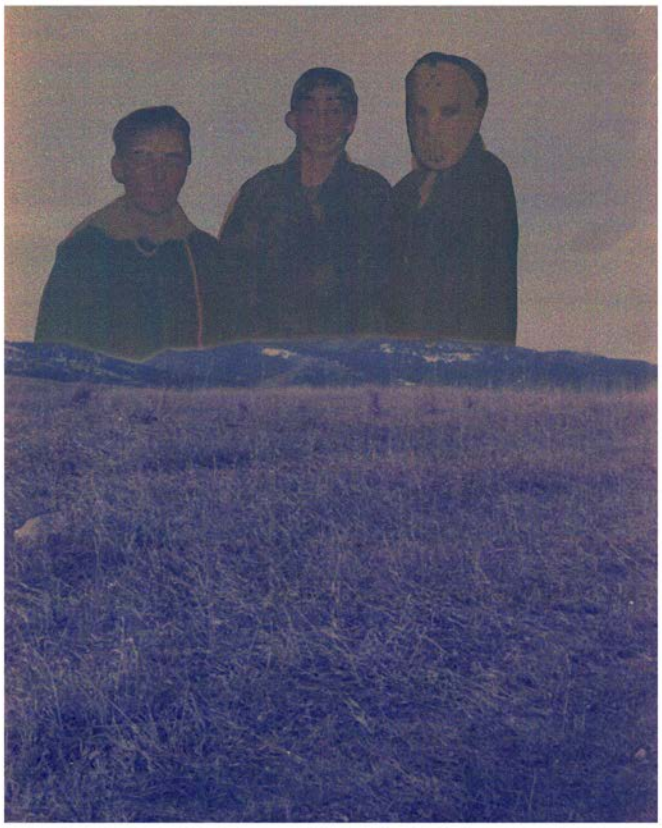
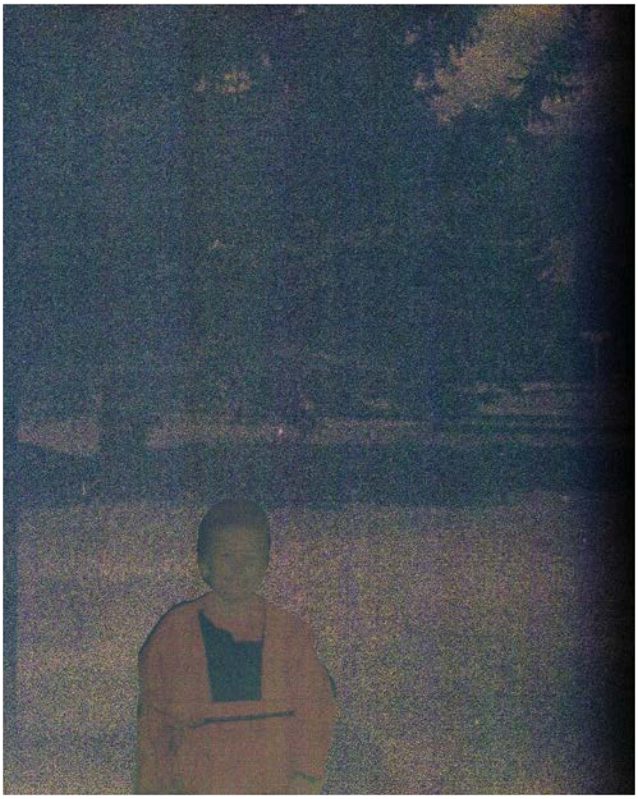
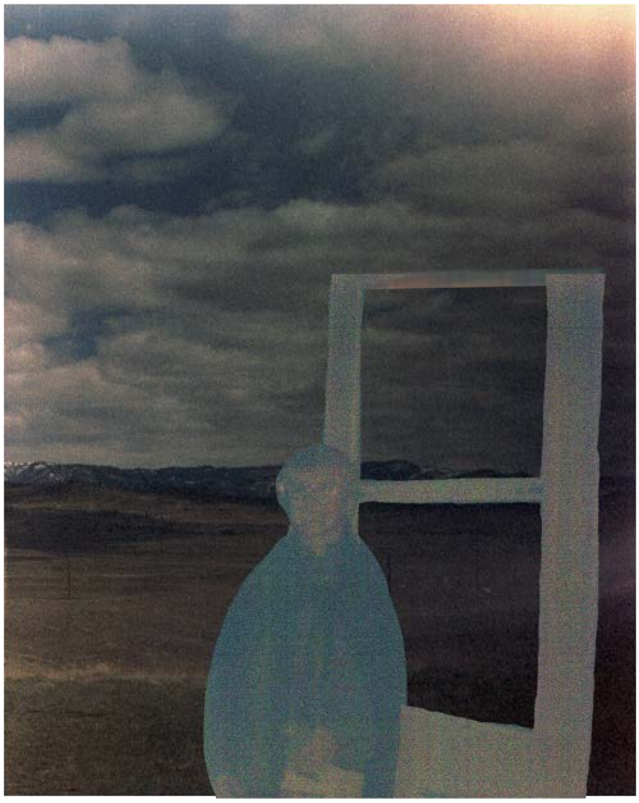
Sierrah Paul is a junior at Montana State University pursuing dual degrees in Computer Science and Film and Photography. Sierrah had the support of Zach Begler throughout the production of this project. When not photographing, Sierrah is hiking on all the trails that Montana has to offer or curling up with a nice book. After completion of her undergraduate degrees, Sierrah plans to go to graduate school for User Design and Experience.







Epistemic Injustice and Violence Perpetrated Against Indigenous Populations: Is Reconciliation a Modern Manifestation of Epistemic Violence?

Lucia Jackson

This paper explores Indigenous knowledge suppression as a form of epistemic violence and injustice. Through examination of the residential schooling system, I demonstrate how forced assimilation practices, such as language suppression and erasure, severed important epistemic ties for Indigenous children. Drawing on Gayatri Spivak's account of epistemic violence and Miranda Fricker's literature on epistemic injustice, I argue that colonial boarding schools incited epistemic violence which gave rise to testimonial and hermeneutical injustices. Furthermore, I critically analyze modern forms of reconciliation, declaring that such efforts fail to adequately address ongoing harms faced by Indigenous peoples. Instead, they perpetuate systemic oppression and epistemic injustice, thereby diminishing Indigenous testimonies in the modern era. Finally, I engage with José Medina's recognition philosophy to assert the need for a radical shift in the process of recognition as a step towards sufficiently managing epistemic harms.

Introduction

Suppression of Indigenous knowledge has deep historical and colonial roots and constitutes the epistemic smothering and exclusion of Indigenous voices from the intellectual landscape, both historically and currently. This paper investigates the degree to which Indigenous knowledge has been suppressed, and how this has led to differing forms of epistemic injustice. This analysis will include how language was suppressed through forced enrollment in colonial boarding schools. I maintain that instances of cultural suppression in boarding schools represent a more intense form of epistemic injustice, often referred to as epistemic violence. Finally, I argue that historical forms of epistemic violence have disrupted modern intellectual exchange and created new forms of epistemic injustice. Through specific investigation of reconciliation acts, I assert that contemporary forms of reconciliation and recognition do little to quell ongoing epistemic harms; on account of their failure to ensure that Indigenous testimony is meaningfully heard and understood, thus devaluing testimony and perpetuating epistemic injustice.

What is Epistemic Injustice and Epistemic Violence?

It is important to begin with the distinction between epistemic injustice and epistemic violence. Epistemic injustice, first conceptualized by Miranda Fricker in her book *Epistemic Injustice: Power and Ethics of Knowing*, revolves around injustices that are largely testimonial or hermeneutical, and the framework she outlines relies on interpersonal hearer/speaker relations. Testimonial injustices are situations in which, "prejudice will tend surreptitiously to inflate or deflate the credibility afforded the speaker, and sometimes this will be sufficient to cross the threshold for belief or acceptance so that the hearer's prejudice causes him to miss out on a piece of knowledge" (Fricker 17). It is understood that testimonial injustice is a specific instance in which a speaker's testimony or account is devalued based on characteristics unrelated to their capacity as an epistemic agent. An example of epistemic injustice might be a black woman whose sexual assault allegations are not taken seriously by a hearer due to a racial prejudice they hold against her. Through this analysis, it is made clear that Fricker's account of epistemic injustice operates largely on an interpersonal scale, in which speaker/hearer relations unfold to establish belief or disbelief in an individual's testimony. Awarding such belief is dependent on a hearer's biases. Fricker's account of testimonial injustice evolves from an implicit bias or structural ignorance held by the hearer, and the hearer's disbelief in these interpersonal settings is not contingent on intentionally perpetuating systems of silencing and erasure; however, it is important to note such disbelief is informed by historically oppressive structures. In the case of the black woman, racial biases led to the hearer's disbelief in her
testimony.

Alongside testimonial injustice, Fricker also details hermeneutical injustice. Hermeneutical injustice refers to an injustice where an individual is disadvantaged in their ability to communicate or understand a situation due to a rift in the collective conceptual framework. She states, "hermeneutical injustice occurs…when a gap in collective interpretive resources puts someone at an unfair disadvantage when it comes to making sense of their social experiences. …and that hermeneutical injustice is caused by structural prejudice in the economy of collective hermeneutical resources" (Fricker 1). Such an injustice includes women being unable to communicate workplace sexual harassment before workplace legislation was passed that gave such harassment a category. Because women did not have a category or word to convey what they were experiencing, due to a collective rift in understanding and framework, they were unable to make sense of their experience or communicate it effectively. Similar to testimonial injustice, the hearer's disbelief or the speaker's inability to communicate their experience in these interpersonal settings is not contingent on intentional silencing or erasure; however, such injustices do arise from historically oppressive power structures, and reflect on an interpersonal scale, the continuance of oppressive actions towards a specific group. The example of the term sexual harassment not being conceptualized until the 70s reflects a deeper systemic issue arising from the patriarchal framework. While inherently useful in studying epistemic harms, epistemic injustices arise out of epistemic violence, and thus it is imperative to also investigate Gayatri Spivak's account of epistemic violence.

First defined in her essay "Can the Subaltern Speak?" Spivak's conception of epistemic violence constitutes a much more intentional and malicious account of injustice. Whereas Fricker's account of epistemic injustice details more interpersonal and focused instances of epistemic wrongs, Spivak's encompasses a far broader and more structural account of epistemic harms. Epistemic violence refers to harm inflicted when knowledge systems of marginalized groups are distorted or silenced, usually by a dominant group or ideology; instances of epistemic violence are typified by their ties to structural or systemic oppression (Spivak). She frames her argument in the context of Western epistemic traditions, for example, colonialism, and how these dominant discourses systematically erase or misrepresent marginalized peoples and their knowledge systems. "The clearest example of such epistemic violence is the remotely orchestrated, far-flung, and heterogeneous project to constitute the colonial subject as Other. This project is also the asymmetrical obliteration of the trace of that Other in its precarious Subjectivity" (Spivak 76). Spivak expands this definition by offering examples of colonial rule in India, where European colonizers subverted and manipulated Indian structures to privilege their episteme. She offers an account of the codification of Hindu law into British law through Sanskrit:

> "One effect of establishing a version of the British system was the development of an uneasy separation between disciplinary formation in Sanskrit studies and the native, now alternative, tradition of Sanskrit 'high culture'. Within the former, the cultural explanations generated by authoritative scholars matched the epistemic violence of the legal project… A version of history was gradually established in which the Brahmans were shown to have the same intentions as (thus providing the legitimation for) the codifying British" (Spivak 77).

Through manipulation, and thus domination, of the ruling class in India, the British were able to codify colonial law in a manner that was widely accepted and perpetuated throughout Indian history. In doing so, the British committed an obvious act of epistemic violence, controlling and erasing prior aspects of Indian culture to privilege and enunciate their laws. Spivak's definition of epistemic violence concerning intentional acts of colonial suppression situates her conceptualization of epistemic harms as necessarily advantageous to the study of epistemic violence committed against Indigenous Americans.

Epistemic Violence During the Boarding School Era

While there exists both contemporary and historical accounts of epistemic harms perpetuated against the Indigenous peoples of North America, I wish to examine the forced reeducation of Indigenous children through colonial boarding schools. I believe the instance of forced reeducation offers the most poignant analysis of epistemic violence in North America, due to their explicit aim at severing Indigenous children from cultural and epistemic ties. Andrea Smith investigates forced reeducation in her article "Boarding School Abuses, Human Rights, and Reparations,"

Smith maintains that the aim of colonial boarding schools was to sever Indigenous children from their cultural ties and forcibly assimilate them into white culture (90). Investigation of residential schools as institutions intent on destroying Indigenous children's ties with their language, community, and culture makes clear that forced colonial boarding schools align directly with Spivak's account of epistemic violence; due to their inherent aim at destroying any semblance of Indigenous culture in favor of a dominant white culture/ideology. Kristie Dotson concretizes this notion of epistemic violence in her article "Tracking Epistemic Violence," stating that "An epistemic side of colonialism is the devastating effect of the 'disappearing' of knowledge, where local or provincial knowledge is dismissed due to privileging alternative, often Western, epistemic practices" (236).

It is clear that colonial boarding schools are a locus for epistemic violence, however, returning to Miranda Fricker's account of epistemic injustice, through forced assimilation, language suppression, and cultural severance, boarding schools give rise to certain epistemic injustices. In the sense that residential schools stripped Indigenous children of their language and thus the epistemic resources necessary to communicate with others. It also deprived them of the necessary conceptual tools to make sense of their experiences, specifically as their native language was lost to them, thus under-privileging and oppressing them as epistemic agents.

Forced assimilation through the suppression of language is an example of epistemic injustice, specifically testimonial, as outlined by Fricker. She states, "an epistemic injustice wrongs someone in their capacity as a subject of knowledge, and thus in a capacity essential to human value; and the particular way in which testimonial injustice does this is that a hearer wrongs a speaker in his capacity as a giver of knowledge, as an informant" (Fricker 5). I argue that suppression of language is a testimonial injustice because it highlights an important intersection between power and identity within cases of epistemic injustice. In the case of language suppression, a dominant group asserts power over a group that is perceived as less powerful in their social identity, this dichotomy is then exploited to suppress the minority group. The suppression of language is by extension the oppression of individuals who hold membership to that minority group, in this case, Indigenous children. Identity power and testimonial injustice are "operations of power which are dependent upon agents having shared conceptions of social identity—conceptions alive in the collective social imagination that govern for instance, what it is to be a woman or a man, or what it is to be gay or straight, young or old, and so on" (Fricker 14). Being a member of this minority group and using this minority language thus aids in testimonial oppression, as their testimony will not be taken as seriously or heard meaningfully because its origin is outside the dominant group.

More pointedly, language suppression represents a distinct case of hermeneutical injustice, "hermeneutical injustice occurs when a gap in collective interpretive resources puts someone at an unfair disadvantage when it comes to making sense of their social experiences. and that hermeneutical injustice is caused by structural prejudice in the economy of collective hermeneutical resources" (Fricker 1). Suppression of language constitutes a hermeneutical injustice on the grounds that it fully erases an individual's ability to make sense of their experience within a dominant language. Because Indigenous children were forced to learn a language not entirely familiar to them, it can be rightly assumed that they were unable to communicate the full extent of their trauma and abuses because they lacked the necessary framework to do so. Furthermore, in suppressing Indigenous language and Indigenous children's ability to meaningfully communicate their oppression, a rift was opened in the collective understanding and ability to comprehend the abuses sustained in Indigenous boarding schools. This gap in collective resources was caused and perpetuated by the colonial ideology that English should be the dominant mode of communication, therefore language suppression constitutes a form of hermeneutical injustice.

Can Reconciliation Acts Help Address Epistemic Injustice?

One might argue that reconciliation and recognition acts can help fill gaps in collective understanding that would address or at least quell further epistemic harms/injustices. Christine M. Koggel reviews the aims and structures of reconciliation acts in her article "Epistemic Injustice in a Settler Nation: Canada's History of Erasing, Silencing, Marginalizing." In the case of Canada's TRCs (Truth and Reconciliation Commission), reconciliation efforts often involve activities

where survivors present testimony about the abuses committed in boarding schools and create an accessible narrative foregrounding why those practices were oppressive and harmful. Reconciliation acts are generally characterized by a necessity to illuminate historical acts of violence through the personal testimony of those oppressed and establish this as a means to collectively recognize them as wrong. In theory, such acts grant communities and nations the ability to move forward in unity toward a brighter future (Koggel). However, it is precisely a reconciliation act's sole aim of illuminating past injustices while ignoring current structural injustices brought on by historical oppression, that diminishes their value as valid forms of resolution.

I argue that the reality of reconciliation acts is far more sinister than it may appear. In attempting to recognize historical harms through legislative and official means, reconciliation acts often ignore key components of the struggle for acknowledgment and power relationships in post-colonial eras, consequently perpetuating epistemic violence and injustices. Moreover, the inherent fault of reconciliation acts is their engagement in a degree of chrono-politics that historicizes and thus distances the personal testimony of those oppressed from the present. This, in turn, prevents individuals and governments from fully recognizing the ongoing injustices experienced by Indigenous peoples. Anna Cook explores this phenomenon in her article "Recognizing Settler Ignorance in the Canadian Truth and Reconciliation Commission." Cook outlines that acts of reconciliation are largely distributed and orchestrated by the state, a historically colonial agent, through this Indigenous testimony and agency are further subsumed into the colonial structure. "contemporary colonial power and hegemony work not through a process of exclusion but rather through the inclusion and shaping of Indigenous peoples and perspectives by state discourses self-determination cannot be bestowed upon by the state but must result from Indigenous resurgence" (Cook 9), Here, Cook illuminates why reconciliation acts through the state do not account for valid forms of recognition, defined by the fact that the state is a historical source of colonial oppression, specifically in its creation of the residential school system which is a key source of epistemic violence and injustice. Any attempt at reconciliation through the state is an attempt through colonial and oppressive means, and therefore further establishes Indigenous peoples as colonial subjects. As stated by Spivak, " in the constitution of that Other great care was taken to obliterate the textual ingredients with which a subject could cathect, could occupy (invest?) its itinerary – not only ideological and scientific production, but also by the institution of the law" (75). Reconciliation through this lens then becomes an overt instance of epistemic violence because Indigenous self-determination was appropriated by the state in favor of reproducing the dominant ideology of colonialism.

As outlined above, acts of recognition often participate in the purposeful effort to consign personal testimony and oppression to the past, consequently limiting testimonial agency and import in the present.

> "Settler ignorance functions by delegitimizing testimonies by relegating these testimonies to the past … Expressions of ongoing settler-colonial violence are taken to be a form of negative dwelling in the past, rather than taken as an expression of the impact of the ongoing violence of settler colonialism … the temporal distancing works to create a 'consensual hallucination' of the denial of present-day settler-colonial reality, which is required for 'conquest, colonization, and enslavement'" (Cook 19).

Here Cook outlines an overt form of epistemic oppression, dismissing testimony to the past devalues it in the present, denoting an occasion of obvious testimonial injustice. Defined by Fricker as a situation in which prejudice causes the hearer to invalidate the speaker's testimony and overlook key aspects of the testimony. In the case of Indigenous recognition specified above, incorrectly situating residential schools and their abuses as elements of the past causes individuals to remain ignorant of structural abuses in the present.

If reconciliation acts are harmful, why has this not been more widely recognized? In Jose Medina's article "Misrecognition and Epistemic Injustice," he investigates recognition theory and misrecognition of the agent as key components when investigating epistemic injustice. He posits that recognition is key to understanding epistemic injustice, and currently, there is no proper understanding or recognition of oppressed groups and subjects, consequently, knowers are inevitably slighted in their capacity as epistemic agents (2). Here he outlines that misrecognition

accounts for epistemic injustice in the sense that an individual will not be able to meaningfully communicate their experience, and their credibility will be questioned. Medina then extends this definition of misrecognition to include misrecognition of the subject or object of discussion. Medina contends that misrecognition to this degree disrupts conversation surrounding a topic because it does not properly illuminate the degrees of injustice or engage with the subject significantly: "Here the recognition deficiency concerns not whether or not one is recognized, or to what degree, but how one is recognized and whether the way in which one is recognized is appropriate or not" (3), Which is an extremely important distinction when discussing reconciliation acts because it highlights that there are possible defects in the way individuals and governments engage with narratives of oppression. What is of even further importance to his argument is that he suggests mere visibility or increased recognition is not sufficient to counter the oppressive nature of the injustice because visibility does not draw into account systemic issues; instead, there needs to be a drastic transformation in the manner these instances are conceptualized and visualized— "The incremental approach is ineffective here because what is needed is not more images but *a radical shift in the mode of recognition*" (Medina 11). Applying this to reconciliation acts, it becomes increasingly clear that the current framework of visibility and recognition does little to productively assess the oppression of Indigenous peoples, historical or current. Without radical reconfiguration of the manner in which we approach instances of reconciliation of past abuses, we run the risk of perpetuating those abuses, as is seen in the case of Canada's Truth and Reconciliation Commission discussed by Cook.

Conclusion

The historical suppression of Indigenous culture through residential boarding schools represents a profound instance of epistemic violence that worked to intentionally separate Indigenous children from their language, families, and Indigeneity. This violence had pervasive ramifications, fostering testimonial and hermeneutical injustice, which continue to oppress modern Indigenous voices. Contemporary reconciliation acts do little to address these current abuses, instead masquerading as attempts to reconcile past wrongs. Modern acts such as TRCs operate within colonial frameworks that appropriate and falsely historicize Indigenous testimony, failing to meaningfully address past and present epistemic harms. Looking ahead, a radical shift is necessary to properly account for systemic injustices suffered by Indigenous populations, one which centers on Indigenous agency, deconstructing colonial frameworks, and fostering an inclusive epistemic landscape.

About the Author

Lucia Jackson is a senior at Montana State University, majoring in English Literature and Philosophy. She began her studies in 2021 and is set to graduate in 2025. After completing her undergraduate degree, she plans to pursue graduate studies in English Literature. Outside of her academics, Lucia enjoys skiing, climbing, and spending time outdoors.

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A Love Without a Name: Examining the Language of Sexuality, Attraction, and Meaningful Connection Through an Aromantic and Asexual Lens

Ginger Heath

While the English language's ability to describe love and attraction has grown immensely in the past two centuries, many identities have struggled to find a place within the system of sexuality. Those who experience a lack of sexual or romantic attraction often find themselves within a linguistic limbo, lacking the distinction of a name while still facing very real barriers to communication within their relationships. The mainstream language surrounding meaningful human connection places an emphasis on sex and romance, failing to acknowledge the important relationships that can exist outside these two concepts as anything other than "friendship." In rebellion of this invisibility, new vocabulary has been developed to better describe non-normative bonds and orientations. This essay follows the language of love and attraction from the late 1800s to present, highlighting aromantic and asexual perspectives and illustrating just how powerful a name can be.

In Lord Alfred Douglas' 1894 poem *Two Loves*, the narrator is approached by two youths in a heavenly dreamscape. One is "fair and blooming" who sings of "joyous love of comely boy and girl" (Douglas 42, 44); the other is "sad and sweet" with eyes "strange with wondrous brightness," whose beauty and sorrow moves the narrator to tears (Douglas 52, 53). When prompted, the second youth says his name is Love. The first then proclaims, " 'He lieth, for his name is Shame, / But I am Love . . . I am true Love, / I fill the hearts of boy and girl with mutual flame.' " The second responds, " 'Have thy will, / I am the Love that dare not speak its name' " (Douglas 68-74). He speaks of a love that remains unarticulated, undefined; it is condemned to shamefulness because it has only been conceptualized as a twisted deviation from what is real and valuable. By equating the spoken word to the societal recognition of validity—rather than validity itself—Douglas implies that a love that dares not speak its name is no less true in its silence. The word "homosexual" had only been in use for fifteen years at the time of this poem's publication (Stack). Even while nameless, various acts of same-sex love had been criminalized under British law since the sixteenth century (Macleod 356). Following the publication of Douglas' *Two Loves*, "the love that dare not speak its name" became a recognized Victorian-era euphemism for homosexuality (Tearle).

In an essay on asexuality and its place among other sexual orientations, queer researcher CJ DeLuzio Chasin explores the birth of sexualities in the English language. In mid-nineteenth century Europe, an argument had formed around whether homosexuality should be seen as "chosen and therefore morally deficient" or "inborn and therefore neutral and worthy of protection" (Chasin 211, 212). Homosexuality's decriminalization was impeded by the lack of terminology for same-sex attraction, characterizing homosexuality as a deviation from heterosexuality rather than a distinct concept. Opposite-sex attraction was culturally validated as both the default and the moral standard, with the privilege of not needing a name because it could be recognized by face alone. Conversely, same-sex love was a stranger recognized only by those already familiar with it; the lack of a name only served to further strip away its legitimacy. The terms "homosexuality" and "heterosexuality" were coined in 1879, naming the faces on both sides of the argument through the lens of sexual desire (Stack). With this new vocabulary, homosexuality could now be defined as "parallel in nature" to heterosexuality, rather than a chosen deviation (Chasin 212).

Sexualities assume several things: the presence of sexual attraction, the implication of romantic attraction, and the singular object of both. These assumptions fail to describe situations in which the object of attraction differs between the romantic and the sexual. From 1864 to 1880, German researcher Karl Heinrich Ulrichs developed a now-extinct vocabulary to conceptualize male desire. This was meant to satisfy the need

for "positive vocabulary" to describe people like himself who diverged from the norm (Brooks 182). One such term, "uranodionism," refers to concurrent same-sex and opposite-sex attraction. Ulrichs splits uranodionism into two categories: "conjunctive" and "disjunctive" (Brooks 183). Conjunctive uranodionism describes concurrent romantic and sexual attraction toward both men and women, aligning with the modern definition of bisexuality. Disjunctive uranodionism refers to same-sex romantic attraction alongside opposite-sex sexual attraction, which cannot accurately be described as bisexuality because both attractions are not experienced toward the same demographic ("Splitting Attraction"). Ulrichs' work became a vital tool to those previously incapable of conceptualizing their desire as anything other than a twisted variant of heterosexuality. One such man writes that for him, these terms were ultimately "salvation," connecting him to a network of other men experiencing same-sex attraction. Strangers became friends. He rejoices in the knowledge that his sexual desire was "determined by nature" rather than an "aberration" (Stack). When an experience can only be described comparatively, it is denied its true societal value. Ulrichs' work illustrates the validation to be found in establishing new vocabulary to better describe oneself.

A century after Ulrichs, researchers were still attempting to differentiate between romantic and sexual attraction in both language and life. In the 1999 foreword to her 1979 book *Love and Limerence*, American psychologist Dorothy Tennov sums up the prevailing ideas on romantic desire:

> The illustrious and influential Sigmund Freud dismissed romantic love as merely sex urge blocked. Pioneer sexologist Havelock Ellis provided his famous and entirely incorrect mathematical formula [for a romantic relationship]: sex plus friendship. (It seems to be neither.) … Theodore Reik asserted that sex and love are quite different, although the usual interpretation of Freudian concepts is that they are fused. Psychoanalyst Robert Seidenberg comments that the only similarity he could think of is that neither makes sense. (5)

In her book, Tennov explores how romantic attraction can manifest as a cognitive state she dubs "limerence." Most are familiar with the symptoms: the butterflies, the jealousy, the desire to admire and be admired, the state of being in love whether requited or not. She writes, "the expression 'thinking of you' fails to convey either the quantity or quality of this unwilled mental activity. 'Obsessed' comes closer but leaves out the aching" (Tennov xiii). When building a relationship, limerence prioritizes "emotional commitment" above "physical union," deviating from other sex-central theories of the time (x).

In her research, Tennov also stumbled upon those who did not experience romantic desire, who she called "nonlimerents." While these participants may still encounter sexual attraction and/or be engaged in a committed partnership, they could not relate to Tennov's descriptions of infatuation. These interviewees welcomed the label of nonlimerent, "happy to accept their status once they had been given words in which to describe it." (117). For both Ulrichs' men and Tennov's nonlimerents, experience-specific language offer comfort, clarity, and community.

Many of Ulrichs' terms equate to sexualities in today's terminology. Such is the case for conjunctive uranodionism, which can be equated to bisexuality. Disjunctive uranodionism, samesex romantic and opposite-sex sexual attraction, cannot be neatly described as bisexuality because this would require the separation of two "inseparable" concepts, sex and romance. Sexualities lack this distinction; sexual attraction is explicit in the title, and romantic attraction is seen as implicit in wanting sex.

Posters on a 2005 thread from an Asexuality Visibility & Education Network (AVEN) forum discuss ways to describe two groups: asexual people who still experience romantic attraction, and people for whom the objects of sexual and romantic attraction are different. At the time, individuals who experienced neither sexual nor romantic attraction were referred to in the AVEN community as asexual-asexual (a-a) to signify the absence of two distinct types of attraction. The original poster of this thread toys with the idea of a two-part label that allows for mixing and matching the attraction and the object. For those who had identified with disjunctive uranodionism over a century beforehand, their experience of attraction could now be named using the descriptor "heterosexual homoromantic." Posters on the thread use their new system to establish the concept of aromanticism, matching the "a-" prefix

to the "-romantic" suffix to denote a lack of romantic attraction ("Relationship Definitions"). After 25 years, Tennov's nonlimerence had finally been given a modern equivalent.

Within the context of attraction and sexuality, orientations that experience a partial or total lack of attraction, such as asexuality and aromanticism, can be considered to fall on the a-spectrum. Any orientations outside that definition fall on the allo-spectrum, a collective term used to easily reference all people who fully experience attraction. In a culture permeated by allo-spectrum expectations, a-spectrum individuals must often challenge cultural norms built around desires they do not experience.

Sexual attraction has been — and continues to be — seen as a universal characteristic. Sexualities entered the English language at a time when sexual attraction was the only identifiable preference to be described. In Tennov's 1999 *Love and Limerence* foreword, she contends that when someone feels limerence it is always accompanied by sexual desire (Tennov x). The notion that romantic desire does not exist separate from sexual attraction has remained deeply entrenched in how we talk about love and attraction.

Likewise, romantic attraction and an accompanying desire for a romantic relationship are often inadvertently assumed to be universal. In 2012, Dr. Elizabeth Brake of Rice University coined the term "amatonormativity" to refer to the implication that a romantic relationship in someone's life can adequately reflect their happiness, progress toward goals, or overall character. In her book *Minimizing Marriage*, Brake defines amatonormativity as a "disproportionate focus on marital and amorous love relationships as special sites of value [in one's life]." This manifests as a widespread cultural assumption that romantic partnerships are a "universally shared goal" and ought to be "aimed at in preference to other relationship types." Two amatonormative phrases she cites are

"'She hasn't found the one . . .yet' or 'aren't you lonely/immature/irresponsible because you are not married/partnered?'" ("Amatonormativity"). The central theme is that any "valuable relationships must be marital or amorous," which "devalues friendships and other caring relationships" and perpetuates a narrative equating happiness and fulfillment to the romantic bond (*Minimizing Marriage* 88, 89). This idea can be especially harmful to a-spectrum individuals, who may derive the most satisfaction from platonic love, living alone, or non-normative relationships. When meaningful connection is assumed to only occur in a romantic and sexual context, nonromantic love is treated as though it is not true enough, deep enough, committed enough, or valuable enough to support a person's emotional well-being in any significant way

One manifestation of amatonormativity is known as the "audience challenge." This term refers to two assumptions: that some friendships must be romantic, and that some strong platonic bonds must be steppingstones to romance. The audience challenge can manifest as heavy scrutiny of the relationship, onlooker suspicion of romantic or sexual intent, and intrusive commentary about the "true" nature of the friendship. Cross-sex (male-female) friendships experience the audience challenge most severely, which culminates in a social pressure to admit the assumed desire for a romantic relationship. The frequency with which cross-sex friendships perceive the audience challenge in their daily lives, as well as its emotional effects, are investigated in a study conducted by Katie Schoonover for her master's thesis at Western Illinois University, under the direction of Dr. Bree McEwan. They found that when a social network failed to acknowledge the important role platonic intimacy can play in one's emotional health, the participants of cross-sex friendships may experience a higher number of unsolicited comments, opinions, and pressures from friends and family members.

The driving force behind the audience challenge is an amatonormative "hierarchy" of relationships and their worth, wherein society places romantic relationships in a position of higher value than that of platonic and other non-romantic bonds. Subtle traces of this hierarchy can be found in commonplace ways that romance is discussed: "more than friends" (as though "just friends" were somehow lesser) and the concept of the "friend zone," in which romantic advances from one person toward another are unsuccessful. Seen as a tragic and unjust position, at a basic level the friend zone implies that the friendship was only worthwhile if it could eventually morph into a romantic relationship. Platonic love is rarely seen as an adequate source of intimacy and social satisfaction in a person's life.

Amatonormativity alienates those who find greatest happiness in non-romantic connection or solitude. Many people in the a-spectrum community pull substantial love, support and fulfillment from their friendships, deviating from the notion that meaningful happiness can only occur in a romantic relationship. In a study scrutinizing the perceived relationship between love, sex, and happiness, researcher Tiina Vares interviews asexual individuals of various romantic orientations. Although some relied solely on friendships for interpersonal connection, they did not feel as though they were bypassing " 'real' love and intimacy, and therefore unhappy" (Vares 190). One member of the study, Gabriella, acknowledges "a hierarchy which privileges sexual intimacy" so much so that the presence of sex is an indicator of whether a relationship can be considered "close and intimate." Gabriella desires a partnered, non-sexual relationship, but Vares notes that she has "no intelligible way" to the close friends she would "almost count" as partners (Vares 192).

Some nonlimerents interviewed by Tennov reference a desire for, or engagement in, a deep emotional and/or sexual relationship despite their lack of romantic attraction. When one participant, Vera, is introduced to nonlimerence, she remarks, "This is wonderful. Now I know what is happening, and I can tell Barry all about it. Maybe that will make him leave me alone a little more often and not feel so bad about it. I think, from what you say, that he must be limerent" (Tennov 117). It would appear that in Vera and Barry's relationship, there is an underlying expectation for her to perform the duties of a romantic partner. The idea of nonlimerence allows for both her and Barry to better understand her needs, and she hopes that, by giving a name to their differences, they will be able to live together more comfortably.

Ella, another participant in Tennov's study, states that she'd like "someone to feel affectionate toward, maybe sexy toward," and she describes a close friendship with someone, Steve, who she had thought suitable for such a partnership. Their bond had turned sour when he expressed romantic feelings she did not—could not—reciprocate, despite her assumptions that if she "ever married anybody, it would be Steve" (Tennov 112). In a proposal fueled by possessive jealousy and romantic grandeur, Steve asked Ella to move away with him because he " 'couldn't' live without" her and "knew" from their letters that she "felt the same" (Tennov 113). Ella had felt betrayed that someone "safe and comfortable" could expect her to abandon her life just to prove a romantic commitment she didn't feel. After Steve, Ella "often felt it necessary to discontinue seeing" potential partners out of the fear that emotional intimacy would invite the expectation of her sacrificed autonomy to satisfy their romantic desires (Tennov 113, 114).

Tennov remarks what an "expert 'player' in the game of love (limerence) Ella must have seemed to Steve," likening the situation to a misunderstanding perceived as a ruse: "The nonlimerent person who is fond of, affectionate toward, and attracted to you but who does not succumb and does not understand what you want therefore plays the game ingeniously and without artifice, because it is not a game at all" (Tennov 113). Ella's platonic affection was perceived by Steve as an equally strong romantic desire, so she had seemed to be purposefully unwilling to return his interest. However, the "game of love" requires mutual limerence, so Ella is accused of withholding a romantic love she does not feel and therefore cannot withhold.

These nonlimerents, Vera and Ella, were unable to navigate interpersonal relationships because they lacked the vocabulary to describe their experiences and goals. Vera could not communicate her inability to meet her partner's needs without sacrificing her own. Ella's hope for a deep, nonromantic bond was left unarticulated, costing her a close friend. What both participants seem to desire is a bond centering emotional connection rather than romantic love while being equivalent in depth, rejecting the idea that a committed partnership requires romance.

In 2010, blog site Dreamwidth users kaz and melouhkia contribute to a conversation lamenting the relatively nonexistent terminology for just such a relationship. Phrases like "sex plus friendship" or "dating without the romance" fail to convey the innate worth of a deeply committed non-romantic relationship, and such an inadequacy can only be bridged by language that refers to platonic love directly. They suggest "queerplatonic" as a unique term for those types of nonnormative bonds that, while centering on "deep . . . emotional connection," are not romantic in nature and not adequately described as friendship ("A/romanticism"). In a later tumblr post by S.E. Smith (melouhkia), queerplatonic relationships are defined as any non-normative bonds

built on "intense emotional connection" without being "romantic in nature," not excluding non-romantic sexual intimacy or polyamorous relationships (which involve multiple consenting partners). The participants are not required to personally identify as queer because in this context, "queering" characterizes an effort to accurately representt the value of relationships that do not fit the "normal," and are therefore treated as lesser by simply being unusual. Smith stresses that the "key feature" defining queerplatonic bonds is the state of "being deeply connected to someone, without a romantic element" (Smith).

The concept of queerplatonicism has gained popularity over the past decade, especially with the younger demographic and those who frequent online spaces. In Vares' study, the acronym QPR (queerplatonic relationship) is used by James, an 18-year-old aromantic, to describe "a mode of relationship he might like to have with another man" (Vares 192). The emergence of this new vocabulary has allowed James the freedom to articulate his objectives without first translating his platonic attraction into some acknowledged romantic or sexual equivalency.

Participants in both Vares' and Tennov's studies express the desire for a queerplatonic relationship without the necessary terminology. Their inability to communicate is so profound that it alienates these people from themselves, not just from those that they care for. In Two Loves, Douglas writes of a love that dare not speak its name—one that deviates from the normal, the assumed, and the accepted. This love is characterized as shame in its silence, a nameless deviation; as such, it is denied a place in larger conversations about meaningful connection. Only through the ongoing invention and reinvention of language can love be named and valued in all its forms.

About the Author

Ginger Heath is a junior at Montana State University majoring in Paleontology. Their research into Queer linguistics has now spanned almost four years and began with Professor Arwen Spicer at Clark College in Vancouver, WA. Ginger is an avid French horn player and a member of the MSU Symphony Orchestra, the MSU Horn Ensemble, and the Bitterroot Brass Quintet. In their free time, they enjoy designing concert posters, reading about historic polar voyages, and rockhounding on the banks of the Yellowstone River. After graduation, Ginger hopes to attend taxidermy school.

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Jugular Vein Catheterization for Continuous Multi-hour Infusions in Mice

Zoe Seaford

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In vivo metabolic labeling in animal models is difficult and poorly described in method papers. This is an underutilized technique when it comes to identifying important metabolic components. In this paper we describe a detailed up to date protocol for metabolic administration of metabolites into mice. This protocol is designed to make these procedures more available to the research community. This methodology can be utilized for delivery for other compounds such as drugs and isotopes. The primary focus of this review is to emphasize that jugular catheterization is a versatile and effective way of studying the effects of compounds on the entire body.

Introduction

In vivo studies are a key tool when it comes to studying the roles of complex physiological processes. However, current methodology for studying these differences in metabolic fluctuations are seemingly difficult and outdated. Single or repeated inoculations of compounds into mice generally result in dynamic circulating compound concentrations and, consequently, dynamic downstream metabolic outcomes. Compounds can be administered in feed or drinking water, or by using osmotic pumps that are implanted into the mice. These long-term stable delivery approaches require extended periods of time for drug concentrations to reach equilibrium in the mice. As such, none of the above approaches are typically acceptable for achieving stable circulating compound concentrations over periods of several hours. While this exposure can be carried out in a controlled cell culture environment, these models lack the physiological complexity of entire organisms. To track molecular transformations in vivo rather than just measuring steady-state metabolite levels, jugular catheterization offers a reliable solution. This technique allows real-time tracing of specific metabolites—such as sulfur-containing amino acids—across multiple tissues, making it particularly useful for studying transient metabolic intermediates. Despite its advantages, jugular catheterization remains underutilized for isotope labeling in mammalian systems, limiting the scope of individualized tissue analysis.

Metabolism is central to life by providing energy, synthesizing complex biomolecules, eliminating waste, and maintaining homeostasis.1 Beyond these fundamental roles, metabolic enzymes also influence genomic, epigenomic, and proteomic regulation by acting as cofactors and substrates for gene-modifying processes such as methylation and acetylation. To fully understand cellular function, it is essential to study not only gene and protein expression, but also metabolic activity. Since standard proteomic analyses may overlook dynamic metabolic changes, investigating the metabolome through isotope labeling offers deeper insights into cellular regulation.2 However, studying metabolic pathways presents challenges due to the vast chemical diversity of metabolites, their rapid turnover, and their movement across tissues. To address this, isotopic labeling combined with mass spectrometry (MS) is a powerful approach for tracing metabolites, allowing precise identification based on mass and fragmentation patterns. Unlike whole-animal radiolabeling, MS-based isotopic tracing minimizes waste disposal concerns while providing high-resolution metabolic data.3

In this paper, we demonstrate the accessibility and effectiveness of jugular catheterization for delivering labeled metabolites. By detailing our optimized methodology, we aim to provide a practical guide for researchers interested in using this approach to study metabolic flux in vivo, enabling more comprehensive insights into systemic metabolism.

Protocol

Mice were housed in forced-air HEPA-filtered caging systems (Tecniplast or equivalent) on 14/10 h light/dark cycles with unrestricted access to water and feed. All experimental mice were at least 8 weeks of age. Mice were anesthetized with isoflurane at 3% and

maintained at 1-2% with a continuous flow of oxygen at 1 liter per minute throughout the procedure. Anesthetized mice were prepared for surgery on a heating pad for temperature regulation, eye ointment was applied, and hair was removed via an electric razor on the dorsal and ventral areas of the neck.

A chlorhexidine scrub followed by a chlorhexidine rinse was done 3 times for asepsis on the incision sites. The front paws were fixed to the abdomen with sterile tape and the stockinette was placed on the mice. Mice were then moved from the preparatory bench to the sterile operating table.

The sterile operating table was staged with a heating pad under a microscope. Alongside, a sterile field was dedicated for sterilized surgical instruments in addition to 4-0 suture, catheter, catheter plug, vessel loop, and distinct sterile syringes for the heparin, lidocaine, and saline solutions along with two, 25-gauge needles and one, 21-gauge needle.

The mice were positioned into the anesthesia nose cone on their back with the head of the mouse pointed toward the surgeon. A sterile drape was placed over the mice.

The initial incision site was approximately 1 cm below the right cheek, visually confirmed by pulsation of the jugular vein seen on the skin. Fine scissors were used to make a 2 cm vertical incision slightly right of midline on the neck.

The skin was separated from the subcutaneous layer with two curved micro-tissue forceps, one in each hand, using blunt dissection technique. The catheter insertion site was revealed by resection of adipose and connective tissues and best selected where the external jugular vein meets the subclavian vein. The insertion site was isolated with careful resection until the ventral surface of the vein was clear of connecting tissues, visually identified by exposure to the bright red color of the vein. Notably, resection of tissue near the vessel threatened the integrity of the fragile vein and increased the risk of rupture. Following isolation, pointed micro-forceps were used to create a subcutaneous "tunnel" under the vein using blunt dissection technique. Next, the vessel loop was inserted into the "tunnel" to isolate and expose the vein, with care not to twist the vein.
Two pieces of 4-0 suture were cut approximately 10 cm in length. Both pieces of suture were threaded under the vein alongside the vessel loop with pointed micro forceps. With one 10 cm section of suture, a loose, overhand loop was made on the inferior side of the vessel loop. A hemostat was used to hold both ends of the suture, and moderate, upward tension was placed on the jugular without completely occluding the vein. Adjusting the upward tension of this suture served to regulate blood flow to the vein. With the second piece of suture, a single overhand knot was tied on the superior side of the vessel insertion site, this time completely occluding the vein. A loose, overhand loop was made on top of that knot. Each end of the suture was attached to a hemostat.

To prepare the catheter for insertion, a 45-degree bevel was cut on the catheter tip, and the catheter was flushed with saline, ensuring air bubbles were removed from the line. The jugular vein was punctured for insertion in one of two ways: either using high precision dissecting micro-scissors to cut a very small incision (less than the diameter of the catheter tubing) or using a 25-gauge needle, bevel up, inserted at approximately a 22.5-degree angle to puncture the vein.

Immediately following puncture of the vein, upward pressure was placed on the overhand loop on the inferior side of the vessel loop to prevent significant blood loss. The catheter was held with notched forceps behind the anchor of the catheter and threaded through the superior suture loop. Using one hand, the catheter was inserted into the jugular vein while the other hand released tension as needed to close the overhand oop on the inferior side of the vessel loop using the attached hemostats.

The hand that was used for releasing tension was then used to pull closed the overhand loop on the superior side of the vessel block to create a tight overhand knot superior to the catheter anchor. The knot was secured with a square knot. A small amount of saline was flushed into the vein (approx. 200ul), avoiding large air bubbles in the tubing as an air embolism was a possible complication. If pooling of saline was visualized, this was a sign that the catheter was not in the lumen of the vein. Catheter placement in the vein was confirmed by slowly pulling back blood into the tubing. Next, a small amount of heparin (conc. and volume per mouse) was pushed through the catheter to prevent

blood clots around the implanted device. The catheter tubing was capped with a sterile, stainless steel catheter plug. Superior and inferior ends of suture were used to make square knots on either side of the catheter. A single stitch was made on the adipose tissue of the neck for added security of the catheter.

Mice were gently turned onto their anterior side in a prone position. The anesthesia decreased 25% at this time. A 1 cm vertical incision was made on the skin between the shoulder blades. A hemostat was placed into the incision and using the blunt dissection technique, the skin was separated from the body wall down the back. This created a space for the catheter tubing to be fed to the dorsal side of the mouse. A trocar was inserted into the dorsal incision and passed alongside the left side of the neck to the catheter placement site. The catheter with the stainless-steel plug was fed through the trocar and gently pulled out the dorsal incision with care ensuring the catheter rested with a gentle curve away from the insertion site and jugular vein, rather than with sharp angles or kinks.

The skin was then stitched on the anterior side of the neck using a simple running suture finished with an Aberdeen knot. The mice were rotated back to a prone position. The catheter was fed under the skin in one loop until the plugged end of the catheter emerged from the dorsal incision. Using several half hitches around the catheter plug to the base of the tubing, the catheter was secured to the skin with the plug accessible. The dorsal incision was then closed with a simple running suture finished with an Aberdeen knot. Anesthesia was disconnected, and the mice were able to recover under the post operative protocols approved.

Results

Effective administration of the jugular catheter was effective in dispersing the metabolite throughout the body.

Discussion

The successful implantation of jugular vein catheters in mice demonstrates the feasibility of this method for isotopic labeling and metabolic flux analysis in vivo. This technique provides a valuable approach for studying metabolic pathways by enabling real-time tracing of metabolites across multiple tissues. Jugular catheterization facilitates a more comprehensive understanding of metabolic dynamics in a physiological context.

One of the key advantages of this approach is its ability to bypass many of the limitations associated with alternative metabolic tracing techniques. Traditional methods, such as whole-animal radiolabeling, present challenges related to waste disposal and long-term radioactive exposure, making them less practical for traditional use. In contrast, stable isotope labeling combined with mass spectrometry (MS) provides a safer and more precise alternative for identifying metabolic transformations. The direct venous infusion of labeled metabolites ensures their efficient distribution throughout the circulatory system, allowing for a thorough assessment of metabolic flux across different tissues. This systemic reach is particularly beneficial for tracking transient metabolic intermediates that may not be adequately captured through steady-state metabolite measurements.

The surgical methodology employed in this study highlights the importance of precision in ensuring successful catheter implantation. The meticulous preparation, including proper anesthesia, temperature regulation, and tissue handling, minimizes procedural complications such as infection, catheter displacement, or vessel rupture. The stepwise approach used to secure the catheter further enhances long-term catheter stability.

Comparing this method to other metabolic tracing approaches, jugular catheterization offers unique advantages in terms of metabolic resolution and physiological relevance. Alternative methods, such as dietary incorporation of labeled nutrients or intraperitoneal injections, often suffer from slower metabolite uptake or inconsistent distribution, limiting their ability to provide real-time insights into metabolic flux. This is particularly useful for capturing fast-turnover metabolites, which are often challenging to study using less direct labeling techniques.

The findings of this study also highlight the potential applications of jugular catheterization beyond basic metabolic research. In biomedical studies, this technique could be leveraged to investigate disease-related metabolic alterations in conditions such as cancer, diabetes, and neurodegenerative disorders. By refining and expanding the use of this method, future studies could explore a wide range of physiological and

precision.

In conclusion, jugular catheterization represents a powerful yet underutilized technique for in vivo metabolic tracing. The methodological refinements outlined in this study enhance its feasibility, reliability, and reproducibility, making it a valuable tool for researchers interested in studying systemic metabolism. The benefits of this approach, particularly its ability to provide real-time, tissue-specific metabolic insights, make it an indispensable addition to the toolkit of biological researchers.

About the Author

Zoe Seaford is a senior at Montana State University pursuing a degree in Cell Biology and Neuroscience. Zoe has worked in the Schmidt lab throughout the entirety of her undergraduate career. As a Montana native, Zoe enjoys hiking, biking, and fishing. In her free time she enjoys hanging out with friends, cooking, and reading. In the future, Zoe hopes to continue onto graduate school.

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All animal protocols were reviewed and approved by the Montana State University Institutional Animal Care and Use Committee (Committee (MSU IACUC; approval numbers 2018-118-01, 2019-50-97, 2021-118-01, 2021-118-IA, 2022-50-IA, or 2023-225-IA) or the University of Veterinary Medicine Budapest, Hungary, Animal Research Ethics Committee (approval numbers PE/EA/00744-6/2022 and PE/EA/00977-6/2023).

Designing and Assessing the Efficacy of Protein Inhibitors of IscB Endonucleases

Heidi Hansch

Mentor: Dr. Mensur Dlakić (Department of Microbiology and Cell Biology)

Many bacteria and archaea possess Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) and CRISPR-associated (Cas) proteins, forming a CRISPR-Cas system that defends against viral infection. These microbes incorporate fragments of viral DNA as spacers between short DNA repeats, then transcribe these regions of alternating spacers and repeat units into guide RNA (gRNA) sequences that form complexes with Cas proteins. Upon subsequent viral attack, the gRNA sequences bind regions of complementary viral DNA, and the Cas proteins act as endonucleases, cleaving the DNA to curb the infection. The CRISPR-Cas system has been adapted into a gene editing technology, but viruses have evolved anti-CRISPR proteins to inhibit Cas proteins. There are many known anti-CRISPR proteins and they utilize different strategies to achieve the inhibition. However, no anti-CRISPR proteins have been described for the recently discovered group of transposon-encoded IS200/IS605 proteins known as IscB endonucleases, which are likely ancestors of the RNA-guided endonuclease Cas9. Our goal was to design artificial inhibitor proteins and assess their influence on the function of the IscB endonuclease.

Introduction

The CRISPR-Cas system is a defense mechanism commonly employed by bacteria to fend off viral invaders (1). Upon viral infection, CRISPR-Cas components integrate viral DNA fragments as spacers in their own genome. These regions of alternating spacers and CRISPR units are later transcribed into guide RNA (gRNA), which interacts with Cas proteins. If the same virus attempts to reinfect the bacterium, the gRNA guides the Cas proteins to the matching viral DNA, where the Cas proteins cut the DNA to stop the infection. Due to its capacity for precise gene modification, the CRISPR-Cas system has been implemented as a gene editing technology in medicine, agriculture, and biotechnology (2).

Whether in the context of bacterial immune defense or gene editing, Cas endonucleases are a crucial component of the CRISPR-Cas system (1). One Cas endonuclease, Cas9, can execute both target DNA recognition and cleavage. It was recently proposed that a subset of IS200/IS605 transposons are ancestors of Cas9 (3). These proteins act in association with non-coding RNAs (ncRNAs) known as ωRNA, which form hairpin regions that guide the cleavage of complementary DNA. One of these proteins, IscB, is capable of reprogrammable, ωRNA-guided endonuclease activity (4). The evolution of CRISPR-associated IscBs likely occurred as a series of independent events, including the potential emergence of CRISPR arrays from the duplication of ωRNA segments. Cas9 likely descends from one such evolutionary event. Indeed, in addition to their similarities in endonuclease activity, IscB and Cas9 display structural similarities: a comprehensive protein search has indicated the presence of two domains that are only found in both IscB and Cas9. While the use of Cas9 is more prevalent in bacterial immune defense, several bacteria have retained the use of ancestral IscB.

Many viruses have evolved anti-CRISPR proteins to inhibit Cas endonucleases. There are several known anti-CRISPR proteins for Cas9 and they utilize different strategies to achieve the inhibition (5). However, the family of IscB endonucleases has no known natural or synthetic anti-CRISPR proteins (4). This study aims to design artificial inhibitor proteins and assess their influence on the function of IscB. Thus far, one inhibitor protein has been successfully cloned and its interaction with IscB was tested.

This study involved inhibitor protein designs that target the bridge helix region of IscB. The bridge helix, a tightly wound, coiled structure stabilized by intramolecular hydrogen bonding, connects the two predominant regions of the endonuclease's polypeptide

chain (6,7). As seen in Figure 1A, the bridge helix, shown in yellow, is surrounded by a complex formed by DNA and complementary RNA, shown in orange and blue. Thus, if an inhibitor protein—shown in red in Figure 1B— binds to the bridge helix, this would presumably prevent the assembly of the adjacent DNA-RNA complex, and subsequently impede or hinder IscB function.

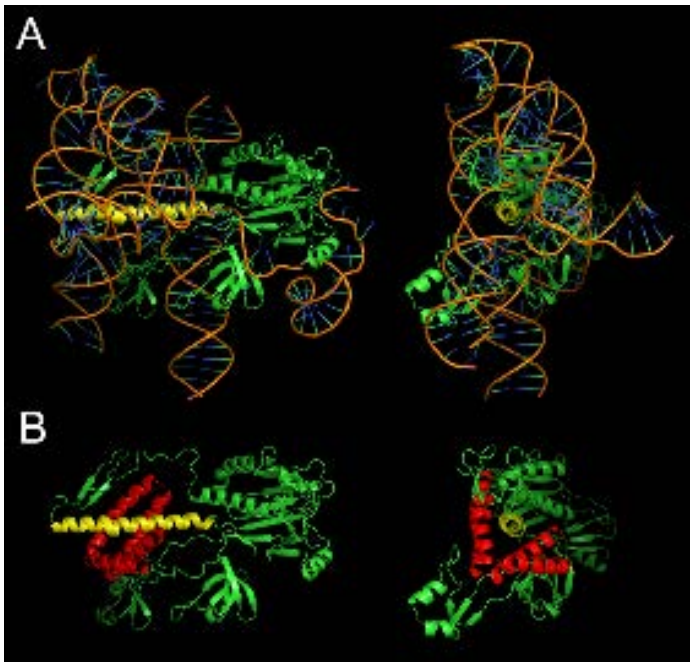

Figure 1. Panel A displays two perpendicular views of IscB (6), with the bridge helix shown in yellow, the DNA-RNA complex shown in orange, and the remainder of IscB shown in green. Panel B displays two perpendicular views of a designed inhibitor, shown in red, targeting the bridge helix of IscB, shown in yellow.

Methods

This study was completed in two stages: computational design of IscB inhibitors, followed by experimental testing of inhibitor efficacy. A total of six IscB inhibitors were tested, all of which were predicted to bind to the endonuclease's bridge helix.

The computational design of each inhibitor was performed using a novel three-step procedure (8). Firstly, a structure of IscB was used to define the site of inhibitor binding—the bridge helix. RFdiffusion generated a poly-glycine model for a potential inhibitor protein known as a scaffold structure (8). Secondly, to determine the potential inhibitor's amino acid sequence, the scaffold structure was passed through the ProteinMPNN computer program (9), which generated several compatible amino acid sequences. Thirdly, this group of chosen sequences was fed into the AlphaFold2 computer program, which predicted an inhibitor structure based on the amino acid sequence (10). This procedure was performed thousands of times, and the amino acid sequence with the closest match between the RFdiffusion scaffold and the AlphaFold2 inhibitor structural design was predicted to correspond to the most effective inhibitor.

Next, this amino acid sequence, augmented with a histidine tag for easy purification, was back-translated into its corresponding DNA sequence, and this sequence was optimized for expression in E. coli. Coding sequences for all inhibitors were synthesized using commercial sources. Designed synthetic DNA sequences were amplified by PCR. After, this gene was cloned into an expression vector, which was inserted into a BL21 strain of E. coli, enabling gene expression and subsequent inhibitor synthesis.

To test inhibitor efficacy via in vitro analysis, inhibitors were purified via a process involving tagging with six histidine residues. Next, inhibitor extracts were passed through a Ni-NTA column that binds His-tagged molecules; the tagged inhibitor binds the column with high affinity. After the application of a washing buffer, both proteins were eluted using high imidazole concentrations.

Results

After generating six inhibitor protein designs, the interaction surface areas and binding energies for each design were calculated (Table 1). Four of these inhibitors were sequence variants of the structural design shown in Figure 1. They were predicted to interact with IscB over a large surface area, and their binding energies were consistent with tightly bound protein complexes.

Binder name	Interaction area Å²	ΔG binding kcal/mol	Length AA
design6_n8	2441.8	-31.6	83
design6_n9	2504.5	-28.6	83
design6_n14	2555.6	-27.9	83
design6_n19	2513.2	-27.1	83
design52	2009.5	-20.1	100
design127	2214.8	-12.2	117

Table 1. This table displays the predicted interaction surface areas and free energies of binding for the six inhibitor designs. Large surface areas and low binding energies indicate a high likelihood of effective inhibition.

A brief animation showing the three-dimensional structure of one IscB inhibitor is available via the following QR code. The endonuclease is green, the RFdiffusion scaffold structure is red, and the AlphaFold2 structure based on the designed amino acid sequence is blue. The close overlap between the red and blue structures indicates that the protein was predicted to be an effective inhibitor.

After cloning all six inhibitor protein designs into expression vectors via recombination and insertion into E. coli, bacterial colony screening was performed. An agarose gel was used to confirm successful cloning.

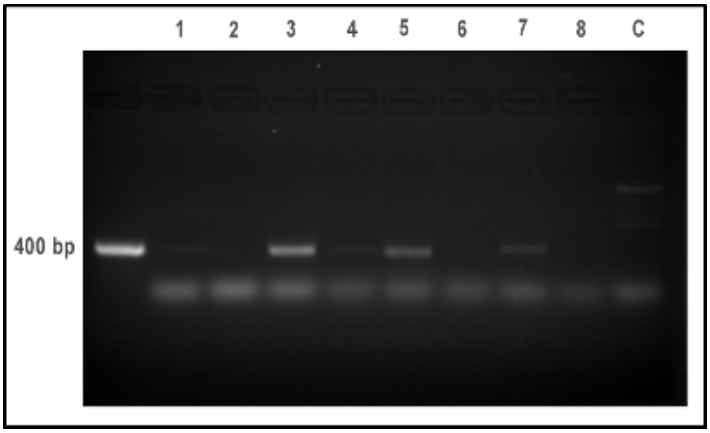

Figure 2. Bacterial colony screening gel. The gel included a 400 base pair marker (1); the six inhibitor proteins (2-8), each of which had an expected size of 400-420 base pairs; and a positive control (C) containing a faint band of an expected size of 2400 base pairs. Lanes 3, 5, and 7 yielded positive clones of 417 base pairs.

One successfully cloned inhibitor protein was named L2. Ni-NTA column chromatography was performed on L2 involving multiple fractions.

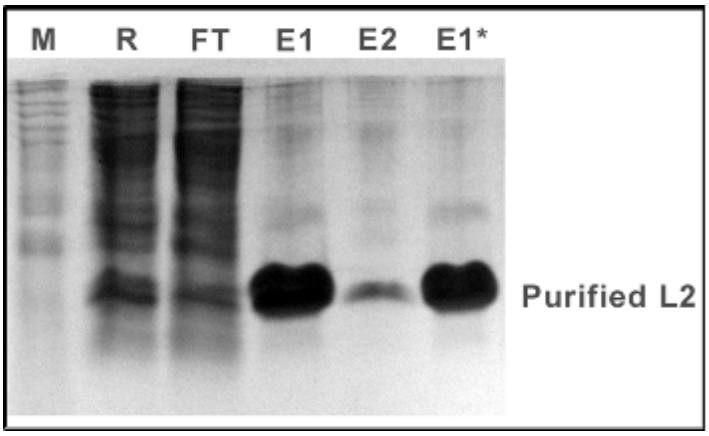

Figure 3. Purified L2 on SDS acrylamide gel. The gel included a marker sample (M), raw L2 extract (R), flow-through (FT), elution 1 (E1), and elution 2 (E2) fractions. In addition, Elution 1 was further concentrated (E1). The highly concentrated E1 and E1* bands had molecular weights of approximately 10 kDa.*

Ni-NTA chromatography was also performed on IscB.

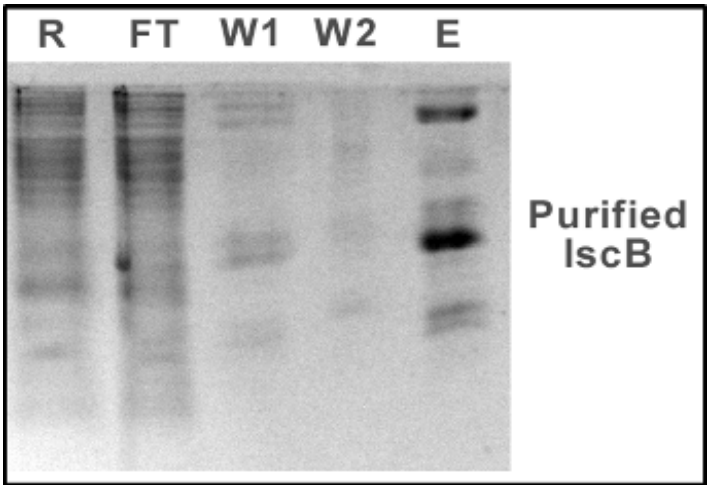

Figure 4. Purified IscB on SDS acrylamide gel. The gel included raw IscB extract (R), flow-through (FT), wash 1 (W1), wash 2 (W2), and elution (E) fractions. The labeled IscB band had a molecular weight of approximately 45 kDa.

Purified L2 and its target, IscB, were mixed and allowed to bind at room temperature. Protein binding was monitored using a native acrylamide gel. One lane contained L2, another contained IscB, and the remaining lanes maintained a constant L2 concentration with increasing IscB concentrations.

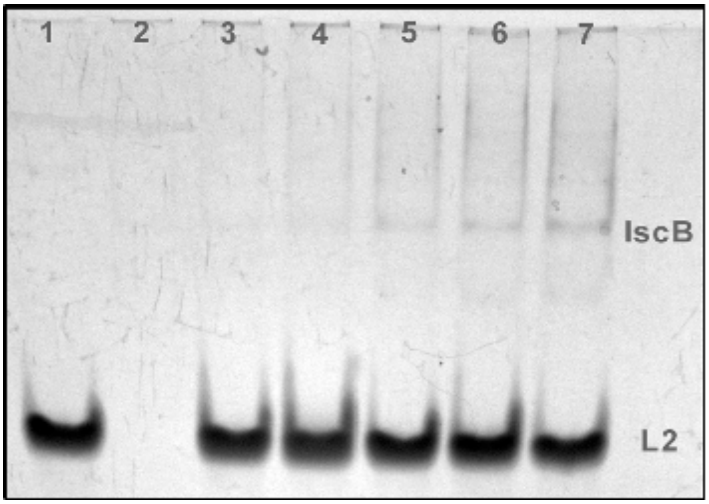

Figure 5. Binding native acrylamide gel. The gel included purified L2 alone (lane 1) and IscB alone (lane 2). In the remaining lanes, the concentration of L2 was kept constant at 200 ng. The concentration of IscB was increased from 10 to 50 ng by an extra 10 ng in each subsequent lane.

Conclusions

Of the six inhibitor protein designs from the computational stage, one inhibitor named L2 was successfully cloned. As shown in Figure 3, the L2 sample was adequately purified in conjunction with the purification of IscB, shown in Figure 4. However, the binding acrylamide gel in Figure 5 demonstrates no observed binding interaction between L2 and IscB. Despite an increase in the concentration of L2 in lanes 3 through 7, the absence of a conclusive extra band above the IscB bands fails to support the binding hypothesis. This negative result was not unexpected, since this experiment had a small sample size of six designs and this binding procedure has an overall success rate of 30-40%. Potential sources of error during the experiment include possible procedural flaws during the cloning, agarose gel, column chromatography, or acrylamide gel process. Additionally, the inhibitor protein designs may not have been sufficiently compatible with IscB in terms of interaction surface area and binding energy. Future research efforts will continue to explore inhibitor protein binding.

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About the Author

Heidi Hansch is a senior at Montana State University majoring in Applied Mathematics. She has conducted research in Dr. Mensur Dlakić's lab since January of 2023. After her graduation, Heidi plans to apply to medical school. In her free time, she enjoys playing the flute. with friends, cooking, and reading.

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Diving into the Depths of Paleontology

Rory Rossi
Mentor: Dr. John Scannella (Museum of the Rockies)

Rory Rossi has always been awed by the natural world and the history of this planet and has dreamed of being a paleontologist since he was very young. He came to Montana State University to pursue this lifelong passion. Rory is an undergraduate student in the Department of Earth Sciences, with a focus on paleontology. Under the guidance of his mentors, he is researching duck-billed dinosaurs at the Museum of the Rockies. Over the course of his undergraduate education he has been able to participate in research opportunities and international conferences, sharing his work with the larger paleontology community. He continues to overcome various challenges and believes in being open about his experiences in order to encourage and inspire future generations.

Paleontology, the study of ancient life, has always drawn me in—the pull of the past and the need to understand the Earth beneath my feet are irresistible. Imagining the life back in the ancient bones, the stories those fossils could tell is truly awe-inspiring. Prior to coming to Montana, I volunteered at the Morrison Natural History Museum in Colorado with Curator Matthew Mossbrucker, who took me under his wing and introduced me to the wonders of the ancient world.

My dream of studying ancient life and exploring how the Earth has changed over time is one of the main reasons I applied to Montana State University (MSU). Montana is known for its incredible fossil record and MSU is one of the best places in the world to study paleontology. I knew that Museum of the Rockies (MOR) was also part of MSU, and I was excited to see this museum that houses one of the largest collections of dinosaurs on the planet. I hoped I could become part of the exciting research going on there. When I arrived in Bozeman, I almost immediately began reaching out to the paleontologists at the museum, hoping that my initiative would help me find my way to a research project working with some of the incredible fossils that have been discovered in Montana.

I contacted everyone I could to inquire about possible volunteer opportunities at the museum. I eventually was able to start volunteering in the MOR Fossil Preparation Lab, where I worked to piece together dinosaur fossils so they would be ready for research and education. I hoped this would be the first step toward meeting and collaborating with the scientists I had read about before coming to Montana—people who were working at a museum I had dreamed about being a part of. One day while I was preparing dinosaur fossils in the preparation lab, I was able to meet the museum's Curator of Paleontology, John Scannella. I simply walked up to him and introduced myself. We shook hands, and a tattoo of a very controversial tyrannosaur specimen on my forearm caught his attention. "Is that the Cleveland skull?" he asked.

My tattoo of the tyrannosaur skull in the collections of the Cleveland Museum of Natural History—which, depending on who you talk to, is either a juvenile Tyrannosaurus rex or its own species, Nanotyrannus lancensis—has special meaning to me. Matt, the Morrison curator, has a T. rex skull tattoo on his left forearm. In a sort of homage to my mentor, I got the controversial Cleveland skull tattooed on my right. No matter what it is, it's a tribute to someone who took a chance on me and my dream of being a paleontologist.

At that moment, when John asked such a simple question, my heart dropped. In the past, research conducted at the museum had favored the hypothesis that the Cleveland skull was a juvenile T. rex. Matt and I, however, thought it might be a separate species. I thought "He's never going to let me work here." But I responded that my tattoo was indeed the Cleveland skull. Instead of telling me to leave the lab, John set a time to meet and discuss what exactly I wanted to research.

Coming into the Museum of the Rockies after having volunteered at another museum, one that often disagreed with some of the studies done by MOR, was odd. I worried about navigating the various disagreements and about how exactly to approach being a

researcher. I had never done research before, and I didn't even know what I wanted to study. Matt always reminded me, "Generalists survive, specialists go extinct" when I proposed possible research subjects. With so many different groups of dinosaurs, their evolutionary history, and extinction, it all felt overwhelming.

Some of my classmates at MSU could name almost every dinosaur and their characteristics. There were more dinosaurs and anatomical terms than I even thought possible. I worried that my skills were lacking. What was I supposed to know? I felt lost in a sea of information and had no idea where the shore was. Was I lagging behind my peers? Could I simply not break through into a new field?

My first meeting with John primarily focused on Nanotyrannus. Despite having this controversial animal tattooed on my arm I do not want to study tyrannosaurs. They are awesome, don't get me wrong, but I wanted to investigate something overlooked. I didn't want to focus on something that felt like it would draw the attention of many. I wanted to understand the ecology of the past, something that could bring deeper insight into new aspects of paleontology.

I told John I wanted to look at the larger picture. If possible, I wanted to have a good overall understanding of Dinosauria as a whole. I didn't want to pigeonhole myself into only studying one thing forever.

I was a little disappointed at first when John first showed me his idea for my research project. He opened a drawer filled with an array of tan-colored bones. All we really knew about the specimen in the drawer was it was from a marine deposit. It appeared to be some kind of hadrosaur, or duck-billed dinosaur. I knew almost nothing about hadrosaurs. I had seen hadrosaur teeth while in the field, but nothing else. The fact that this specimen had no skull only added to my dismay. This would be hard. How do you even write a description of something with random bones? I had never even taken an anatomy class. Suddenly I was in over my head.

I spent those first weeks drawing, measuring, familiarizing myself with the fossils, and attempting to figure out what my next steps were. How do I progress, how do I move to the next level? I spent hours examining the hadrosaur bones, exploring how I might be able to identify what kind of duck-billed dinosaur this was. Fueled by my dream of contributing something to paleontology, I asked many questions. I wanted to understand every aspect of the museum and every part of this field. I wanted this research project to be the foundation for my future career.

I saw my peers seemingly knowing exactly what to do. Their deep knowledge of the subjects they were passionate about made me worry. I felt behind my peers again. I entrusted Eric Metz, the MOR Paleontology Collections Manager-Registrar, with those worries. He sat down, as tears welled up in my eyes, and reminded me that it didn't matter if my knowledge wasn't encyclopedic yet. I was putting in the time to learn and to grow. He reminded me that if I was in the MSU paleo program, it meant I could succeed. I had goals and determination; I wanted to thrive in paleontology. I just needed to remember I couldn't know everything.

Although I still wished there were step by step instructions, a way for me to learn everything all at once, research follows its own path. Sometimes it will lead you down surprising roads where you learn things you'd never even thought of.

By studying scientific literature and making comparisons with other specimens in the MOR collections, I discovered that the subject of my research, MOR 1121, is a saurolophine hadrosaur. This group of duck-billed dinosaurs typically lacked the elaborate cranial crests found in other hadrosaurs. Maiasaura, Montana's state fossil, is a good example of a saurolophine hadrosaur. Large, powerful, and resilient creatures, hadrosaurs were among the most common herbivorous dinosaurs throughout the Late Cretaceous. Despite not being a rare type of dinosaur, MOR 1121 is special, at least to me.

Working with long-extinct animals for hours at a time in a basement with no windows only helps make a specimen more special. I grew to care deeply about this dinosaur. As I studied MOR 1121, I began to realize that instead of one animal, the bones seemed to represent at least two individuals. If true, this would be a rare, if not unique, occurrence in the marine rocks of Montana.

Time is such a hard thing for humans to process. Our

lives are short, especially when put against the eons that occurred before us. I started picturing the two dinosaurs swept out to sea, one a subadult and the other a larger adult. I wondered if they knew each other in life, if they were aware of each other in their final moments. I wondered what brought them together, in such a way that they would forever be preserved together through millions of years.

The thing about research is that life doesn't stop happening around it. As much as I wish I could put my life on pause, I can't. A few months into my hadrosaur research, I was diagnosed with fibromyalgia, an understudied medical condition little is known about. On top of that, I have issues with my joints and my back, along with chronic fatigue and brain fog. Still, I kept researching, reading papers in my free time, and reviewing my photos and drawings. I wanted to piece together this mystery. I felt connected, connected to the past. It often makes me wonder about all the things that had to go right or wrong, for me to be sitting there, holding a specimen that is close to 81 million years old. I think of all the moments that led me here and it leaves me speechless.

I presented some of my initial findings at the MSU Earth Sciences Student Colloquium and received positive and helpful feedback from my peers. Working with John and MOR's former Curator of Paleontology, Jack Horner, I submitted an abstract on my hadrosaur research for the 2024 meeting of the Society of Vertebrate Paleontology (SVP) in Minneapolis. I felt honored when I was fully funded by Vocational Rehabilitation, a Federal Program dedicated to helping disabled individuals, to attend the SVP conference and present my research. My work, my effort, and my dedication had come to fruition. I was attending a conference I had spent years dreaming of, and I would get to share MOR 1121's story.

I felt so seen when I arrived at SVP and saw so many different people. I saw other queer paleontologists, I saw other disabled paleontologists, and I met paleontologists I had dreamed of one day meeting. The most amazing part was that I felt like this was the start of something new. I felt my confidence in myself was restored. People agreed my work was good; and there were no arguments against my results. I felt reassured. This pathway was for me.

At times, I still feel ashamed when I use my crutches and have to rely on others for help. I feel I must prove myself—that I can do all the things that my able-bodied peers can. However, there are times my body simply will not cooperate. At SVP, I had another paleontologist tell me, "I thought about bringing my cane, but I was worried about what people would think." She thanked me for giving her confidence to use her cane more often. Since I use mobility aids in different ways every day, I felt proud I could inspire someone else who needs theirs to feel less ashamed. No one can ever be certain they will not end up with a disability. It can be hard to overcome the societal perceptions of what it means to have a disability.

Part of why I am so open about these parts of my life is because I believe in being the representation that I needed as a kid and the representation that I need now. Representation in the sciences is important, because without it, many may feel discouraged to even try as I have. Being transgender in a STEM field is difficult, especially when women are just beginning to break the barriers of science. I knew that to get opportunities in my dream field, I needed to be proactive. I knew I needed to work hard to break barriers and to clear the pathway to something that had for so many years felt out of reach. I had spent years wondering if I could even "make it" in the field.

The conference opened my eyes, it reminded me I do have a place in research and in paleontology. I gained new insight into worlds I didn't even know were possible. I saw a potential future; one I had been so unsure of. I have often wondered how my disability will affect my career as a paleontologist. It is something I worry about —I often think about how my body deteriorating at such a young age, on top of being transgender, might limit my options. This is something that drives me to work harder and to be noticed, because I love this field. I love paleontology. I find ways to participate that don't leave my body screaming, and I find ways I can manage my pain. Research lets me do that while also opening doors to future opportunities for me.

I may still be wading through uncertainties, unsure of what my next steps are and how to proceed, but that is part of what research is. It is trial and error. It is going down rabbit holes to answer interesting questions, even if they are not directly related to the project at hand, because they may lead to new questions and new

ways of seeing the world. I wonder where my research will take me. What I can do as a disabled, trans paleontologist is encourage others to pursue science. This changing world scares me, but it does not dissuade me from my passion. It doesn't ever make me feel like I should quit paleontology. If anything, it makes me more determined to be open about this part of me, especially within my scientific community. Without people in science being their honest selves, there cannot be progress. To conform to what is expected is not the way to true scientific innovation. It does not lead to breakthroughs. Science will persist. The world is changing, which means adaptation and perseverance, but it also means finding joy. I have found joy in being transgender, which is a long process , to unlearn hate and fear. I have found joy in my research, my family, my friends, and my ferrets. For me, research has been a chance to change the world and to change people's perceptions of what it means to be transgender.

To me, research is curiosity in its rawest form. There is nothing like discovery. Throughout all the life events, my disability, my identity, these questions still need answering. These questions pull me into a different world. I think of the hadrosaurs, what stories they still might be able to share with me. I think of what those bones might whisper to me—those echoes of a world that existed 81 million years ago—and I am excited for what I may discover in the future.

About the Author

Rory Rossi is a second-year student at Montana State University majoring in Earth Sciences with a concentration in Paleontology, and a minor in Museum Studies. Rory has worked with Dr. John Scannella at Museum of the Rockies since the Fall of 2023. Rory moved to Bozeman to pursue a lifelong dream of being a paleontologist. In his free time Rory loves to knit, spend time with their ferrets and their husband, as well as paint and swim. They hope to continue their studies in graduate school and continue to advocate for disabled and transgender students.

SASHA MAGUIRE

Hey, I'm Sasha!

I'm a Graphic Design student at Montana State University, originally from Maine. I am passionate about creating design that communicates clearly and evokes emotion. This semester, I launched *Women Who Design*, a project aimed at amplifying voices and celebrating design. Through interviews, visual storytelling, and curated work samples, I'm showcasing the stories, challenges, and successes of women designers in Bozeman.

Women Who Design is more than just a collection of stories; it's about fostering recognition, promoting inclusivity, and encouraging future generations of women designers. Why should you care? Because the impact of women in design is often overlooked, and these stories deserve to be heard. My research is shedding light on their contributions, challenging the status quo, and advocating for equity in the design world.

THE GOAL

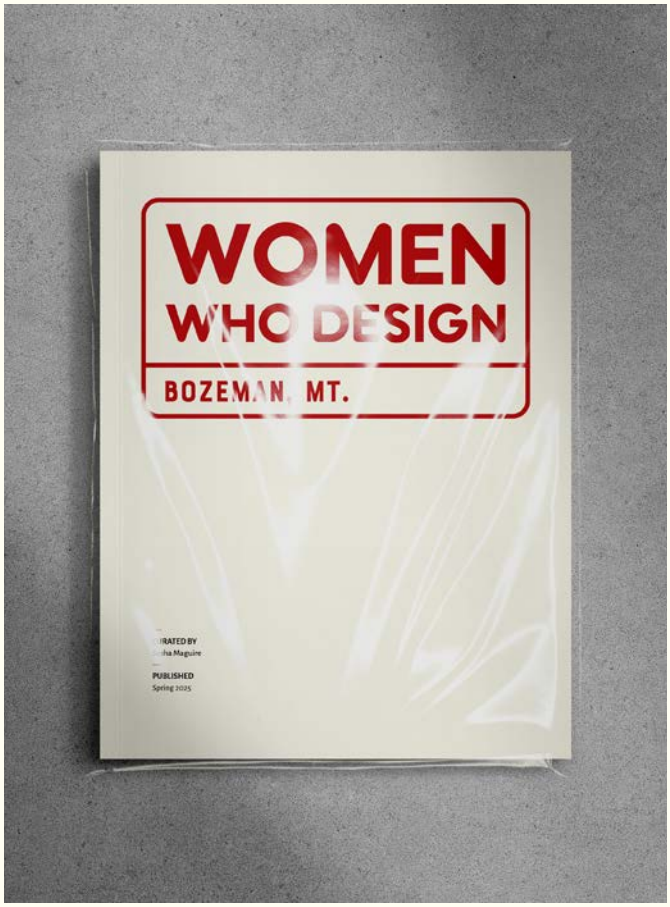
WOMEN WHO DESIGN

BOZEMAN, MT.

To see the full series of published photos please see Scholarworks

Women Who Design is a research project dedicated to amplifying the stories, challenges, and achievements of women designers in Bozeman. Through interviews, visual storytelling, and curated work samples, this project highlights their creative processes and showcases the unique contributions of local designers, shedding light on their impact within both the industry and the broader community.

By documenting and sharing these stories, *Women Who Design* seeks to foster greater recognition and appreciation for women in the design field while creating a lasting resource for aspiring designers. This project celebrates the individuals featured and contributes to a broader conversation about equity, representation, and inclusivity in design.



AMPLIFYING VOICES. CELEBRATING DESIGN.

Stacy and Sasha in a hallway outside her shop

"MY POINT OF VIEW ON DESIGN IS THAT THAT IT'S A TOOL TO HELP. I WANT TO SUPPORT THE NONPROFITS AND SMALL BUSINESSES IN THIS TOWN — IT'S JUST WHAT'S IN MY TOOL BELT TO HELP THEM GROW AND BE SUCCESSFUL."

EXCERPT FROM INTERVIEW WITH STACY TOWNSEND

Space Drifters

Zoe Johnson

"Space Drifters" is a poem that describes two beings wandering the galaxy together, possibly after a catastrophic event destroyed their planet. Space is lonely, but these entities hold on to each other, spiraling together like the double helix of DNA. Rather than succumbing to the darkness, the beings find beauty in their drifting. The imagery attempts to capture the glory of the universe—stars, planets, swirling masses of color. Ultimately, the universe is not uncaring. It guides the couple, illuminating the path to new beginnings. Together, the space

We took what we could
from the errant stars,
and fashioned a way of living,
a sort of subsistence on spacedust.

And like universal urchins,
we traverse these mobile masses,
thickening swaths of darkness
split by our ultraviolet madness—

you, the blue glow of your eyes,
the billow of an atmospheric dress,

and I, my solar soul
iridescent and orange—

breaching the gravitational fields of broken worlds.
Weeping when celestial bodies brighten for us.
Just us, as we navigate the galaxy.
Blinking, flickering, going dark.

Knowing we, too, will one day plummet,
accelerate toward a baby planet,
split the rock in two. Merge, expand,
pulling hapless remnants into us.

But when we plunge, we'll cling together,
and the stars will light the way:
the brilliance of the spotlight,
the setting of a stage.

About the Author

Zoe Johnson is a senior pursuing dual degrees in Writing and Cell Biology and Neuroscience, with a French minor. She has been a Writing Center tutor since 2022. Zoe was born and raised in Bozeman, and enjoys reading, drawing, and watching black and white movies. After graduating in May 2025, she plans to focus on writing stories and poetry.

A Spatial Analysis of the Association Between Abandoned Hard-Rock Mining Locations, Granite Bedrock Stratigraphy, and Contaminated Streams

Wesley Cousin

This investigation examines spatial correlations between hard-rock mining, granitic bedrock stratigraphy, and stream contamination across three HUC8 sub-watersheds in central Montana. Using GIS methodologies and datasets from MBMG, DEQ, and USGS, I analyzed the geospatial relationships between abandoned mining sites and contaminated waterways, focusing on lead contamination. The analysis incorporated hydrologic mapping, elevation analysis, and strategic overlays of geological formations with mining sites. Results revealed that of 1,258 abandoned mines, 60.7% are situated within granitic formations. The study identified streams with lead concentrations exceeding the EPA's 15 µg/L threshold, with 512 mining sites located within 0.6 miles of contaminated streams—a significant distance for potential contamination through runoff and acid-mine drainage. Five predominant metal contaminants were identified: lead, copper, aluminum, iron, and arsenic. While spatial analysis alone cannot establish causation, findings demonstrate an intriguing association between mining in granitic terrains and lead contamination in nearby fluvial systems. This research contributes to understanding mining impacts on watersheds and provides insights for remediation strategies. Future research could explore specific mechanisms between mining activities and pathways of contamination.

This project became an educational endeavor after I incorporated the bedrock layer from the Montana Bureau of Mines and Geology (MBMG) database. Once I inserted the layer into the map and corrected the symbology, an intriguing spatial relationship between hydrologic topology, granite bedrock, hard-rock mining locations and stream contamination with multiple analytes, especially that of lead (Pb) was noticeable. During this analysis, my research questioned changed from "Is there a spatial association between mining and stream contamination" to "Is there a geographic association between abandoned hard-rock mining, granite bedrock (possible granite mining), and its proximity to contaminated streams? Could granite mining be causing the most contamination of streams within this watershed boundary and if so, is lead (Pb) the leading contaminant caused by mining within granite bedrock areas?" However, we cannot define causation from this analysis alone.

The first map in the layout includes the slope-line elevation layer, the hydrologic topology raster layer and the contaminated streams within the watershed boundary. The defined area for the watershed boundary includes 3 HUC8 sub-watersheds in Montana from the USGS database: The Upper Missouri, the Boulder, and the Jefferson sub-watersheds. The hydrologic topology raster layer and the slope-line layer both came from the MBMG database, and the contaminated streams layer is from the DEQ.

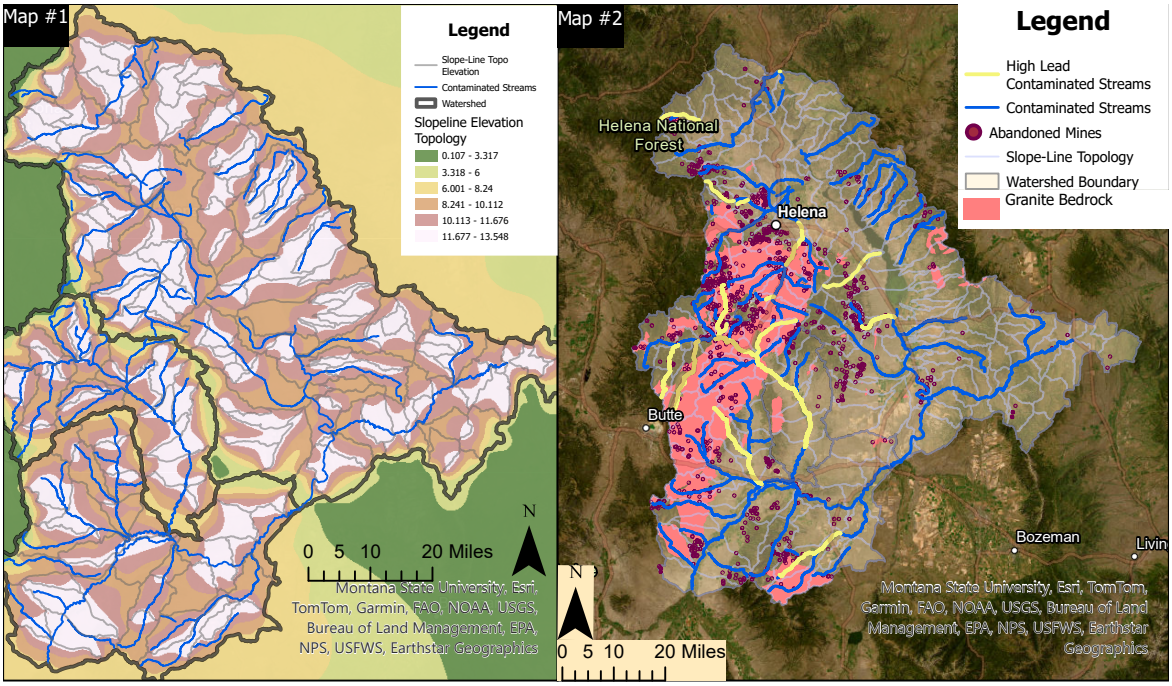
The second map includes the merged collection of watersheds, the abandoned hard rock mining layer (DEQ), the slope-line elevation, the contaminated streams, high lead contaminated streams, and introduces the granite bedrock layer (MBMG) in pink. This map provides a look at the geographic association between the mines that are in relation to the contaminated streams, mines to streams where lead is the top contaminant, and the mines and contaminated streams as they relate spatially to granite bedrock stratigraphy. From this part of the spatial analysis, we can begin to identify a spatial relationship between mining, granite bedrock, and the contaminated streams within these high-volume mining areas. This watershed selection has 5 leading metal contaminants including lead, copper, aluminum, iron and arsenic. I included a bar chart that shows how many contaminated streams have these metals as a leading contaminant that is over each metal's EPA standard. The contaminated streams layer

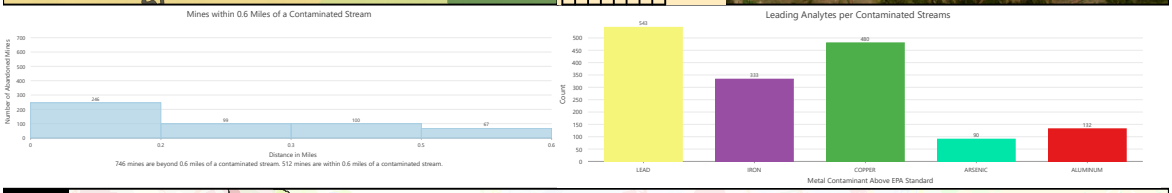
The third and conclusive map in this layout shows the bedrock stratigraphy layer within and surrounding the watershed area, the number of abandoned hard-rock mines in relation to granite bedrock, the slope-line layer, and the streams that have lead (Pb) as their highest contaminant. I chose to not include the other bedrock layers in my analysis because they do not show a spatial relationship to abandoned hard-rock mining and there is a noticeable spatial association to granite bedrock, hard-rock mining, and high lead contamination. I also included a context map which shows the study area, i.e., watershed. My vector analysis was performed by calculating the number of mines within granite. I also calculated the distance of mines to streams. Hard-rock mining can produce many types of metal contamination in streams due to unwanted metals that are discarded and often lead to runoff and similar phenomenon of seepage through the ground into groundwater systems.

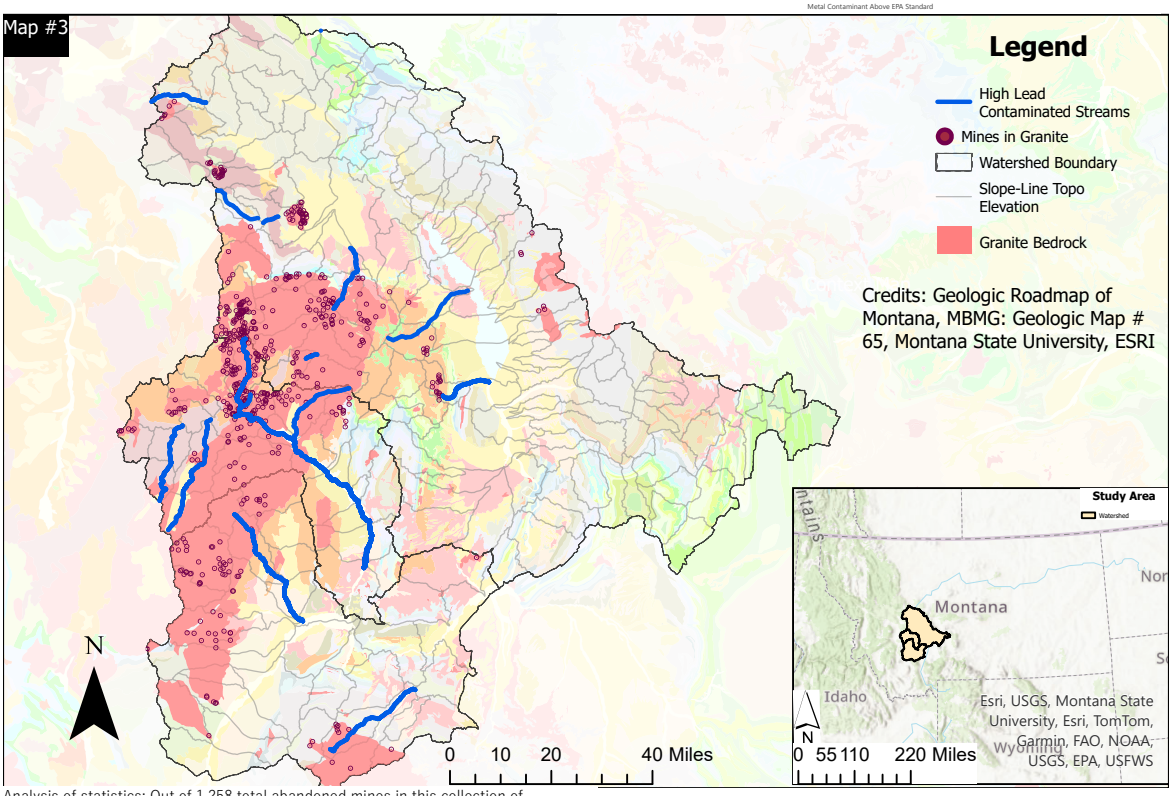
I included one bar graph, a histogram, and a pie chart. The bar graph shows the number of streams that show contamination levels above the EPA standard for each analyte. The histogram shows how many mines are within 0.6 miles of a contaminated stream (0.6 miles is a distance set to show plausibility between mining operations, mining runoff, acid-mine drainage, and contamination in streams). The total number of mines within 0.6 miles of a contaminated stream is 512. The pie chart shows the percent of contaminated streams that contain one or more of the 5 metal analytes above and below the calculated EPA standard of 1.0 µg/L. 60.0% are above 1.0 µg/L and 40.0% are below 1.0 µg/L. Aluminum and iron do not have primary health benchmarks and are classified as nuisance contaminants that effect taste as well as watercolor, but are subject to the secondary maximum contaminant levels (SMCL's) which are; aluminum at 50-200 µg/L and 300 µg/L for iron. The contaminated streams layer includes the EPA standard of 1.0 µg/L, which is calculated for each contaminant by using the health standard for each analyte and its hazard quotient. The health standards for each analyte vary, which represents whether a stream that is contaminated is fit for lifetime consumption of drinking water. The health benchmarks for lead (Pb) and arsenic (As) are 0.1µg/L. For copper is it 1300 µg/L. The DEQ for data stream contamination was calculated using the health standards and public drinking water standards for each analyte. This is calculated
by dividing the health benchmark of a contaminant by the hazard quotient of 0.5 µg/L. If the concentration of a contaminant exceeds the standard, it is unsafe for lifetime consumption, and that ratio will be > 1.0 µg/L. "Note that one could alternatively apply the EPA public drinking water supply treatment standard for the Maximum Contaminant Level Goal (MCLG) for lead (15 µg/L), the MCLG for arsenic (10 µg/L) and the Maximum Contaminant Level (MCL) for copper (1300 µg/L)." However, this study was calculated using the health standards and not the public drinking water standards. These health standards can be found within the DEQ or USGS database. The Federal Clean Water Act and the Safe Drinking Water Act oversee these standards where each U.S state, such as Montana, must follow these regulations. The high lead contaminated stream layer shows the streams that use the ratio for the health benchmark hazard quotient that indicates whether a contaminant is above the EPA standard. The contaminated streams layer in the first two maps show the health benchmark/hazard quotient for contaminants in streams above and below the EPA standard which is illustrated in the bar chart. These data for contaminated streams were collected from the MTDEQ database.

About the Author

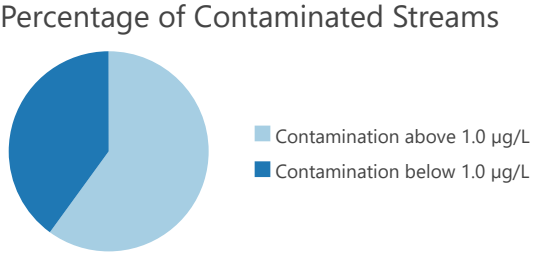
Wesley Cousin is a senior Microbiology major with a concentration in Environmental Health with a minor in Global Health. Since transferring to MSU in 2021, he has done well in research concerning water quality and human health. In 2024 he was accepted to present his water quality research in Long Beach at the National Conference of Undergraduate Research. Wesley has focused on research at MSU and hopes to persue further education after graduation, with plans to attend law school and become an Environmental Lawyer.







Analysis of statistics: Out of 1,258 total abandoned mines in this collection of watersheds in west-central Montana, there are 763 that are located within the granite bedrock layer. Out of 266 contaminated streams within this watershed there are 68 lead contaminated streams (16 rivers). I converted the distance from mines to contaminated streams by setting the meters to miles (1609.34 M = 1 mile). In the histogram above you can see the number of mines within 0.6 miles of a contaminated stream. There are 746 mines outside of the 0.6 mile radius. Within this distance mines are more likely to be associated with contamination of streams due to acid-mine drainage and runoff. This analysis attempts to show the spatial distribution of contaminated rivers to abandoned mines and granite bedrock. The abandoned mining layer does not include what type of ore they are mining for. All the mines are listed as hard-rock. With the granite layer we can begin to assume that the majority of the mines within the granite layer are mining for granite. This analysis can be useful when there is a need for a spatial relationships between mining and stream contamination to be seen. There is a lot more analysis that can be done using this data, but this investigation is based on spatial correlations.



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Sleep Neruobiology and Mental Health: A Brief Review

Emma Howard
Mentor: Dr. Cara Palmer (Department of Psychology)

This review examines the neurobiology of rapid eye movement sleep and non-rapid eye movement sleep as it relates to mental health. The review aims to highlight the importance of sleep health in treating mental illness and discusses how sleep stages broadly impact mood, emotion, and memory. Materials were gathered throughout the sourcing of various research in the MSU Sleep and Development Lab. Results indicate a great level of complexity between the frequency and duration of brainwaves in the sleep-wake cycle. The neurobiology also suggests the need for a larger emphasis on sleep as a potential avenue for understanding and treating a variety of mental health conditions.

Decades of research have demonstrated that sleep is essential to learning, memory consolidation, and behavioral outcomes (Anwer et al., 2019). Sleep problems have also been identified as a major contributing factor to mental health difficulties, such as depression and anxiety (Ioannou et al., 2020). While the literature most commonly examines sleep behaviors such as sleep duration and subjective sleep quality, neurobiological activity during sleep is not uniform across the night. In addition, the type of sleep obtained may vary between individuals and on a nightly basis (Ong, Lo, Gooley, & Chee, 2016). Understanding the complexity of sleep neurobiology and how it relates to mental health introduces the potential for targeted sleep treatments to accompany mental health diagnoses. This brief review will identify several sleep characteristics that have been linked with mental health in prior research.

Neurobiology

Neural activity is commonly observed via the electrical impulses that are transmitted between neurons and used for cell-to-cell communication. Electrochemical gradients across neuron membranes are created when chemical messages sent between cells open channels to change sodium and potassium gradients. Changes in charge across the cell membrane generate action potentials that give neurons the property of conductivity, allowing signals to transmit across the brain and body. Rhythmic fluctuations of voltage across the brain called brain waves are classified by frequency and denoted by the Greek letters a, b, q, d, and g. When measuring brain waves, electrodes are placed on specific locations of the scalp to record the electrical impulses occurring in the brain.

An Overview of Neural Activity during Sleep

Electroencephalography (EEG), facial electromyography (fEMG), and electrooculography (EOG) are methods of observation that are commonly used in sleep studies to track sleep neurobiology. Measurements of electrical impulses in the brain are recorded and then classified into different sleep stages. Sleep is composed of two primary types: Non Rapid Eye Movement (NREM) sleep, and Rapid Eye Movement (REM) sleep. NREM is further broken into three stages, NREM stage 1 (N1), NREM stage 2 (N2), and NREM stage 3 (N3). We cycle through these stages each night, with the majority of N3 sleep primarily occurring during the first half of the night, and REM primarily dominating the second half of the night.

During the transition between wakefulness and sleep, b-waves resting at a frequency between 16- 32 Hz begin to slow and become a-waves (8-13 Hz). This decrease in neuroelectric frequency is associated with the experience of relaxation and sleepiness prior to entering N1. Once the body enters N1, another drop in frequency is observed between 4-8 Hz. N2 sleep is comprised of theta waves, and includes unique defining wave architectures - sleep spindles and K-complexes. Sleep spindles are short bursts of electrical activity between 12-14 Hz, and have been theorized to contribute to neural plasticity and learning, while K-complexes are high-amplitude slow waves that may suppress cortical arousal and may contribute to memory consolidation. From there, electrical frequency decreases again to what is classified as N3, which is also known as slow wave sleep (<1 Hz oscillations) and d-waves (1-4 Hz), which is the deepest and most physiologically restorative sleep stage.

Comparatively, REM sleep accounts for roughly a quarter of a typical sleep time and displays EEG patterns more similar to wakefulness. Brain waves in REM sleep are composed of low amplitudes and include faster rhythms correlating with an increase in cortical activity. REM sleep is also accompanied by ocular saccades and muscle atonia. REM sleep is when most dreaming activity occurs.

The regulation and maintenance of the sleep cycle is heavily dependent upon neuromodulatory milieu. Some of the largest neuro-orchestrators include the lateral hypothalamus, basal forebrain, and the ventral tegmental area. Within each of these regions, collections of dopamine, GABA, and acetylcholine neurons are responsible for the activation and suppression of wakefulness (Gottesmann, 2002) . Accompanying these regions, chemogenic and optogenetic regulation occur via extensions of neuromodulators in the dorsal raphe nucleus, parabrachial nucleus, and locus coeruleus, as well as complexly integrated neural tracts of the thalamus. The parabrachial nucleus, for example, is a node responsible for relaying visceral sensory information such as temperature, pain, and touch. Chemogenic inhibition or legion of this area will result in a coma- like state and suppress wakefulness (Sulaman, Wang, Tyan, & Eban-Rothschild, 2023) . Molecularly, specific neuro-orchestrating regions and neuromodulators contribute to the physiological conditions experienced during the sleep cycle.

REM Sleep

Some theories posit that dreaming plays a role in memory consolidation and emotional regulation, thus highlighting REM sleep as a potential target in treating mental illness (Maquet et al., 2000). For example, the sleep architecture of depressed individuals consists of a shorter REM latency, the time it takes to fall asleep or enter a specific sleep stage (Gottlieb, Goel, Chen, & Young, 2020) and a distinct increase in theta frequency bands in REM sleep (Steiger & Pawlowski, 2019). REM sleep density-the frequency of eye movements observed while sleeping- has also shown to be a factor in post-traumatic stress disorder (PTSD) causing a greater risk for hypersomnolence and lower thresholds for stress (Mellman, Bustamante, Fins, Pigeon, & Nolan, 2002). The sleep to remember, sleep to forget hypothesis (Walker & van der Helm, 2009). states that during REM sleep, there is an increase in cholinergic activity and hippocampal activity, resulting in memory recollection and consolidation. At the same time, activity of aminergic systems is inhibited or greatly reduced, resulting in suppressed norepinephrine. This can result in sleep-dependent emotional memory consolidation, where memories are preserved, but the emotional tone associated with the memory is blunted.

NREM Sleep

NREM sleep disturbances have also been hypothesized to impact the restorative properties of N1 and N2 when cortical abnormalities are observed (Germain, Nofzinger, Kupfer, & Buysse, 2004). For example, decreases in glucose metabolism differing between healthy individuals and depressed individuals has shown to support the overarousal hypothesis for depression, and therefore sleep deprivation, as an accompanying treatment to antidepressants (van den Burg, 1975). Similarly, brain activity of arousal-targeted regions such as the locus coeruleus and raphe nuclei as well as increases in blood flow and metabolism in the mesophilic brainstem, thalamus, and basal forebrain are abnormal and often characterizes sleep of a depressed individual. Further, disturbances to bistable pattern of slow-wave oscillations and d-waves have been shown to contribute to a variety of mental health disorders (Aquino et al., 2024). Slow-wave sleep not only plays a role in endocrine regulation and physical health, but also is credited with homeostatic mechanisms of neuroplasticity and regulation of glymphatic flow. Delta activity has also been observed to reflect neural synchrony to regions of the prefrontal cortex (Scholes, Santisteban, Zhang, Bertone, & Gruber, 2020), suggesting greater significance between behavioral regulation, mood-based disorders, and sleep neurobiology.

Summary

In addition to the potential decrease of emotional regulation as a result of inhibited or impaired REM sleep, disturbances to NREM sleep, the frequency of micro-arousals, and successful regulation of neuromodulators all play a much larger role in sleep health than previously understood. Thus, complexity of the sleep-wake relationship and its impact on symptomatic consequences in mental health diagnosis require much greater emphasis and attention.

About the Author

Emma Howard is a junior at Montana State studying Cell Biology and Neuroscience with a concentration in Biomedical Science and a minor in Biochemistry. She joined the MSU Sleep and Development Lab in Fall 2023 under Dr. Cara Palmer aiding in sleep and social behavioral studies before beginning to investigate the neuroscience of sleep and its applications to mental health. Originally from Colorado Springs, Emma moved to Bozeman in Fall 2022 and has since enjoyed hiking and camping under the big sky. She hopes to attend medical school shortly after graduating where she will continue to investigate applications of
Neuroscience.

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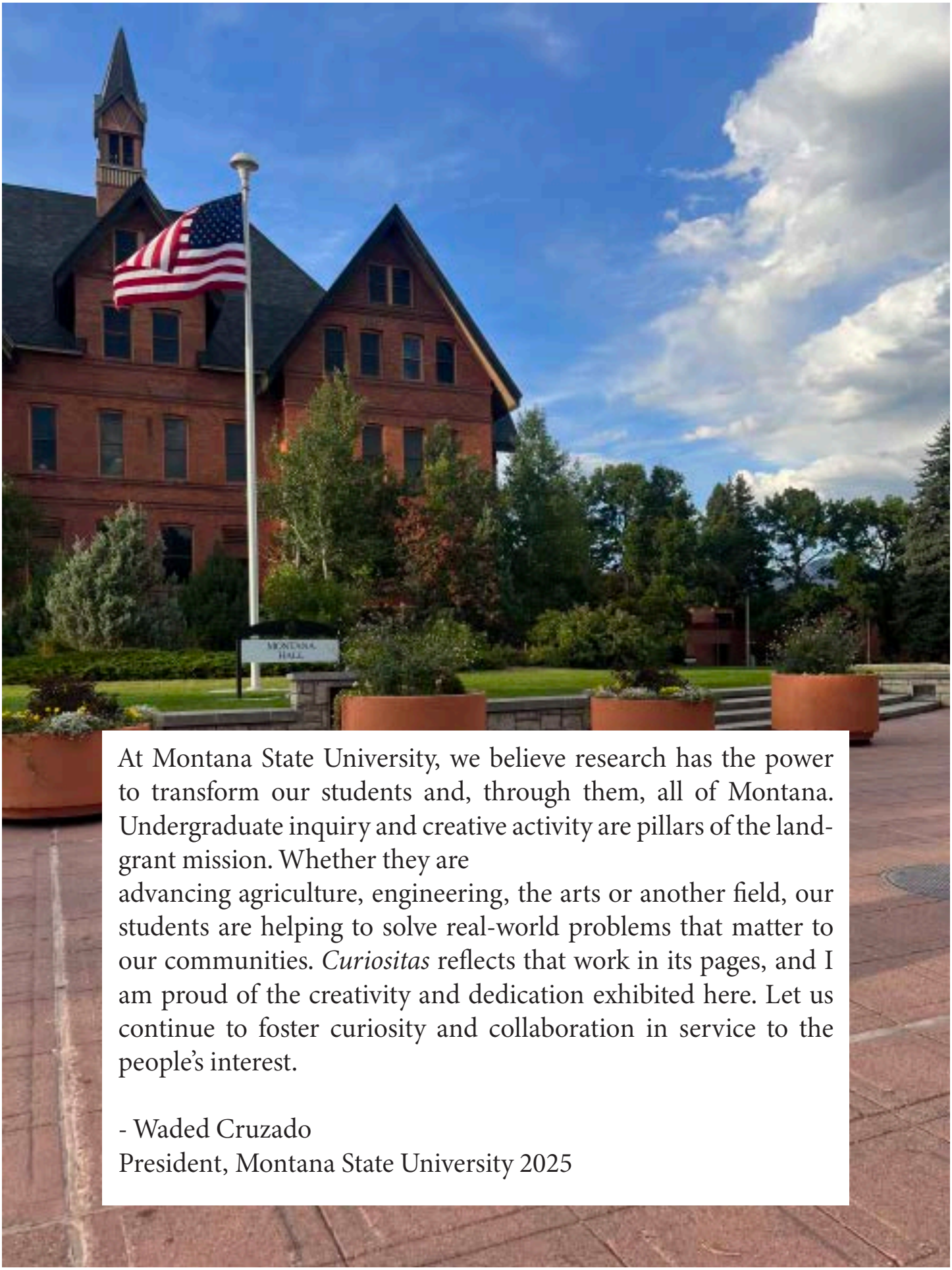

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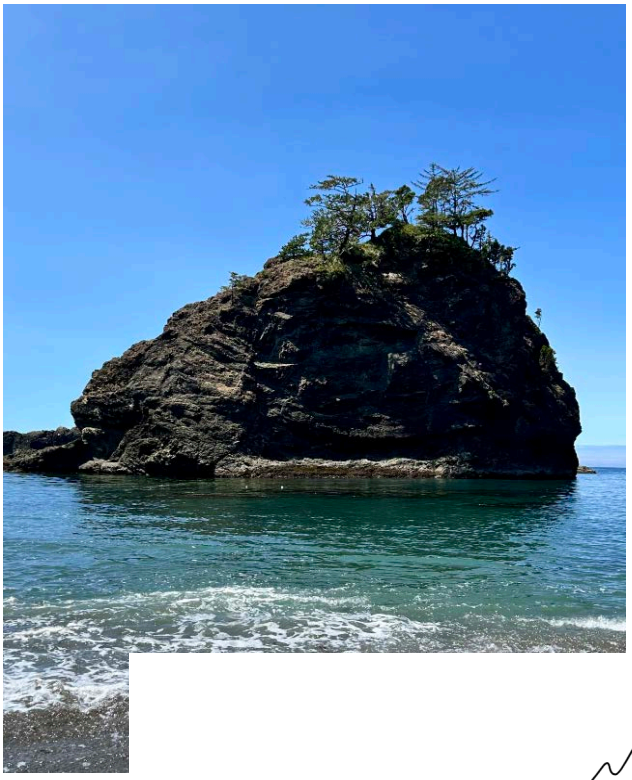

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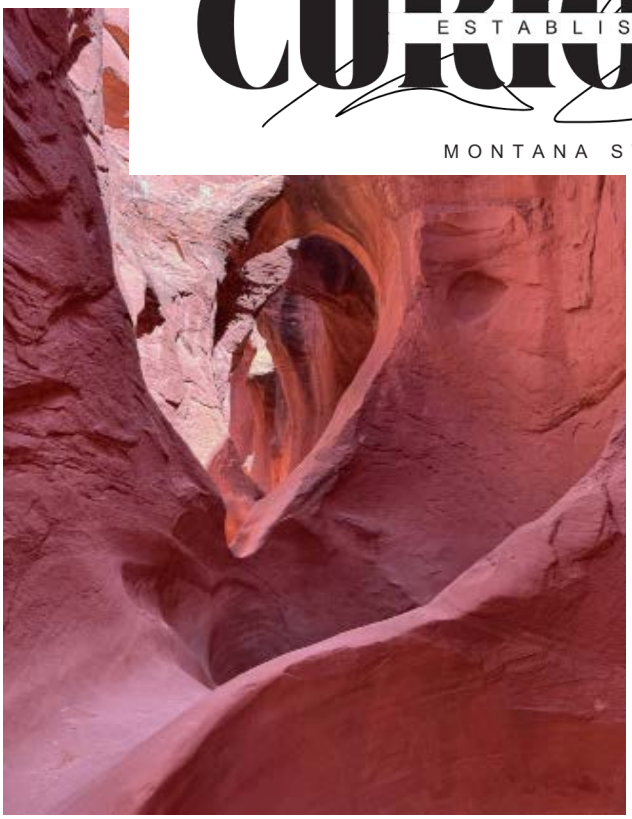

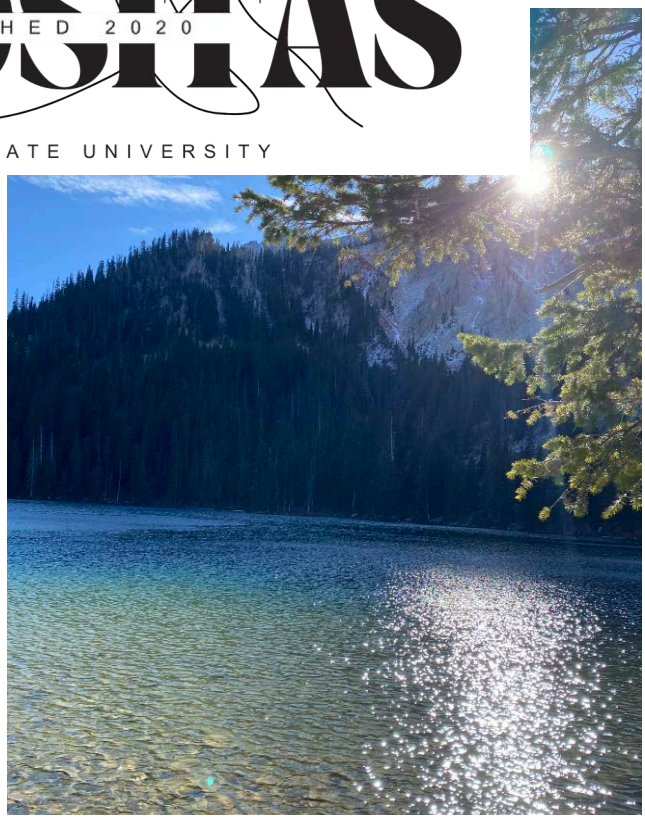

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Charlton T. Lewis, Charles Short, *A Latin Dictionary*, 1879

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