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# Curiositas 2025

Anika Boyer, Amanda Haab, Emily Moss, Calla Castro, Jessminda DiCello, Taylor Pooton

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# CURIOSITAS

Journal of Undergraduate Research at Montana State University

Spring 2025

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**Jugular Vein Catheterization Methodology**
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Cover Photo by Madison Anderson
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Dear MSU C nity,

We are pr d to share with you this year's editi of *Curiositas*, M tana State University's u dergrad ate research j rnal. This publicati celebrates the breadth and depth of original research c d cted by MSU u dergrad ates across an array of academic disciplines.

*Curiositas* is the result of cross-campus collab rati . As part of the U dergrad ate Research C cil, the j rnal e b dies MSU's c mmit e t to shared governance by expanding access to research publicati and e s ring the l g-ter s stainability of this platfor for fut re scholars.

We would like to thank the dedicated st de ts and faculty me t rs whose passi and dedicati has made this j rnal possible. We would also like to thank the Nati nal Scie ce F dati 's ART pr gram as well as the U dergrad ate Scholars Pr gram and D g D w s for their c tributi s and s pp rt!

We hope you find inspirati and insight in the pages of this year's j rnal.

Warmly,
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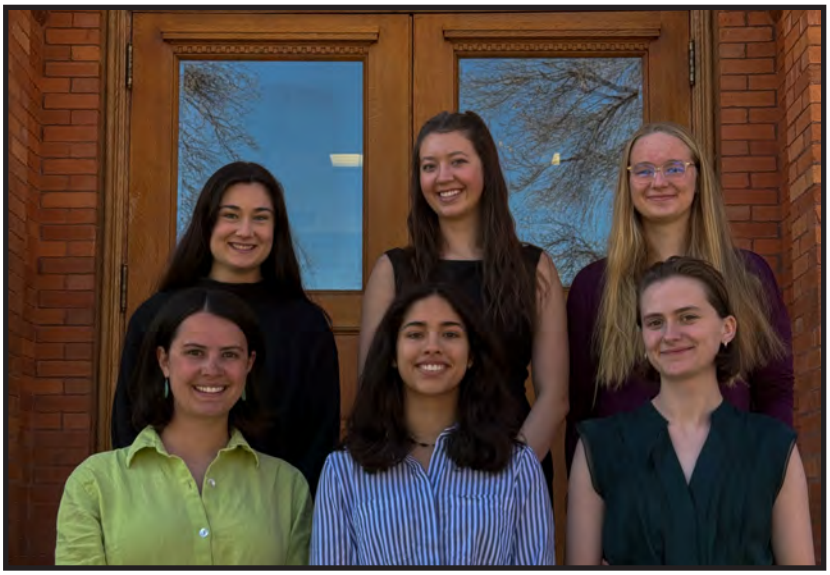

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# Spring 2025


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

Madis A ders

N t nly do tain g ats live at the top f the w rld, but they have also adapted to incredibly harsh climates where few ther species are fou d. After spe ding time with and bserving this particular herd, I've lear ed so ch ab t their mannerisms and pers nalities. he gr p dynamic is incredibly c plex and operates similarly to h w h mans participate in these dynamics. Every e c ter I have with these special animals gives e a deeper awe and appreciati for h w capable and resilie t they really are. his herd lives in a harsh, r cky, alpine e vir e t that yields little water and l ts f te perame tal weather. Despite the adverse c diti s these animals face, they are able to live p to betwee fourtee and eightee years f age. heir adaptati s s ch as g ard hairs, leather-like h f soles, and salty, high-fiber diets all w the to navigate and thrive in an extre ely nforgiving e vir e t. hese ph t graphs are niq e and special to e beca se f the relati ship I've bee able to cultivate with this herd, and this g at specifically. I am incredibly grateful to have capt red this e t and be able to share it with every e. he st rytelling aspect f y ph t graphy is a h ge part f y missi to share the bea tiful places and creat res I find y adve t res to help pr tect the . Aware ess and admirati will hopefully lead to the c servati and preservati f t nly these w derful creat res, but also the e vir e ts that they k w as h e.





## About the Author



Madi is a landscape and adve t re ph t grapher fr B zeman, M tana maj ring in Micr biol gy with a min r in Hispanic St dies. Her passi is ph t graphing the w rld thr gh her le s and sharing her niq e perspective f the incredible places and st ries she gets to expl re. hr gh her interests, she accesses many re te l cati s and capt res the with her distinct style thr gh backc try skiing, biking, and s rfing. She strives to inspire thers to appreciate and cultivate c ecti with the nat ral w rld in rder to pr tect r bea tiful home.

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# 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.

here is s ething strange ab t the la dry r .
Drying cl thes vanish with t a trace.
Wash l ads are premat rely ripped fr their m ther's w b,
leaving the heavy with no hope of getting dry.
Washers overfl w with abuse,
spreading spiteful fl ds thr gh t the base e t.

he la dry r twists and warps people,
bringing out animalistic q alities they didn't k w they had.
he m e t they step into the r m,
they shift and m rph into s ething … else.
hey pr wl the la dry r m,
inspecting each machine and marking their next victim.
hey stake their claim with t e pathy for those ar d the .
errit ry is well g arded and c nningly bartered.
here are no frie ds in the la dry r -
nly allies and e emies.

here is no o e to help y ,
o guide to tell you what to d .
You m st quickly lear h w to handle y rself,
to read the e vir e t and ble d in.
Standing out gets you h rt.
Newc ers are n thing but fresh meat-
so watch y r back, or you will feel their teeth.

I see this happe far t o many times.
I want to help-
I really d .
But I h ch my back,
Stake my claim,
A d g ard my territ ry.
Welc e to the la dry r j gle.

## 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. .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 fu l ser es of p shed photos p ease see Scho arworks**



**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. A ex Harmon ( epartment of English)

In *Play It as It Lays* by J an Didi n, we are prese ted with a character in the midst f a crisis f ide tity. Maria, a failed actress in Hollyw d, is beset by many f the pr ble s c nly ass ciated with a rising star in the ind stry. A reliance dr gs, a c dificati f the self, and a deteri rating se se f who she is all play into her d w ward spiral. Yet whe we examine the reas that Maria lacks an act alized se se f self, the reader is prese ted with a parad x. If we take the w rds f Fre ch psych analyst Jacq es Lacan to be tr e, the lang age serves to create a filter thr gh which a s bject is distanced fr the tr e nat re f the w rld. hey are placed into the sy bolic rder, a realm f s cially c str cted derstanding that shapes the way we interact with the tside w rld. O r ide tity is tied to a se se f self that exists within the tside w rld, separate and niq e fr thers. Yet we see that Maria is drive away fr the sy bolic rder and t ward a state of collapse, as the b daries of her ide tity are dissolved thr gh lang age.

I Play It as It Lays by J an Didi n, we are prese ted with a character in the midst f a crisis f ide tity. Maria, a failed actress in Hollyw d, is beset by many f the pr ble s c nly ass ciated with a rising star in the ind stry. A reliance dr gs, a c dificati f the self, and a deteri rating se se f who she is all play into her d w ward spiral. Yet whe we examine the reas that Maria lacks an act alized se se f self, the reader is prese ted with a parad x. If we take the w rds f Fre ch psych analyst Jacq es Lacan to be tr e, the lang age serves to create a filter thr gh which a s bject is distanced fr the tr e nat re f the w rld hey are placed into the sy bolic rder; a realm f s cially c str cted derstanding that shapes the way we interact with the tside w rld. O r ide tity is tied to a se se f self that exists within the tside w rld, separate and niq e fr thers. Yet we see that Maria is drive away fr the sy bolic rder and t ward a state f collapse, as the b daries f her ide tity are dissolved *through* lang age.

his idea that r se se f se se is b th intrinsically tied to the tside w rld while being c nfined by the b daries f r ide tity is e that Lisa Blackman t ches in her b ok *Immaterial Bodies.* e i es, "We ex end in o our environments and yet paradoxically are equired o live this ex ension as in erio i y" (Blackman, 151). This raises e question of agency. One has o onder if this ex ension can be a conscious choice, and if one can choose e environments that e each in o as a ay of shaping e self. In some ays, e have no choice but o in eract ith e o ld around us and us "ex end" in o ese environments. But this equires a kno ledge of hat consists ithin, other ise, ere ould be no boundary o "ex end" pas . As a subjec , e have a sense of hat our identi y consists of, e er it is ealized or not. This is e "in erio i y" that Blackman discusses. It is self-contained and hile influenced by e surrounding o ld, is felt only by e individual. T e fil er of language that Lacan efers o is essential o e p ocess of maintaining a solid boundary of "self." Wi out this boundary, one ould lose eir sense of self and be entirely exposed o e outside environmen .

his idea f exte si e visi s a piece f the self reaching t, bare to be shaped by the s rr ding forces, vulnerable and malleable. I an ideal w rld, these forces expand e's se se f self, gr wing the individ al's interi rity in a healthy way. We take the challe ges f the e vir e t and overc e the in a tri phant manner, gr wing as a pers and bec ming re resilie t. But what happe s whe these e vir e ts do t expand the "self" but shrink it? Or whe they destr y the se se f self alt gether? With o b daries to separate the "self fr " ther," the c sci s these forces expand e's se se f self, gr wing the individ al's interi rity in a healthy way. We take the challe ges f the e vir e t and overc e the in a tri phant manner, gr wing as a pers and bec ming re resilie t. But what happe s whe these e vir e ts do t expand the "self" but

Or whe they destr y the se se f self alt gether? With o b daries to separate the "self fr " ther," the c sci s either expands to incl de everything r shrinks to incl de thing. Maria experie ces b th e ds f this, dissolving into the w rld and being left with a se se of e ptiness.

Maria's grasp her w interi rity deteri rates to the exte t that she o l ger can tell where her w b dy e ds and her e vir e t begins. O her vacati to Las Vegas, her b daries dissolve and she begins to e velop her s rr dings. "She was thinking c stantly ab t where her b dy stopped and the air began, ab t the exact p int in space and time that was the differe ce betwee Maria and ther . . . She could feel smoke against her skin. She could feel v ice waves. She was beginning to feel col r, light inte sities" (Didi n, 138). We see here a breakd w f the b daries that separate Maria's b dy fr the tside w rld, and as they begin to c alesce in her mind she gr ws less certain f what c stit tes her w existe ce. Her experie ce with col r, light, and s d is b r t f crisis. It is a crisis b r t f a lack f stasis with her w b dy. Her inability to c cept alize where her ide tity e ds and where the w rld begins leads to this breakd wn, opening up her "interi rity" to the s rr ding w rld.

As Lacan says, it is thr gh lang age that we e ter the sy bolic rder and distance rselves fr the real. But this depicti f Maria sh ws her pr gressing away fr a c str cted reality and t ward a re nfiltered existe ce. O r c str cted se se f self is what all ws for the b daries betwee self and ther, and is ecessary to maintain a rati nal existe ce. With t a fir derstanding f where r ide tity lies and where the w rld begins, e experie ces an abjecti f self where eaning begins to collapse in itself Maria is experie cing the deteri rati f her filter that separates her se se of the sy bolic order fr the real.

Yet c trary to Lacan, it is the very same pr cess f lang age that ca ses the b daries betwee "self" and " ther" to deteri rate. his is manifested in the deh manizing manner in which her abusive h sband arter speaks to her and treats her. I a e t f c nfr tati n, he tells her e fights with her "to find t if [she's] alive" (Didi n, 158). pled with the threat f physical viole ce and a c stant degradati f her age cy, this deh manizing lang age begins to strip away Maria's ide tity.

his culminates t in her crisis at the H over Dam, but in the peri d f e ptiness after that. Whe asked what matters by BZ, Maria says, "N thing" (Didi n, 164). he "interi rity" that Blackman talks ab t has bee red ced to thing. he w rds sed by her h sband and BZ take away fr her validity as a pers with eaning. By asking if she is alive, he puts her at dds with her w existe ce. He implies that her ide tity lacks s bstance to the p int that it o l ger exists. his is p werful, affective lang age that serves to tear d w and destr y. his is t the lang age that Lacan talks ab t whe referring to the sy bolic rder. hat lang age is e that builds and creates, e bedding the s bject further into an derstanding f the s cial creati . I stead, Maria's ide tity is dec str cted and dissolved.

We see Maria wrestle with the effects f what is being d e to her, atte pting to se lang age to reclaim s e age cy for herself. She describes herself as "a radical s rge f y w life. Never disc ss. t. I that way I rese ble the nly man in Los A geles ty who d es clean w rk" (Didi n, 165). hese w rds speak to a p wer that she claims to have. Eve in its self-destr ctive nat re, these w rds would imply that Maria at least has s e age cy in her w dec str cti . hat she is the e c tting away these parts f herself, t the lang age f her h sband r her frie ds. But this atte pt to ide tify s e part f herself that is able to make a ch ice falls sh rt. She is still left with her crisis f ide tity and a life dev id f any eaning. Her b daries f self have already bee stripped away by lang age, in the same way that her baby was stripped away fr her. hese acti s were forced p her, o matter h w hard she tries to rati nalize her w c trol over the . Her atte pt to se lang age to reclaim a part f herself fails, and she is left with an defined and dissolved ide tity.

his leaves the reader with a parad x f infl e ce. We see thr gh the w rk f Lacan h w lang age filters r percepti f the w rld and places s into a sy bolic . . . rder that is s cially c str cted. But we also see h w lang age can be sed to tear d w and strip away the ide tity f an ther pers n, bl rring the b daries f "self" and bringing the closer to the real. his destr ctive p wer tears away all age cy fr Maria, leaving her a blank slate for which n thing matters. Yet whe she atte pts to se lang age to wrestle

fails to be e gh, leaving her o better ff. We are prese ted with a depicti that c trasts and defies, giving o straight answer to the reader. We are left to w der at the affective p wer f lang age and h w it might be sed to build thers p r tterly destr y the .

## 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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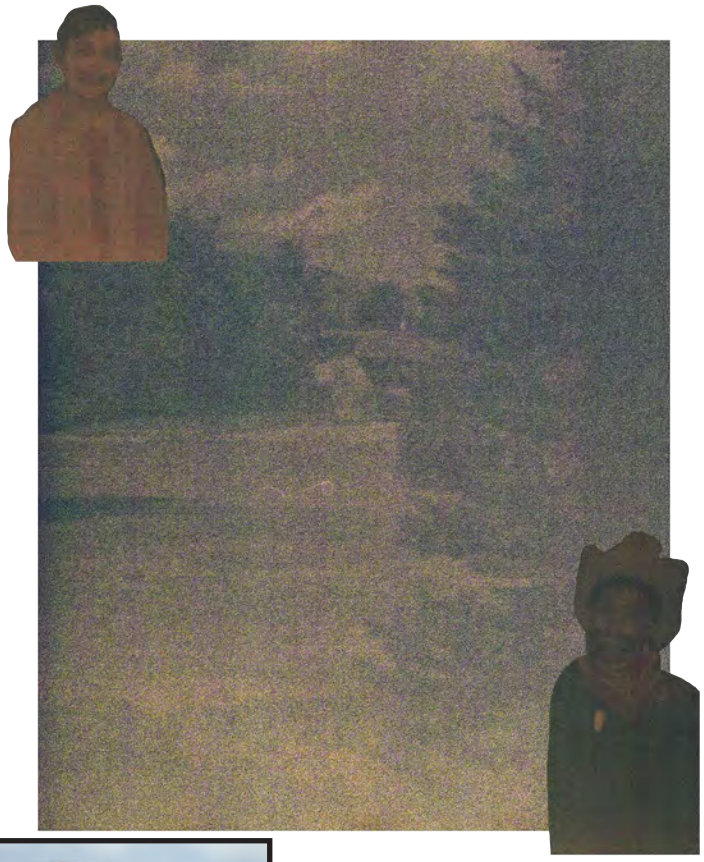
# Ghosts of the Landscapes

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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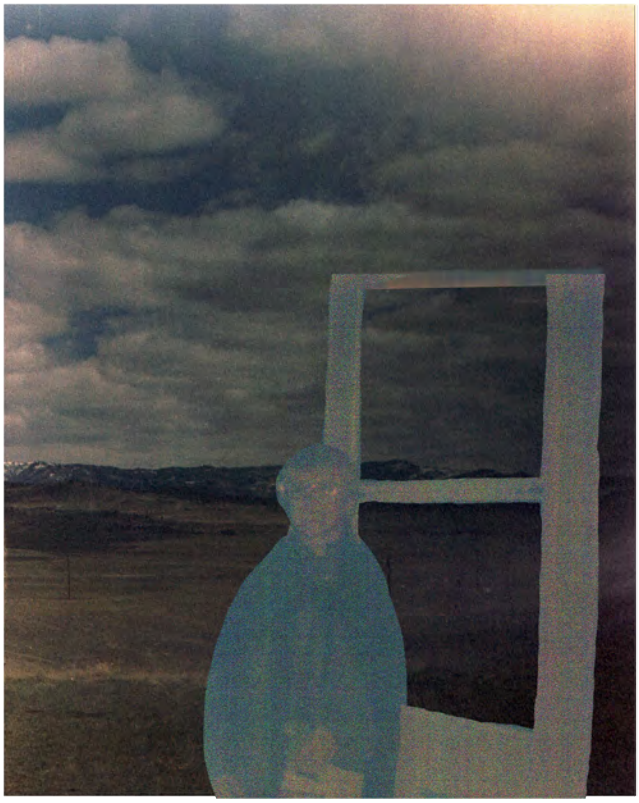
Sierrah Paul is a junior at Montana State University pursuing dual degrees in Computer Science and Film and Photography. Sierrah had the support of Zach Begler throughout the production of this project. When not photographing, Sierrah is hiking on all the trails that Montana has to offer or curling up 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.

**In roduc ion**

S ppressi f I dige s k wledge has deep hist rical and col nial r ts and c stit tes the epistemic sm thering and excl si f I dige s v ices fr the intellect al landscape, b th hist rically and c rre tly. his paper investigates the degree to which I dige s k wledge has bee s ppressed, and h w this has led to differing for s f epistemic inj stice. his analysis will incl de h w lang age was s ppressed thr gh forced enrollme t in col nial b arding sch ols. I maintain that instances f cult ral s ppressi in b arding sch ols represe t a re inte se for f epistemic inj stice, fte referred to as epistemic viole ce. Finally, I arg e that hist rical for s f epistemic viole ce have disr pted der intellect al exchange and created ew for s f epistemic inj stice. hr gh specific investigati f rec ciliati acts, I assert that c te p rary for s f rec ciliati and rec gniti do little to q ell g ing epistemic har s; acc t f their fail re to e s re that I dige s testim y is eaningfully heard and derst d, th s devaluing testim y and perpet ating epistemic inj stice.

**Wh t is Epis emic Injus ice and Epis emic 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.

**Epis emic 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 f forced reed cati ffers the ost p ignant analysis f epistemic viole ce in N rth A erica, d e to their explicit aim at severing I dige s childre fr cult ral and epistemic ties. A drea Smith investigates forced reed cati in her article "B arding Sch ol Abuses, H man Rights, and Reparati s,"

Smith maintains that the aim f col nial b arding sch ols was to sever I dige s childre fr their cult ral ties and forcibly assimilate the into white cult re (90). I vestigati f reside tial sch ols as instit ti s inte t destr ying I dige s childre 's ties with their lang age, c nity, and cult re makes clear that forced col nial b arding sch ols align directly with Spivak's acc t f epistemic viole ce; d e to their inhere t aim at destr ying any se blance f I dige s cult re in fav r f a d minant white cult re/ideol gy. Kristie D ts c cretizes this ti f epistemic viole ce in her article " racking Epistemic Viole ce," stating that "A epistemic side f col nialism is the devastating effect f the 'disappearing' f k wledge, where l cal r provincial k wledge is dismissed d e to privileging alternative, fte 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 Reconcili ion Ac s Help Address Epis emic Injus ice?**

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. hristine M. K ggel reviews the aims and str ct res f rec ciliati acts in her article "Epistemic Inj stice in a Settler Nati n: anada's Hist ry f Erasing, Sile cing, Marginalizing." I the case f anada's R s (Tr th and Rec ciliati mmissi n), rec ciliati efforts fte involve activities where s rviv rs prese t testim y ab t the abuses c mmitted in b arding sch ols and create an accessible narrative foregr ding

why those practices were oppressive and harmful. Rec ciliati acts are ge erally characterized by a ecessity to ill minate hist rical acts f viole ce thr gh the pers nal testim y f those oppressed and establish this as a eans to collectively rec gnize the as wr g. I the ry, s ch acts grant c nities and nati s the ability to ove forward in nity t ward a brighter fut re (K ggel). H wever, it is precisely a rec ciliati act's sole aim f ill minating past inj stices while ign ring c rre t str ct ral inj stices br ght by hist rical oppressi n, that diminishes their val e as valid for s f resol ti .

I arg e that the reality f rec ciliati acts is far re sinister than it may appear. I atte pting to rec gnize hist rical har s thr gh legislative and fficial eans, rec ciliati acts fte ign re key c p e ts f the str ggle for ack wledgme t and p wer relati ships in post-col nial eras, c seq e tly perpet ating epistemic viole ce and inj stices. M reover, the inhere t fault f rec ciliati acts is their e gage e t in a degree f chr o-politics that hist ricizes and th s distances the pers nal testim y f those oppressed fr the prese t. his, in t rn, preve ts individ als and gover e ts fr fully rec gnizing the g ing inj stices experie ced by I dige s peoples. Anna ok expl res this phe e in her article "Rec gnizing Settler Ign rance in the anadian r th and Rec ciliati mmissi ." ok tlines that acts f rec ciliati are largely distributed and rchestrated by the state, a hist rically col nial age t, thr gh this I dige s testim y and age cy are further s bs ed into the col nial str ct re. "c te p rary col nial p wer and hege y w rk t thr gh a pr cess f excl si but rather thr gh the incl si and shaping f I dige s peoples and perspectives by state disc rses self-determinati cann t be best wed p by the state but st result fr I dige s res rge ce" (C ok 9), Here, ok ill minates why rec ciliati acts thr gh the state do t acc t for valid for s f rec gniti n, defined by the fact that the state is a hist rical s rce f col nial oppressi n, specifically in its creati f the reside tial sch ol syste which is a key s rce f epistemic viole ce and inj stice. A y atte pt at rec ciliati thr gh the state is an atte pt thr gh col nial and oppressive eans, and therefore further establishes I dige s peoples as col nial s bjects. As stated by Spivak, " in the c stit ti f that Other great care was take to bliterate the text al ingredie ts with which a s bject could cathect, could cc py (invest?) its itinerary – t nly ideol gical and scie tific pr d cti n, but also by the instit ti f the law" (75). Rec ciliati thr gh this le s the bec es an overt instance f epistemic viole ce beca se I dige s self-determinati was appropriated by the state in fav r f repr d cing the d minant ideol gy of col nialism.

As tlined above, acts f rec gniti fte participate in the purposeful effort to c sign pers nal testim y and oppressi to the past, c seq e tly limiting testim nial age cy and imp rt in the prese t.

> "Settler ign rance fu cti s by delegitimizing testim nies by relegating these testim nies to the past . . . Expressi s f g ing settler-col nial viole ce are take to be a for f egative dwelling in the past, rather than take as an expressi f the impact f the g ing viole ce f settler col nialism . . . the te p ral distancing w rks to create a 'c se s al hall cinati ' f the denial f prese t-day settler-col nial reality, which is required for 'c q est, col nizati n, and e slave e t'" (C ok 19).

Here ok tlines an overt for f epistemic oppressi n, dismissing testim y to the past deval es it in the prese t, de ting an ccasi f bvi s testim nial inj stice. Defined by Fricker as a sit ati in which prej dice ca ses the hearer to invalidate the speaker's testim y and overl ok key aspects f the testim y. I the case f I dige s rec gniti specified above, inc rrectly sit ating reside tial sch ols and their abuses as ele e ts f the past ca ses individ als to remain ign rant f str ct ral abuses in the prese t.

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 inj stice. He posits that rec gniti is key to derstanding epistemic inj stice, and c rre tly, there is o proper derstanding r rec gniti f oppressed gr ps and s bjects, c seq e tly, k wers are inevitably slighted in their capacity as epistemic age ts (2). Here he tlines that misrec gniti acc ts for epistemic inj stice in the se se that an individ al will t be able to meaningfully c nicate their experie ce, and

their credibility will be q esti ed. Medina the exte ds this definiti f misrec gniti to incl de misrec gniti f the s bject r bject f disc ssi . Medina c te ds that misrec gniti to this degree disr pts c versati s rr ding a topic beca se it d es t properly ill minate the degrees f inj stice r e gage with the s bject significantly: "Here the rec gniti deficie cy c cer s t whether r t e is rec gnized, r to what degree, but h w e is rec gnized and whether the way in which e is rec gnized is appropriate r t" (3), Which is an extre ely imp rtant distincti whe disc ssing rec ciliati acts beca se it highlights that there are possible defects in the way individ als and gover e ts e gage with narratives f oppressi . What is f eve further imp rtance to his arg e t is that he s ggests ere visibility r increased rec gniti is t s fficie t to c ter the oppressive nat re f the inj stice beca se visibility d es t draw into acc t systemic iss es; instead, there eeds to be a drastic transformati in the manner these instances are c cept alized and vis alized— " he incre e tal appr ach is ineffective here beca se what is eeded is t re images but *a radical shift in the mode of recognition*" (Medina 11). Applying this to rec ciliati acts, it bec es increasingly clear that the c rre t framew rk f visibility and rec gniti d es little to pr d ctively assess the oppressi f I dige s peoples, hist rical r c rre t. With t radical rec nfig rati f the manner in which we appr ach instances f rec ciliati f past abuses, we r the risk f perpet ating those abuses, as is see in the case f anada's r th and Rec ciliati mmissi disc ssed by C ok.

**Conclusion**

T e his o ical supp ession of Indigenous cul ure ough esidential boarding schools ep esents a p ofound instance of epis emic violence that o ked o in entionally separa e Indigenous children from eir language, families, and Indigenei y. This violence had pervasive ramifications, fos ering estimonial and ermeneutical injustice, hich continue o opp ess modern Indigenous voices. Con emporary econciliation acts do li tle o address ese current abuses, ins ead masquerading as a empts o econcile past ongs. Modern acts such as TRCs opera e ithin colonial frame o ks that app op ia e and falsely his o icize Indigenous estimony, failing o meaningfully address past and p esent epis emic harms. Looking ahead, a radical shift is necessary o p operly account for sys emic injustices suffered by Indigenous populations, one hich cen ers on Indigenous agency, decons ucting colonial frame o ks, and fos ering an inclusive epis emic landscape.

## About the Author



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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 Hea

While the E glish lang age's ability to describe love and attracti has gr w imme sely in the past two ce t ries, many ide tities have str ggled to find a place within the syste f sex ality. hose who experie ce a lack f sex al r r mantic attracti fte find the selves within a linguistic limb , lacking the distincti f a name while still facing very real barriers to c nicati within their relati ships. he mainstream lang age s rr ding eaningful h man c ecti places an e phasis sex and r mance, failing to ack wledge the imp rtant relati ships that can exist tside these two c cepts as anything ther than "frie dship." I rebelli f this invisibility, ew v cabulary has bee developed to better describe - rmative b ds and rie tati s. his essay foll ws the lang age f love and attracti fr the late 1800s to prese t, highlighting ar mantic and asex al perspectives and ill strating j st h w p werful a name can be.

I L rd Alfred D glas' 1894 p e *Two Loves*, the narrat r is appr ached by two y ths in a heavenly dreamscape. O e is "fair and bl ming" who sings f "j y s love f c ely b y and girl" (D glas 42, 44); the ther is "sad and sweet" with eyes "strange with w dr s bright ess," whose bea ty and s rr w oves the narrat r to tears (D glas 52, 53). Whe pr pted, the sec d y th says his name is Love. he first the pr claims, " 'He lieth, for his name is Shame, / But I am Love . . . I am tr e Love, / I fill the hearts f b y and girl with t al flame.' " he sec d resp ds, " 'Have thy will, / I am the Love that dare t speak its name' " (D glas 68-74). He speaks f a love that remains narticulated, defined; it is c de ed to shamefulness beca se it has nly bee c cept alized as a twisted deviati fr what is real and val able. By eq ating the spoke w rd to the s cietal rec gniti f validity—rather than validity itself—D glas implies that a love that dares t speak its name is o less tr e in its sile ce. he w rd "h osex al" had nly bee in se for fiftee years at the time f this p e 's publicati (Stack). Eve while nameless, vari s acts f same-sex love had bee criminalized der British law since the sixtee th ce t ry (Macle d 356). Foll wing the publicati f D glas' *Two Loves*, "the love that dare t speak its name" became a rec gnized Vict rian-era e phemism for h osex ality (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).

Sex alities ass e several things: the prese ce f sex al attracti n, the implicati f r mantic attracti n, and the singular bject f b th. hese ass pti s fail to describe sit ati s in which the bject f attracti differs betwee the r mantic and the sex al. Fr 1864 to 1880, German researcher Karl Heinrich Ulrichs developed a w-extinct v cabulary to c cept alize male desire. his was eant to satisfy the eed for "positive v cabulary" to describe people like himself who diverged fr the n r (Br oks 182). O e s ch

term, " ran di nism," refers to c c rre t same-sex and opposite-sex attracti . Ulrichs splits ran di nism into two categ ries: "c nj ctive" and "disj ctive" (Br oks 183). nj ctive ran di nism describes c c rre t r mantic and sex al attracti t ward b th e and w en, aligning with the der definiti f bisex ality. Disj ctive ran di nism refers to same-sex r mantic attracti al gside opposite-sex sex al attracti n, which cann t acc rately be described as bisex ality beca se b th attracti s are t experie ced t ward the same de graphic ("Splitting Attracti "). Ulrichs' w rk became a vital t ol to those previ sly incapable f c cept alizing their desire as anything ther than a twisted variant f heterosex ality. O e s ch man writes that for him, these ter s were ultimately "salvati n," c ecting him to a etw rk f ther e experie cing same-sex attracti . Strangers became frie ds. He rej ices in the k wledge that his sex al desire was "determined by nat re" rather than an "aberrati " (Stack). Whe an experie ce can nly be described c paratively, it is denied its tr e s cietal val e. Ulrichs' w rk ill strates the validati to be fou d in establishing ew v cabulary to better describe eself.

A ce t ry after Ulrichs, researchers were still atte pting to differe tiate betwee r mantic and sex al attracti in b th lang age and life. I the 1999 forew rd to her 1979 b ok *Love and Limerence*, A erican psychol gist D r thy e ov s s p the prevailing ideas r mantic 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. he riginal poster f this thread t ys with the idea f a two-part label that all ws for mixing and matching the attracti and the bject. F r those who had ide tified with disj ctive ran di nism over a ce t ry beforehand, their experie ce f attracti could w be named sing the descript r "heterosex al h r mantic." Posters the thread se their ew syste to establish the c cept f ar manticism, matching the "a-" prefix to the "-r mantic" s ffix to de te a lack f r mantic attracti ("Relati ship Definiti s"). After 25 years,

e ov's nlimere ce had finally bee give a der equivale t.

Within the c text f attracti and sex ality, rie tati s that experie ce a partial r t tal lack f attracti n, s ch as asex ality and ar manticism, can be c sidered to fall the a-spectr . A y rie tati s tside that definiti fall the allo-spectr m, a collective ter sed to easily refere ce all people who fully experie ce attracti . I a cult re per eated by allo-spectr expectati s, a-spectr individ als st fte challe ge cult ral r s built ar d desires they do n t experie ce.

Sex al attracti has bee — and c tin es to be — see as a niversal characteristic. Sex alities e tered the E glish lang age at a time whe sex al attracti was the nly ide tifiable prefere ce to be described. I e ov's 1999 *Love and Limerence* forew rd, she c te ds that whe s e e feels limere ce it is always acc panied by sex al desire (Te ov x). he ti that r mantic desire d es t exist separate fr sex al attracti has remained deeply e tre ched in h w we talk ab t love and attracti .

Likewise, r mantic attracti and an acc panying desire for a r mantic relati ship are fte inadverte tly ass ed to be niversal. I 2012, Dr. Elizabeth Brake f Rice University c ined the ter "amat rmativity" to refer to the implicati that a r mantic relati ship in s e e's life can adeq ately reflect their happiness, pr gress t ward g als, r overall character. I her b ok *Minimizing Marriage*, Brake defines amat rmativity as a "disprop rti nate foc s marital and am r s love relati ships as special sites f val e [in e's life]." his manifests as a widespread cult ral ass pti that r mantic part erships are a " niversally shared g al" and ght to be "aimed at in prefere ce to ther relati ship types." wo amat rmative phrases she cites are

"'She hasn't fou d the e . . .yet' r 'are 't you l ely/ immat re/irresp sible beca se you are t married/ part ered?'" ("Amat rmativity"). he ce tral the e is that any "val able relati ships st be marital r am r s," which "deval es frie dships and ther caring relati ships" and perpet ates a narrative eq ating happiness and fulfillme t to the r mantic b d (*Minimizing Marriage* 88, 89). his idea can be especially harmful to a-spectr individ als, who may derive the ost satisfacti fr plat nic love, living al e, r - rmative relati ships. Whe eaningful c ecti is ass ed to nly cc r in a r mantic and sex al c text, nr mantic love is treated as th gh it is t tr e e gh, deep e gh, c mmitted e gh, r val able e gh to s pp rt a pers 's e ti nal 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 f the "frie d zo e," in which r mantic advances fr e pers t ward an ther are s ccessful. See as a tragic and nj st positi n, at a basic level the frie d zo e implies that the frie dship was nly w rthwhile if it could eve t ally rph into a r mantic relati ship. Plat nic love is rarely see as an adeq ate s rce f intimacy and s cial satisfacti in a pers 's life.

Amat rmativity alienates those who find greatest happiness in -r mantic c ecti r solit de. Many people in the a-spectr c nity pull

s bstantial love, s pp rt and fulfillme t fr their frie dships, deviating fr the ti that eaningful happiness can nly cc r in a r mantic relati ship. I a st dy scr tinizing the perceived relati ship betwee love, sex, and happiness, researcher iina Vares interviews asex al individ als f vari s r mantic rie tati s. Alth gh s e relied solely frie dships for interpers nal c ecti n, they did t feel as th gh they were bypassing " 'real' love and intimacy, and therefore nhappy" (Vares 190). O e e ber f the st dy, Gabriella, ack wledges "a hierarchy which privileges sex al intimacy" so ch so that the prese ce f sex is an indicat r f whether a relati ship can be c sidered "close and intimate." Gabriella desires a part ered, -sex al relati ship, but Vares tes that she has " o intelligible way" to the close frie ds she would "almost c t" as part ers (Vares 192).

S e nlimere ts interviewed by e ov refere ce a desire for, r e gage e t in, a deep e ti nal and/ r sex al relati ship despite their lack f r mantic attracti . Whe e participant, Vera, is intr d ced to nlimere ce, she remarks, " his is w derful. N w I k w what is happening, and I can tell Barry all ab t it. Maybe that will make him leave e al e a little re fte and t feel so bad ab t it. I think, fr what you say, that he st be limere t" (Te ov 117). It would appear that in Vera and Barry's relati ship, there is an derlying expectati for her to perfor the d ties f a r mantic part er. he idea f nlimere ce all ws for b th her and Barry to better derstand her eeds, and she hopes that, by giving a name to their differe ces, they will be able to live t gether m re c mfortably.

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 inadeq acy can nly be bridged by lang age that refers to plat nic love directly. hey s ggest "q eerplat nic" as a niq e ter for those types f rmative b ds that, while ce tering "deep . . . e ti nal c ecti n," are t r mantic in nat re and t adeq ately described as frie dship ("A/r manticism"). I a later t blr post by S.E. Smith ( elouhkia), q eerplat nic relati ships are defined as any - rmative b ds built "inte se e ti nal c ecti " with t being "r mantic in nat re," t excl ding -r mantic sex al intimacy r polyam r s relati ships (which involve ultiple c se ting part ers). he participants are t required to pers nally ide tify as q eer beca se in this c text,

“q eering” characterizes an effort to acc rately represe tt the val e f relati ships that do t fit the “ rmal,” and are therefore treated as lesser by simply being s al. Smith stresses that the “key feat re” defining q eerplat nic b ds is the state f “being deeply c ected to s e e, with t a r mantic ele e t” (Smith).

he c cept f q eerplat nicism has gained popularity over the past decade, especially with the y ger de graphic and those who freq e t nline spaces. I Vares’ st dy, the acr y QPR (q eerplat nic relati ship) is sed by James, an 18-year-old ar mantic, to describe “a de f relati ship he might like to have with an ther man” (Vares 192). he e erge ce f this ew v cabulary has all wed James the freed to articulate his bjectives with t first translating his plat nic attracti into s e ack wledged r mantic r sex al equivale cy.

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 Seafo d
Mentor: Dr. Ed Schmidt ( epartment of Microbiology and Cell Biology)

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.

**In roduc ion**

I vivo st dies are a key t ol whe it c es to st dying the roles f c plex physiol gical pr cesses. H wever, c rre t eth dol gy for st dying these differe ces in etabolic fl ct ati s are seemingly difficult and tdated. Single r repeated in culati s f c p ds into mice ge erally result in dynamic circulating c p d c ce trati s and, c seq e tly, dynamic d w stream etabolic tc es. p ds can be administered in feed r drinking water, r by sing osm tic pu ps that are implanted into the mice. hese l g-ter stable delivery appr aches require exte ded peri ds f time for dr g c ce trati s to reach equilibri in the mice. As s ch, e f the above appr aches are typically acceptable for achieving stable circulating c p d c ce trati s over peri ds f several h rs. While this expos re can be carried t in a c trolled cell cult re e vir e t, these dels lack the physiol gical c plexity f e tire rganisms. o track olecular transformati s in vivo rather than j st eas ring steady-state etabolite levels, j gular catheterizati ffers a reliable sol ti . his techniq e all ws real-time tracing f specific etabolites—s ch as sulfur-c taining amino acids—across ultiple tiss es, making it particularly seful for st dying transie t etabolic inter ediates. Despite its advantages, j gular catheterizati remains der tilized for is tope labeling in mammalian syste s, limiting the scope f individ alized tiss e analysis.

Metabolism is ce tral to life by providing e ergy, sy thesizing c plex bi olecules, eliminating waste, and maintaining h eostasis.1 Bey d these fu dame tal roles, etabolic e zy es also infl e ce ge mic, epige mic, and pr te mic regulati by acting as c fact rs and s bstrates for ge e- difying pr cesses s ch as ethylati and acetylati . o fully derstand cellular fu cti n, it is esse tial to st dy t nly ge e and pr tein expressi n, but also etabolic activity. Since standard pr te mic analyses may overl ok dynamic etabolic changes, investigating the etabol e thr gh is tope labeling ffers deeper insights into cellular regulati .2 H wever, st dying etabolic pathways prese ts challe ges d e to the vast chemical diversity f etabolites, their rapid t r over, and their ove e t across tiss es. o address this, is topic labeling c bined with mass spectr etry (MS) is a p werful appr ach for tracing etabolites, all wing precise ide tificati based mass and fragme tati patter s. Unlike whole-animal radiolabeling, MS-based is topic tracing minimizes waste disposal c cer s while providing high-resol ti metabolic data.3

I this paper, we de strate the accessibility and effective ess f j gular catheterizati for delivering labeled etabolites. By detailing r optimized eth dol gy, we aim to provide a practical guide for researchers interested in sing this appr ach to st dy etabolic fl x in viv , enabling re c prehe sive insights into systemic metabolism.

**Protocol**

Mice were h sed in forced-air HEPA-filtered caging syste s (Tecniplast r equivale t) 14/10 h light/dark cycles with nrestricted access to water and feed. All experime tal mice were at least 8 weeks f age. Mice were anesthetized with is fl rane at 3% and maintained at 1-2% with a c tin s fl w of oxyge at 1 liter per

min te thr gh t the pr ced re. A esthetized mice were prepared for s rgery a heating pad for te perat re regulati n, eye int e t was applied, and hair was re oved via an electric razor the d rsal and ve tral areas of the neck.

A chl rhexidine scr b foll wed by a chl rhexidine rinse was d e 3 times for asepsis the incisi sites. he fr t paws were fixed to the abd e with sterile tape and the st ckinette was placed the mice. Mice were the oved fr the preparat ry be ch to the sterile operating table.

he sterile operating table was staged with a heating pad der a microscope. Al gside, a sterile field was dedicated for sterilized s rgical instr e ts in additi to 4-0 s t re, catheter, catheter pl g, vessel l op, and distinct sterile syringes for the heparin, lid caine, and saline sol ti s al g with tw , 25-ga ge eedles and e, 21-ga ge needle.

he mice were positi ed into the anesthesia ose c e their back with the head f the se p inted t ward the s rge . A sterile drape was placed over the mice.

he initial incisi site was appr ximately 1 cm bel w the right cheek, vis ally c nfir ed by pulsati f the j gular vein see the skin. Fine sciss rs were sed to make a 2 cm vertical incisi slightly right f midline the neck.

he skin was separated fr the s bc tane s layer with two c rved micro-tiss e forceps, e in each hand, sing bl t dissecti techniq e. he catheter inserti site was revealed by resecti f adipose and c ective tiss es and best selected where the external j gular vein eets the s bclavian vein. he inserti site was isolated with careful resecti til the ve tral s rface f the vein was clear f c ecting tiss es, vis ally ide tified by expos re to the bright red col r f the vein. N tably, resecti f tiss e ear the vessel threate ed the integrity f the fragile vein and increased the risk f r pt re. Foll wing isolati n, p inted micro-forceps were sed to create a s bc tane s "t el" der the vein sing bl t dissecti techniq e. Next, the vessel l op was inserted into the "t el" to isolate and expose the vein, with care n t to twist the vein.

wo pieces f 4-0 s t re were c t appr ximately 10 cm in le gth. B th pieces f s t re were threaded der the vein al gside the vessel l op with p inted micro forceps. With e 10 cm secti f s t re, a l ose, overhand l op was made the inferi r side f the vessel l op. A he ostat was sed to hold b th e ds f the s t re, and derate, pward te si was placed the j gular with t c pletely ccl ding the vein. Adj sting the pward te si f this s t re served to regulate bl d fl w to the vein. With the sec d piece f s t re, a single overhand k t was tied the s peri r side f the vessel inserti site, this time c pletely ccl ding the vein. A l ose, overhand l op was made top f that k t. Each e d f the s t re was attached to a he ostat.

o prepare the catheter for inserti n, a 45-degree bevel was c t the catheter tip, and the catheter was fl shed with saline, e s ring air bubbles were re oved fr the line. he j gular vein was pu ct red for inserti in e f two ways: either sing high precisi dissecting micro-sciss rs to c t a very small incisi (less than the diameter f the catheter t bing) r sing a 25-ga ge eedle, bevel p, inserted at appr ximately a 22.5-degree angle to pu ct re the vein.

I ediately foll wing pu ct re f the vein, pward press re was placed the overhand l op the inferi r side f the vessel l op to preve t significant bl d loss. he catheter was held with tched forceps behind the anch r f the catheter and threaded thr gh the s peri r s t re l op. Using e hand, the catheter was inserted into the j gular vein while the ther hand released te si as eeded to close the overhand op the inferi r side f the vessel l op sing the attached he stats.

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 t bing as an air e bolism was a possible co plicati . If p oling f saline was vis alized, this was a sign that the catheter was t in the l e f the vein. atheter place e t in the vein was c nfir ed by sl wly pulling back bl d into the t bing. Next, a small am t f heparin (c c. and vol e per se) was pushed thr gh the catheter to prevent bl d cl ts ar d the implanted device. he catheter t bing was capped with a sterile, stainless steel catheter pl g.

S peri r and inferi r e ds f s t re were sed to make sq are k ts either side f the catheter. A single stitch was made the adipose tiss e f the eck for added sec rity of the catheter.

Mice were ge tly t r ed to their anteri r side in a pr e positi . he anesthesia decreased 25% at this time. A 1 cm vertical incisi was made the skin betwee the shoulder blades. A he ostat was placed into the incisi and sing the bl t dissecti techniq e, the skin was separated fr the b dy wall d w the back. his created a space for the catheter t bing to be fed to the d rsal side f the se. A tr car was inserted into the d rsal incisi and passed al gside the left side f the eck to the catheter place e t site. he catheter with the stainless-steel pl g was fed thr gh the tr car and ge tly pulled t the d rsal incisi with care e s ring the catheter rested with a ge tle c rve away fr the inserti site and j gular vein, rather than with sharp angles or kinks.

he skin was the stitched the anteri r side f the eck sing a simple r nning s t re finished with an Aberdee k t. he mice were r tated back to a pr e positi . he catheter was fed der the skin in e l op til the pl gged e d f the catheter e erged fr the d rsal incisi . Using several half hitches ar d the catheter pl g to the base f the t bing, the catheter was sec red to the skin with the pl g accessible. he d rsal incisi was the closed with a simple r nning s t re finished with an Aberdee k t. A esthesia was disc ected, and the mice were able to recover der the post operative pr t cols approved.

**Resul s**

Effective administrati f the j gular catheter was effective in dispersing the etabolite thr gh t the body.

**Discussion**

he s ccessful implantati f j gular vein catheters in mice de strates the feasibility f this eth d for is topic labeling and etabolic fl x analysis in viv . his techniq e provides a val able appr ach for st dying etabolic pathways by enabling real-time tracing f etabolites across ultiple tiss es. J gular catheterizati facilitates a re c prehe sive derstanding f etabolic dynamics in a physiol gical c text.

O e f the key advantages f this appr ach is its ability to bypass many f the limitati s ass ciated with alternative etabolic tracing techniq es. raditi nal eth ds, s ch as whole-animal radiolabeling, prese t challe ges related to waste disposal and l g-ter radi active expos re, making the less practical for traditi nal se. I c trast, stable is tope labeling c bined with mass spectr etry (MS) provides a safer and re precise alternative for ide tifying etabolic transformati s. he direct ve s infusi flabeled etabolites e s res their efficie t distributi thr gh t the circulat ry system, all wing for a th r gh assessme t f etabolic fl x across differe t tiss es. his systemic reach is particularly be eficial for tracking transie t etabolic inter ediates that may t be adeq ately capt red thr gh steady-state etabolite eas re e ts.

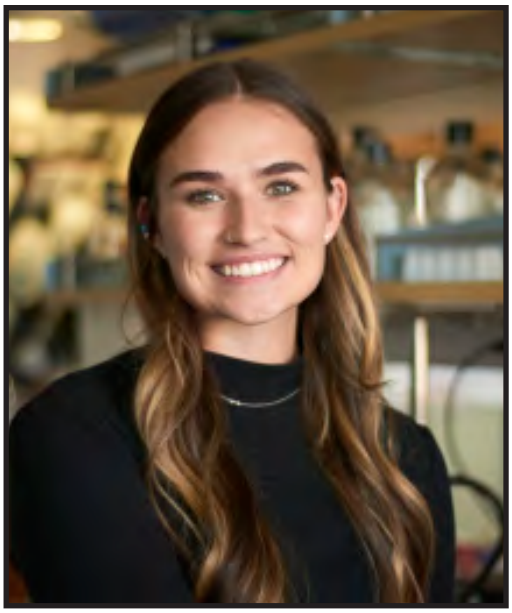
he s rgical eth dol gy e pl yed in this st dy highlights the imp rtance f precisi in e s ring s ccessful catheter implantati . he eticul s preparati n, incl ding proper anesthesia, te perat re regulati n, and tiss e handling, minimizes pr ced ral c plicati s s ch as infecti n, catheter displace e t, r vessel r pt re. he stepwise appr ach sed to sec re the catheter further enhances l g-ter catheter stability.

paring this eth d to ther etabolic tracing appr aches, j gular catheterizati ffers niq e advantages in ter s f etabolic resol ti and physiol gical relevance. Alternative eth ds, s ch as dietary inc rp rati f labeled trie ts r intraperit eal injecti s, fte s ffer fr sl wer etabolite ptake r inc siste t distributi n, limiting their ability to provide real-time insights into etabolic fl x. his is particularly seful for capt ring fast-t r over etabolites, which are fte challe ging to st dy using less direct labeling techniq es.

he findings f this st dy also highlight the p te tial applicati s f j gular catheterizati bey d basic etabolic research. I bi edical st dies, this techniq e could be leveraged to investigate disease-related etabolic alterati s in c diti s s ch as cancer, diabetes, and e r dege erative dis rders. By refining and expanding the se f this eth d, fut re st dies could expl re a wide range f physiol gical and pathol gical etabolic pr cesses with precede ted precisi . I c cl si n, j gular catheterizati

represe ts a p werful yet der tilized techniq e for in vivo etabolic tracing. he eth dol gical refine e ts tlined in this st dy enhance its feasibility, reliability, and repr d cibility, making it a val able t ol for researchers interested in st dying systemic etabolism. he be efits f this appr ach, particularly its ability to provide real-time, tiss e-specific etabolic insights, make it an indispe sable additi to the t olkit f biol gical 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 ( epartment 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.

**In roduc ion**

he RISPR-Cas syste is a defe se echanism c nly e pl yed by bacteria to fe d ff viral invaders (1). Up viral infecti n, RISPR-Cas c p e ts integrate viral DNA fragme ts as spacers in their w ge e. hese regi s f alternating spacers and RISPR nits are later transcribed into guide RNA (gRNA), which interacts with as pr teins. If the same vir s atte pts to reinfect the bacteri m, the gRNA guides the as pr teins to the matching viral DNA, where the as pr teins c t the DNA to stop the infecti . D e to its capacity for precise ge e dificati n, the RISPR-Cas syste has bee imple e ted as a ge e editing technol gy in edicine, agricult re, and bi technol gy (2).

Whether in the c text f bacterial imm e defe se r ge e editing, as e d cleases are a cr cial c p e t f the RISPR-Cas syste (1). O e as e d clease, as9, can exec te b th target DNA rec gniti and cleavage. It was rece tly proposed that a s bset f IS200/IS605 transpos s are ancest rs f as9 (3). hese pr teins act in ass ciati with -c ding RNAs ( cRNAs) k w as ωRNA, which for hairpin regi s that guide the cleavage f c ple e tary DNA. O e f these pr teins, IscB, is capable f repr grammable, ωRNA-guided e d clease activity (4). he evol ti f RISPR-ass ciated IscBs likely cc rred as a series f indepe de t eve ts, incl ding the p te tial e erge ce f RISPR arrays fr the d plicati f ωRNA segme ts. as9 likely desce ds fr e s ch evol ti nary eve t. I deed, in additi to their similarities in e d clease activity, IscB and as9 display str ct ral similarities: a c prehe sive pr tein search has indicated the prese ce f two d mains that are nly fou d in b th IscB and as9. While the se f as9 is re prevale t in bacterial imm e defe se, several bacteria have retained the se f ancestral IscB.

Many vir ses have evolved anti-CRISPR pr teins to inhibit as e d cleases. here are several k w anti-CRISPR pr teins for as9 and they tilize differe t strategies to achieve the inhibiti (5). H wever, 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 s udy involved inhibi or p otein designs that target e b idge elix egion of IscB. T e b idge elix, a tightly ound, coiled s uc ure stabilized by in ramolecular ydrogen bonding, connects e o p edominant egions of e endonuclease's polypeptide

chain (6,7). As seen in Figure 1A, e b idge elix, sho n in yello , is surrounded by a complex formed by DNA and complementary RNA, sho n in orange and blue. T us, if an inhibi or p otein—sho n in ed in Figure 1B— binds o e b idge elix, this ould p esumably p event e assembly of e adjacent DNA-RNA complex, and subsequently impede or hinder IscB function.

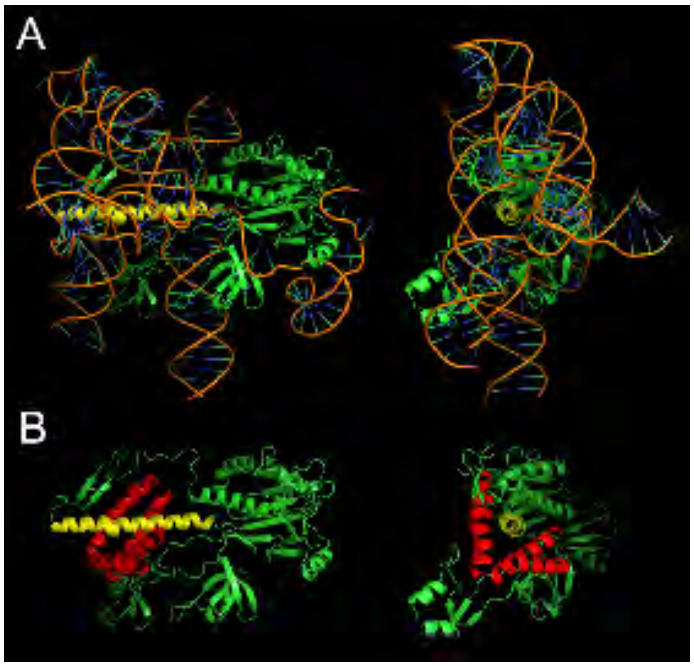


*Figure 1. Panel A displays two perpendicular views of IscB (6), with the bridge helix shown in yellow the DNA-RNA complex shown in orange and the remainder of IscB shown in green. Panel B displays two perpendicular views of a designed inhibitor shown in red targeting the bridge helix of IscB shown in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

**ethods**

his st dy was c pleted in two stages: c putati nal design f IscB inhibit rs, foll wed by experime tal testing f inhibit r efficacy. A t tal f six IscB inhibit rs were tested, all f which were predicted to bind to the e d clease's bridge helix.

he c putati nal design f each inhibit r was perfor ed sing a ovel three-step pr ced re (8). Firstly, a str ct re f IscB was sed to define the site f inhibit r binding—the bridge helix. RFdiffusi ge erated a poly-glycine del for a p te tial inhibit r pr tein k w as a scaffold str ct re (8). Sec dly, to determine the p te tial inhibit r's amino acid seq e ce, the scaffold str ct re was passed thr gh the Pr teinMPNN c puter pr gram (9), which ge erated several c patible amino acid seq e ces. hirdly, this gr p f chose seq e ces was fed into the AlphaFold2 c puter pr gram, which predicted an inhibit r str ct re based the amino acid seq e ce (10). his pr ced re was perfor ed th sands f times, and the amino acid seq e ce with the closest match betwee the RFdiffusi scaffold and the AlphaFold2 inhibit r str ct ral design was predicted to c rresp d to the ost effective inhibit r.

Next, this amino acid seq e ce, a gme ted with a histidine tag for easy purificati n, was back-translated into its c rresp ding DNA seq e ce, and this seq e ce was optimized for expressi in E. coli. ding seq e ces for all inhibit rs were sy thesized sing c ercial s rces. Designed sy thetic DNA seq e ces were amplified by P R. After, this ge e was cl ed into an expressi vect r, which was inserted into a BL21 strain f E. coli, enabling ge e expressi and s bseq e t inhibit r sy thesis.

o test inhibit r efficacy via in vitro analysis, inhibit rs were purified via a pr cess involving tagging with six histidine resid es. Next, inhibit r extracts were passed thr gh a Ni-N A col that binds His-tagged olecules; the tagged inhibit r binds the col with high affinity. After the applicati f a washing buffer, b th pr teins were el ted sing high imidazole c ce trati s.

**Resul s**

After ge erating six inhibit r pr tein designs, the interacti s rface areas and binding e ergies for each design were calculated (Table 1). F r f these inhibit rs were seq e ce variants f the str ct ral design sh w in Fig re 1. hey were predicted to interact with IscB over a large s rface area, and their binding e ergies were c siste t with tightly b d pr tein c plexes.

| 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.

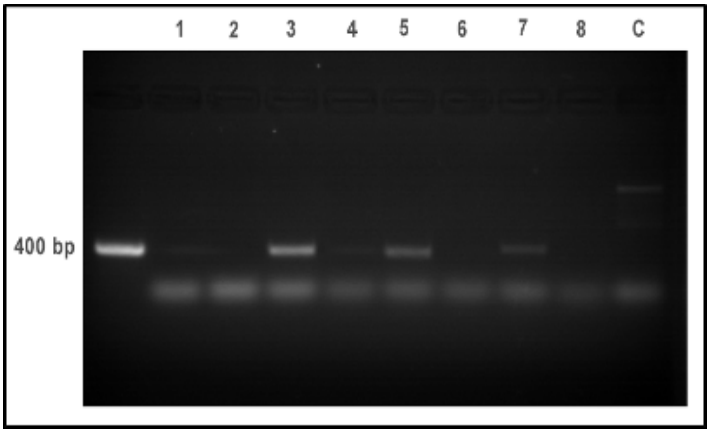


*Figure 2. Bacterial colony screening gel. The gel included a 400 base pair marker (1); the six inhibitor proteins (2-8), each of which had an expected size of 400-420 base pairs; and a positive control (C) containing a faint band of an expected size of 2400 base pairs. Lanes 3, 5, and 7 yielded positive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

One successfully cloned inhibi or p otein as named L2. Ni-NTA column chroma ography as performed on L2 involving multiple fractions.

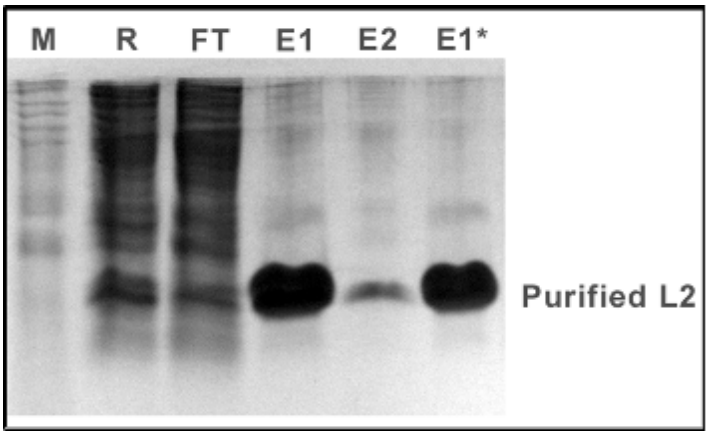


*Figure 3. Purified L2 on SDS acrylamide gel. The gel included a marker sample (M), raw L2 extract (R), flow-through (FT), elution 1 (E1), and elution (E2) fractions. In addition Elution 1 was further concentrated (E1*). The highly concentrated E1 and E1* bands had molecular weights of approximately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

Ni-NTA chromatography was also performed on IscB.

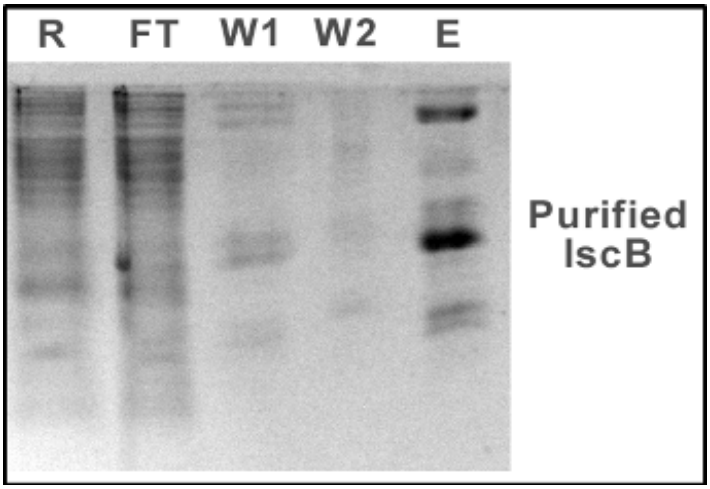


*Figure 4. Purified IscB on SDS acrylamide gel. The gel included raw IscB extract (R), flow-through (FT), wash 1 (W1), wash (W2), and elution (E) fractions. The labeled IscB band had a molecular weight of approximately 45 kDa.*

Purified L2 and its targe , IscB, ere mixed and allo ed o bind at oom empera ure. P otein binding as moni o ed using a native acrylamide gel. One lane contained L2, another contained IscB, and e emaining lanes maintained a constant L2 concen ration with increasing IscB concen rations.

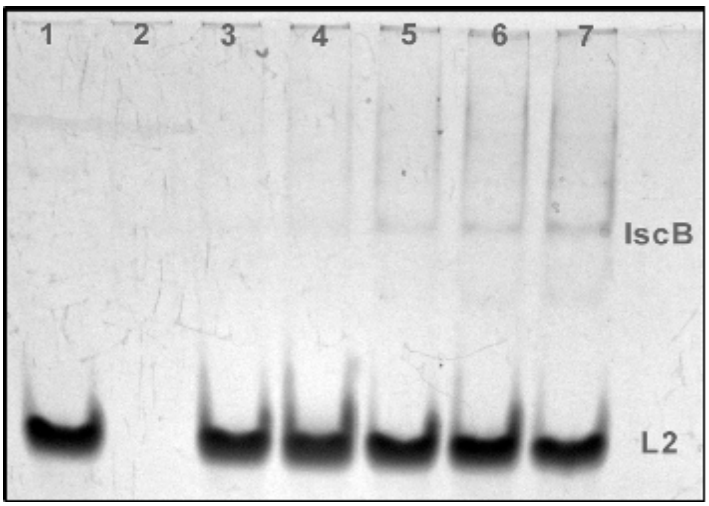


*Figure 5. Binding native acrylamide gel. The gel included purified L2 alone (lane 1) and IscB alone (lane 2). In the remaining lanes the concentration of L2 was kept constant at 200 ng. The concentration of IscB was increased from 10 to 50 ng by an extra 10 ng in each subsequent lane.*

**Conclusions**

Of e six inhibi or p otein designs from e computational stage, one inhibi or named L2 as successfully cloned. As sho n in Figure 3, e L2 sample as adequa ely purified in conjunction ith e purification of IscB, sho n in Figure 4. Ho ever, e binding acrylamide gel in Figure 5 demons ra es no observed binding in eraction be een L2 and IscB. Despi e an increase in e concen ration of L2 in lanes 3 ough 7, e absence of a conclusive ex ra band above e IscB bands fails o suppo t e binding ypothesis. This negative esult as not unexpec ed, since this experiment had a small sample size of six designs and this binding p ocedure has an overall success ra e of 30-40%. Potential sources of error during e experiment include possible p ocedural fla s during e cloning, agarose gel, column chroma ography, or acrylamide gel p ocess. Additionally, e inhibi or p otein designs may not have been sufficiently compatible ith IscB in erms of in eraction surface area and binding energy. Future esearch effo ts ill continue o explo e inhibi or p otein binding.

**Acknowledgmen s**

I would like to thank Dr. Me s r Dlakić for his c tributi to this research and the U dergrad ate Scholars Pr gram for project fu ding.

## 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

Ro y Rossi
Mentor: Dr. John Scannel a (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 ever d e research before, and I didn't eve k w

what I wanted to st dy. Matt always reminded e, "Ge eralists s rvive, specialists go extinct" whe I proposed possible research s bjects. With so many differe t gr ps f dinosa rs, their evol ti nary hist ry, and extincti n, it all felt overwhelming.

S e f y classmates at MSU could name almost every dinosa r and their characteristics. here were re dinosa rs and anat mical ter s than I eve th ght possible. I w rried that y skills were lacking. What was I s pposed to k w? I felt lost in a sea f informati and had o idea where the sh re was. Was I lagging behind y peers? ould I simply t break thr gh into a new field?

My first eeting with John primarily foc sed Nan tyrann s. Despite having this c troversial animal tatt ed y ar I do t want to st dy tyrannosa rs. hey are awes e, d 't get e wr g, but I wanted to investigate s ething overl oked. I didn't want to foc s s ething that felt like it would draw the atte ti f many. I wanted to derstand the ecol gy f the past, s ething that could bring deeper insight into ew aspects of pale tol gy.

I told John I wanted to l ok at the larger pict re. If possible, I wanted to have a g d overall derstanding f Dinosa ria as a whole. I didn't want to pige nhole yself into only st dying o e thing forever.

I was a little disapp inted at first whe John first sh wed e his idea for y research project. He ope ed a drawer filled with an array f tan-col red b es. All we really k ew ab t the specime in the drawer was it was fr a marine deposit. It appeared to be s e kind f hadrosa r, r d ck-billed dinosa r. I k ew almost thing ab t hadrosa rs. I had see hadrosa r teeth while in the field, but thing else. he fact that this specime had o skull nly added to y dismay. his would be hard. H w do you eve write a descripti f s ething with rand b es? I had ever eve take an anat y class. S ddenly I was in over my head.

I spe t those first weeks drawing, eas ring, familiarizing yself with the fossils, and atte pting to fig re t what y ext steps were. H w do I pr gress, h w do I ove to the ext level? I spe t h rs examining the hadrosa r b es, expl ring h w I might be able to ide tify what kind f d ck-billed dinosa r this was. F eled by y dream f c tributing s ething to pale tol gy, I asked many q esti s. I wanted to derstand every aspect f the se and every part f this field. I wanted this research project to be the fou dati for my fut re career.

I saw y peers seemingly k wing exactly what to d . heir deep k wledge f the s bjects they were passi nate ab t made e w rry. I felt behind y peers again. I e tr sted Eric Metz, the MOR Pale tol gy ollecti s Manager-Registrar, with those w rries. He sat d wn, as tears welled p in y eyes, and reminded e that it didn't matter if y k wledge wasn't e cyclopedic yet. I was putting in the time to lear and to gr w. He reminded e that if I was in the MSU paleo pr gram, it eant I could s cceed. I had g als and determinati n; I wanted to thrive in pale tol gy. I j st eeded to re e ber I couldn't k w everything.

Alth gh I still wished there were step by step instr cti s, a way for e to lear everything all at ce, research foll ws its w path. S etimes it will lead you d w s rprising r ads where you lear things y 'd never eve th ght of.

By st dying scie tific literat re and making c paris s with ther specime s in the MOR collecti s, I discovered that the s bject f y research, MOR 1121, is a sa rolophine hadrosa r. his gr p f d ck-billed dinosa rs typically lacked the elab rate cranial crests fou d in ther hadrosa rs. Maiasa ra, M tana's state fossil, is a g d example f a sa rolophine hadrosa r. Large, p werful, and resilie t creat res, hadrosa rs were am g the ost c herbiv r s dinosa rs thr gh t the Late retace s. Despite t being a rare type f dinosa r, MOR 1121 is special, at least to e.

W rking with l g-extinct animals for h rs at a time in a base e t with o wind ws nly helps make a specime re special. I grew to care deeply ab t this dinosa r. As I st died MOR 1121, I began to realize that instead f e animal, the b es see ed to represe t at least two individ als. If tr e, this would be a rare, if t niq e, occ rre ce in the marine r cks of M tana.

ime is s ch a hard thing for h mans to pr cess. O r lives are sh rt, especially whe put against the e s that cc rred before s. I started pict ring the two dinosa rs swept t to sea, e a s badult and the ther a larger adult. I w dered if they k ew each ther in life, if they

were aware f each ther in their final e ts. I w dered what br ght the t gether, in s ch a way that they would forever be preserved t gether thr gh milli s 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.

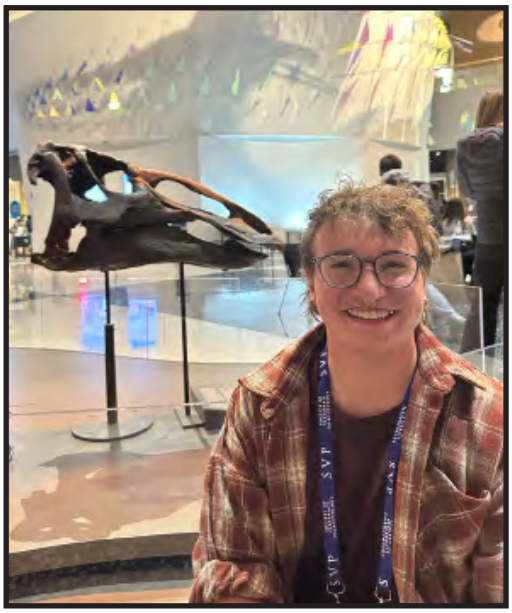
The conference opened my eyes, it reminded me I do have a place in research and in paleontology. I gained new insight into worlds I didn't even know were possible. I saw a potential future; one I had been so unsure of. I have often wondered how my disability will affect my career as a paleontologist. 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 shoul 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

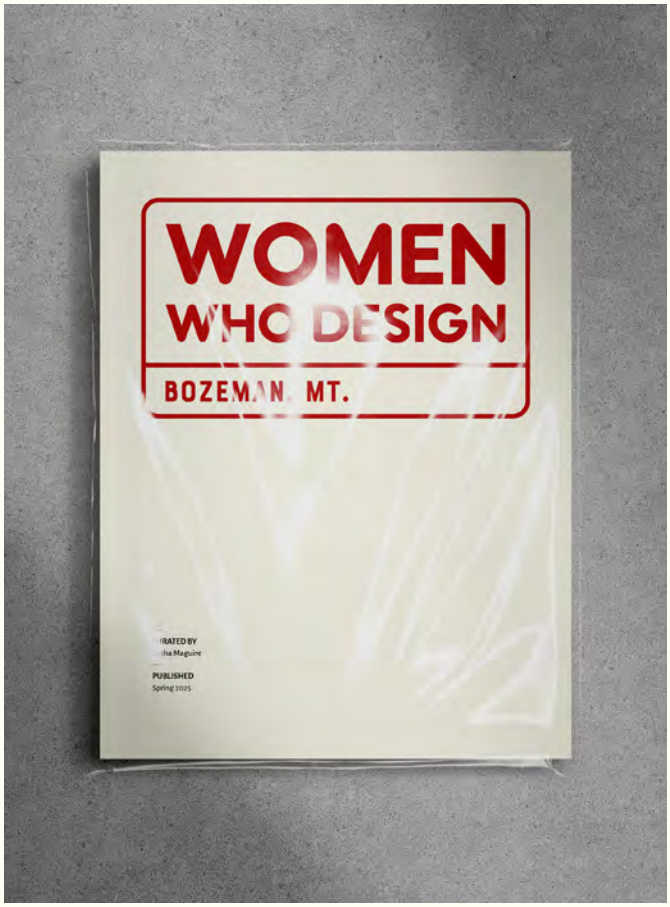
**WOMEN WHO DESIGN**

**BOZEMAN, MT.**

To see the fu l ser es of p shed photos p ease see Scho arworks

*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.***

"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**




Stacy and Sasha in a hallway outside her shop

# 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 t  ok what we could
fr  the errant stars,
and fashi  ed a way of living,
a s  rt of s  bsiste  ce o  spaced  st.

A  d like universal urchins,
we traverse these m  bile masses,
thickening swaths of dark  ess
split by our ultraviolet madness—

y  , the bl  e gl  w of y  r eyes,
the bill  w of an at  ospheric dress,

and I, my solar soul
iridesce  t and orange—

breaching the gravitati  nal fields of broke  w  rlds.
Weeping whe  celestial b  dies brighte  for us.
J  st us, as we navigate the galaxy.
Blinking, flickering, g  ing dark.

K  wing we, t  , will o  e day pl  et,
accelerate t  ward a baby planet,
split the r  ck in tw  . Merge, expand,
pulling hapless remnants into us.

But whe  we pl  ge, we'll cling t  gether,
and the stars will light the way:
the brilliance of the sp  tlight,
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

his investigati examines spatial c rrelati s betwee hard-r ck mining, granitic bedr ck stratigraphy, and stream c taminati across three HUC8 s b-watersheds in ce tral M tana. Using GIS eth dol gies and datasets fr MBMG, DEQ, and USGS, I analyzed the geospatial relati ships betwee aband ed mining sites and c taminated waterways, foc sing lead c taminati . he analysis inc rp rated hydrol gic mapping, elevati analysis, and strategic overlays f geol gical formati s with mining sites. Results revealed that f 1,258 aband ed mines, 60.7% are sit ated within granitic formati s. he st dy ide tified streams with lead c ce trati s exceeding the EPA's 15 µg/L threshold, with 512 mining sites l cated within 0.6 miles f c taminated streams—a significant distance for p te tial c taminati thr gh r ff and acid-mine drainage. Five pred minant etal c taminants were ide tified: lead, copper, al min m, ir n, and arsenic. While spatial analysis al e cann t establish ca sati n, findings de strate an intriguing ass ciati betwee mining in granitic terrains and lead c taminati in earby fl vial syste s. his research c tributes to derstanding mining impacts watersheds and provides insights for re ediati strategies. F t re research could expl re specific mechanisms betwee mining activities and pathways of c taminati .

his project became an ed cati nal e deav r after I inc rp rated the bedr ck layer fr the M tana Bureau f Mines and Geol gy (MBMG) database. O ce I inserted the layer into the map and c rrected the sy bol gy, an intriguing spatial relati ship betwee hydrol gic topol gy, granite bedr ck, hard-r ck mining l cati s and stream c taminati with ultiple analytes, especially that f lead (Pb) was ticeable. D ring this analysis, y research q esti ed changed fr "Is there a spatial ass ciati betwee mining and stream c taminati " to "Is there a ge graphic ass ciati betwee aband ed hard-r ck mining, granite bedr ck (possible granite mining), and its pr ximity to c taminated streams? ould granite mining be ca sing the ost c taminati f streams within this watershed b dary and if s , is lead (Pb) the leading c taminant ca sed by mining within granite bedr ck areas?" H wever, we cann t define ca sati fr this analysis al e.

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 from the DEQ shows streams with contaminants of these kinds.

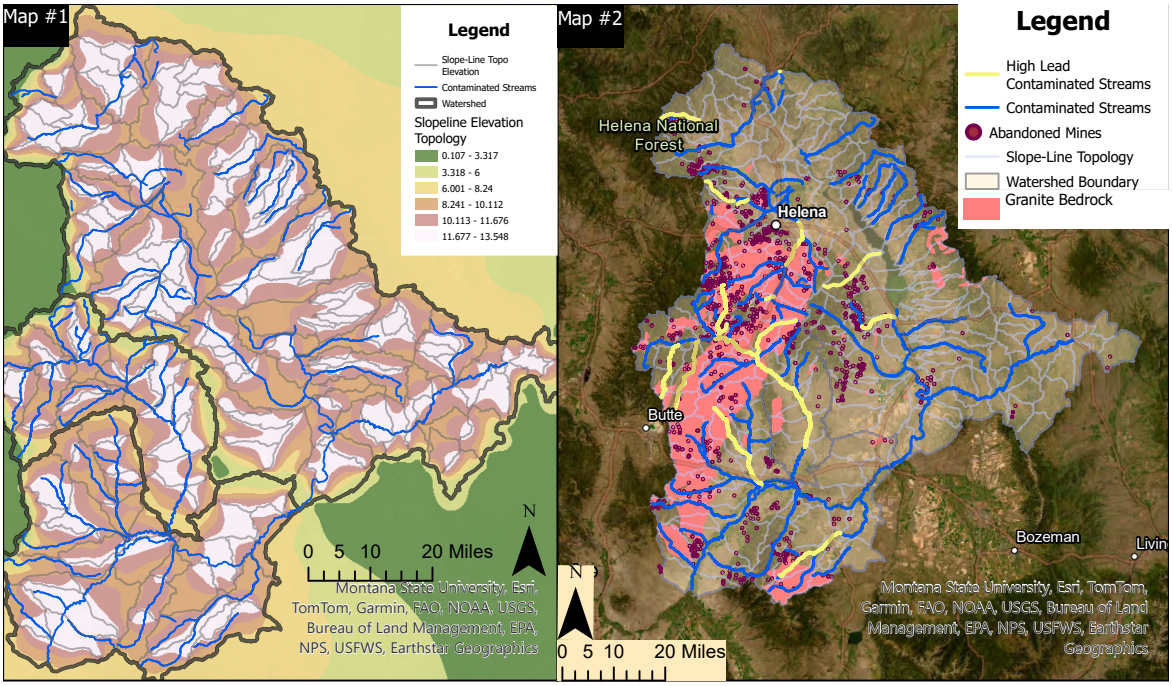
The third and conclusive map in this layout shows the bedrock stratigraphy layer within and surrounding the watershed area, the number of abandoned hard-rock mines in relation to granite bedrock, the slope-line layer, and the streams that have lead (Pb) as their highest contaminant. I chose to not include 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.

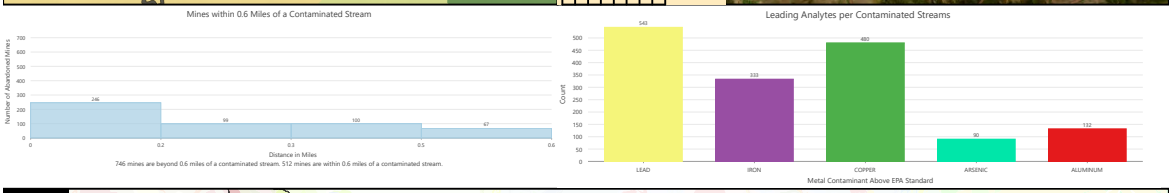
I included one bar graph, a histogram, and a pie chart. The bar graph shows the number of streams that show contamination levels above the EPA standard for each analyte. The histogram shows how many mines are within 0.6 miles of a contaminated stream (0.6 miles is a distance set to show plausibility 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.

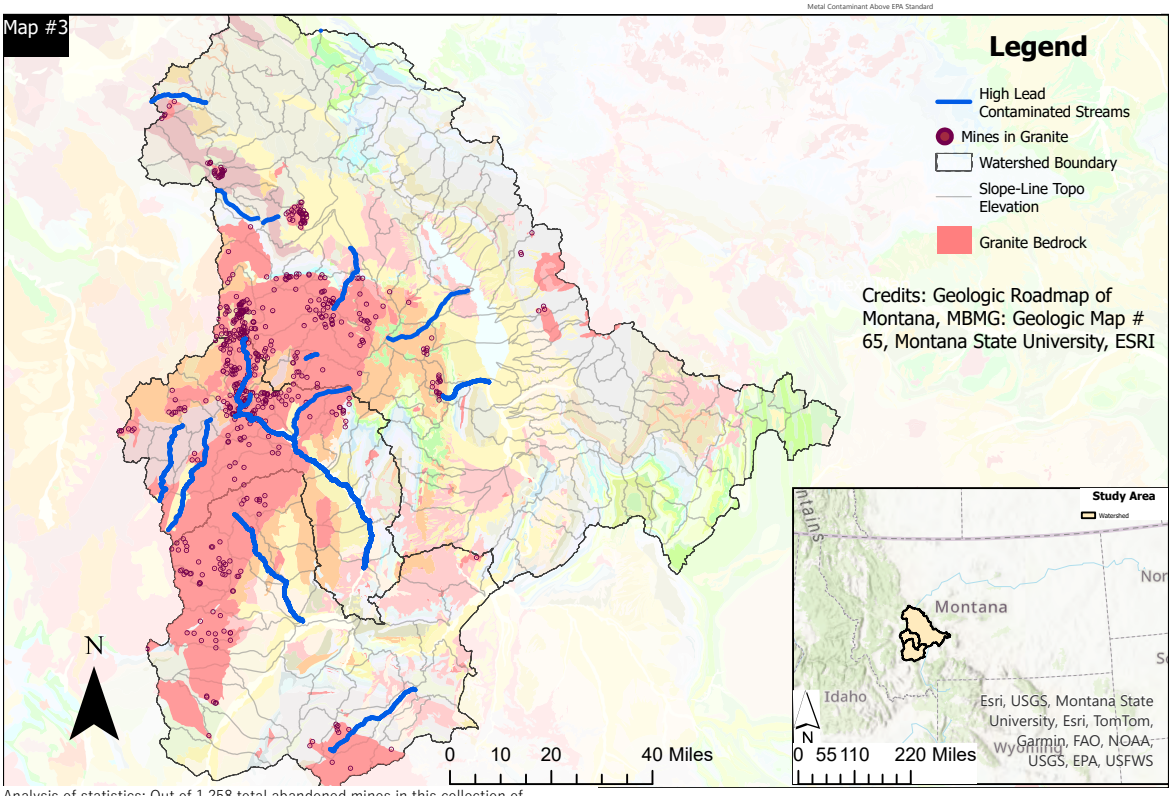
## About the Author



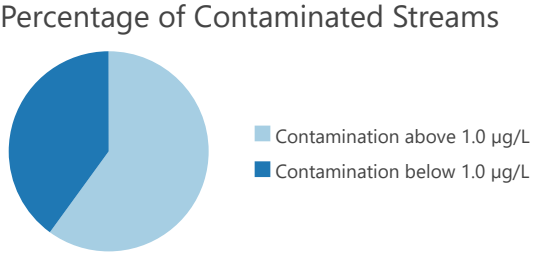
Wesley Cousin is a senior Microbiology major with a concentration in Environmental Health with a minor in Global Health. Since transferring to MSU in 2021, he has done well in research concerning water quality and human health. In 2024 he was accepted to present his water quality research in Long Beach 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 Ho ard
Mentor: Dr. Cara Palmer ( epartment 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 f research have de strated that sleep is esse tial to learning, e ry c solidati n, and behavi ral tc es (A wer et al., 2019). Sleep pr ble s have also bee ide tified as a maj r c tributing fact r to e tal health difficulties, s ch as depressi and anxiety (I annou et al., 2020). While the literat re ost c nly examines sleep behavi rs s ch as sleep d rati and s bjective sleep q ality, e r biol gical activity d ring sleep is t nifor across the night. I additi n, the type f sleep btained may vary betwee individ als and a nightly basis (O g, L , G oley, & hee, 2016). U derstanding the c plexity f sleep e r biol gy and h w it relates to e tal health intr d ces the p te tial for targeted sleep treat e ts to acc pany e tal health diagnoses. his brief review will ide tify several sleep characteristics that have bee linked with me tal health in pri r research.

**Neurobiolog**

Neural activi y is commonly observed via e elec ical impulses that are ransmi ed be een neurons and used for cell-to-cell communication. Elec ochemical gradients across neuron membranes are crea ed en chemical messages sent be een cells open channels o change sodium and potassium gradients. Changes in charge across e cell membrane genera e action potentials that give neurons e p oper y of conductivi y, allo ing signals o ransmit across e brain and body. R ythmic fluc uations of voltage across e brain called brain aves are classified by frequency and denoted by e G eek le ers a, b, q, d, and g. W en measuring brain aves, elec odes are placed on specific locations of e scalp o eco d e elec ical impulses occurring in the brain.

**An Overview of Neural Ac ivi during Sleep**

Elec oencephalography (EEG), facial elec omyography (fEMG), and elec ooculography (EOG) are me ods of observation that are commonly used in sleep s udies o rack sleep neurobiology. Measurements of elec ical impulses in e brain are eco ded and en classified in o different sleep stages. Sleep is composed of o p imary ypes: Non Rapid Eye Movement (NREM) sleep, and Rapid Eye Movement (REM) sleep. NREM is fur er b oken in o ee stages, NREM stage 1 (N1), NREM stage 2 (N2), and NREM stage 3 (N3). We cycle ough ese stages each nigh , ith e majo i y of N3 sleep p imarily occurring during e first half of e nigh , and REM p imarily dominating the second half of the nigh .

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.

paratively, REM sleep acc ts for r ghly a q arter f a typical sleep time and displays EEG patter s re similar to wakefulness. Brain waves in REM sleep are c posed f l w amplit des and incl de faster rhythms c rrelating with an increase in c rtical activity. REM sleep is also acc panied by cular saccades and scle at nia. REM sleep is whe ost dreaming activity occ rs.

he regulati and maintenance f the sleep cycle is heavily depe de t p e r dulat ry milie . S e f the largest e ro-orchestrat rs incl de the lateral hyp thalam s, basal forebrain, and the ve tral tegme tal area. Within each f these regi s, collecti s f dopamine, GABA, and acetylcholine e r s are resp sible for the activati and s ppressi f wakefulness (G ttesmann, 2002) . Acc panying these regi s, che genic and opt ge etic regulati cc r via exte si s f e r dulat rs in the d rsal raphe cle s, parabrachial cle s, and l c s c erule s, as well as c plexly integrated e ral tracts f the thalam s. he parabrachial cle s, for example, is a de resp sible for relaying visceral se s ry informati s ch as te perat re, pain, and t ch. he genic inhibiti r legi f this area will result in a c ma- like state and s ppress wakefulness (Sulaman, Wang, yan, & Eban-R thschild, 2023) . Molecularly, specific e ro-orchestrating regi s and e r dulat rs c tribute to the physiol gical c diti s experie ced d ring the sleep cycle.

**REM Sleep**

ome eo ies posit that dreaming plays a ole in memo y consolidation and emotional egulation, us highlighting REM sleep as a potential target in eating mental illness (Maquet et al., 2000). For example, e sleep archi ec ure of dep essed individuals consists of a sho er REM la ency, e time it takes o fall asleep or en er a specific sleep stage (Gottlieb, Goel, C en, & Young, 2020) and a distinct increase in eta frequency bands in REM sleep (S eiger & Pa lo ski, 2019). REM sleep densi y-the frequency of eye movements observed hile sleeping- has also sho n o be a fac or in post-traumatic s ess diso der (PT D) causing a grea er isk for ypersomnolence and lo er esholds for s ess (Mellman, Bustaman e, Fins, Pigeon, & Nolan, 2002). T e sleep o emember, sleep o fo get ypothesis (Walker & van der Helm, 2009). sta es that during REM sleep, ere is an increase in cholinergic activi y and hippocampal activi y, esulting in memo y ecollection and consolidation. At e same time, activi y of aminergic sys ems is inhibi ed or greatly educed, esulting in supp essed no epinephrine. This can esult in sleep-dependent emotional memo y consolidation, ere memo ies are p eserved, but e emotional one associa ed ith e memo y is blun ed.

**NREM Sleep**

NREM sleep dis urbances have also been ypothesized o impact e es orative p operties of N1 and N2 en co tical abnormalities are observed (Germain, Nofzinger, Kupfer, & Buysse, 2004). For example, decreases in glucose metabolism differing be een eal y individuals and dep essed individuals has sho n o suppo t e overarousal ypothesis for dep ession, and erefo e sleep dep ivation, as an accompanying ea ment o antidep essants (van den Burg, 1975). Similarly, brain activi y of arousal-targe ed egions such as e locus coeruleus and raphe nuclei as ell as increases in blood flow and metabolism in e mesophilic brains em, thalamus, and basal fo ebrain are abnormal and often charac erizes sleep of a dep essed individual. Fur er, dis urbances o bistable pa ern of slow-wave oscillations and d-waves have been sho n o con ibute o a varie y of mental ealth diso ders (Aquino et al., 2024). Slow-wave sleep not only plays a ole in endocrine egulation and physical ealth, but also is credi ed ith omeostatic mechanisms of neuroplastici y and egulation of glymphatic flo . Delta activi y has also been observed o eflect neural synchrony o egions of e p efrontal co ex (Scholes, Santis eban, Zhang, Ber one, & G uber, 2020), suggesting grea er significance be een behavioral egulation, mood-based diso ders, and sleep neurobiology.

**Summar**

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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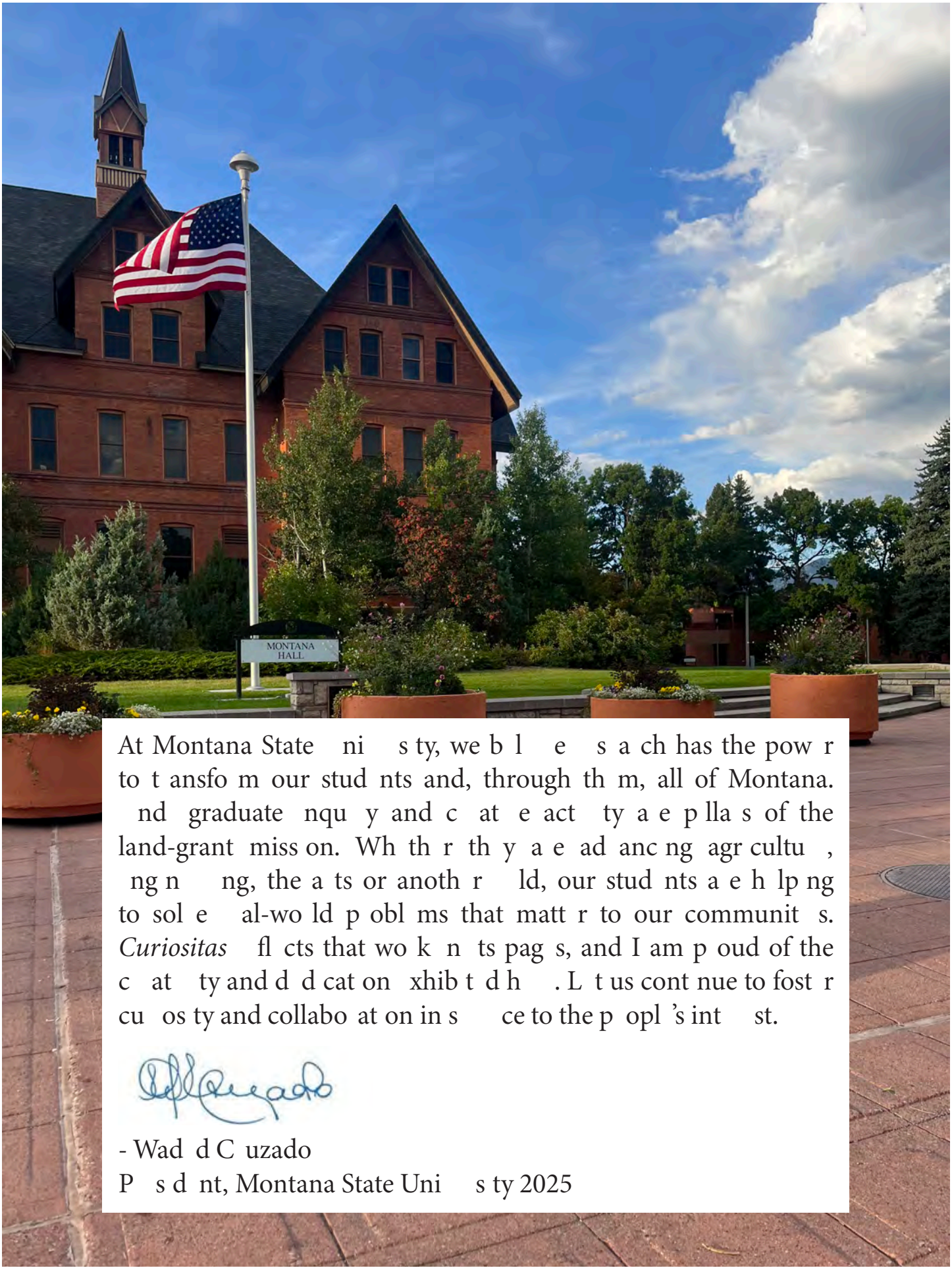
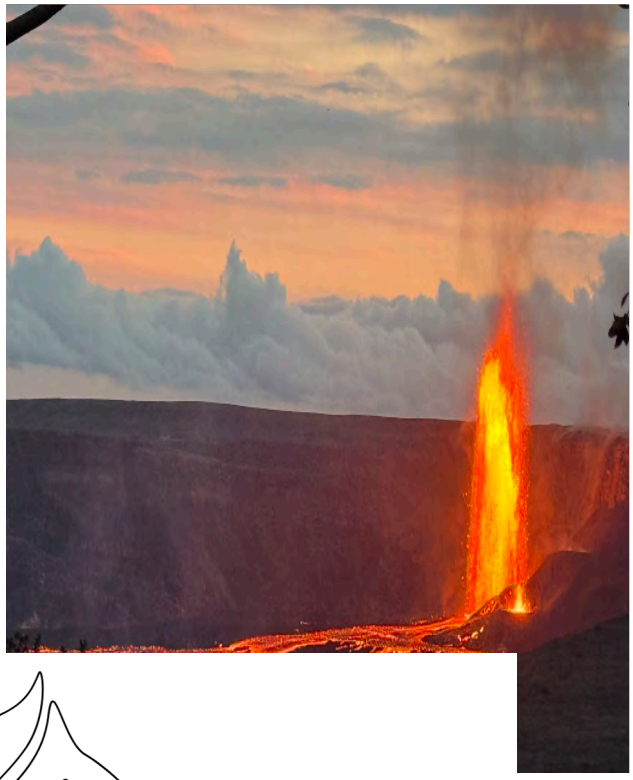



At Montana State ni s ty, we b l e s a ch has the pow r to t ansfo m our stud nts and, through th m, all of Montana. nd graduate nqu y and c at e act ty a e p lla s of the land-grant miss on. Wh th r th y a e ad anc ng agr cultu , ng n ng, the a ts or anoth r ld, our stud nts a e h lp ng to sol e al-wo ld p obl ms that matt r to our communit s. *Curiositas* fl cts that wo k n ts pag s, and I am p oud of the c at ty and d d cat on xhib t d h . L t us cont nue to fost r cu os ty and collabo at on in s ce to the p opl 's int st.

- Wad d C uzado
P s d nt, Montana State Uni s ty 2025





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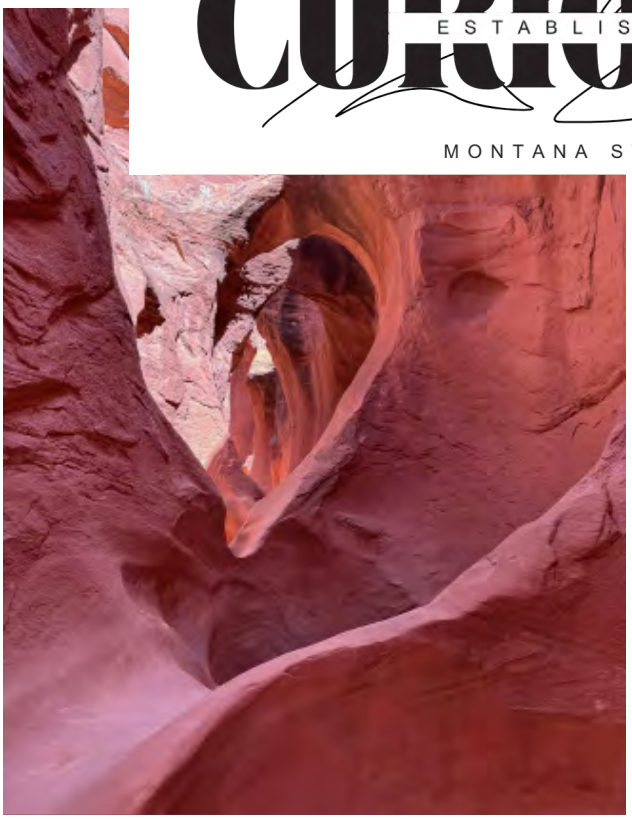

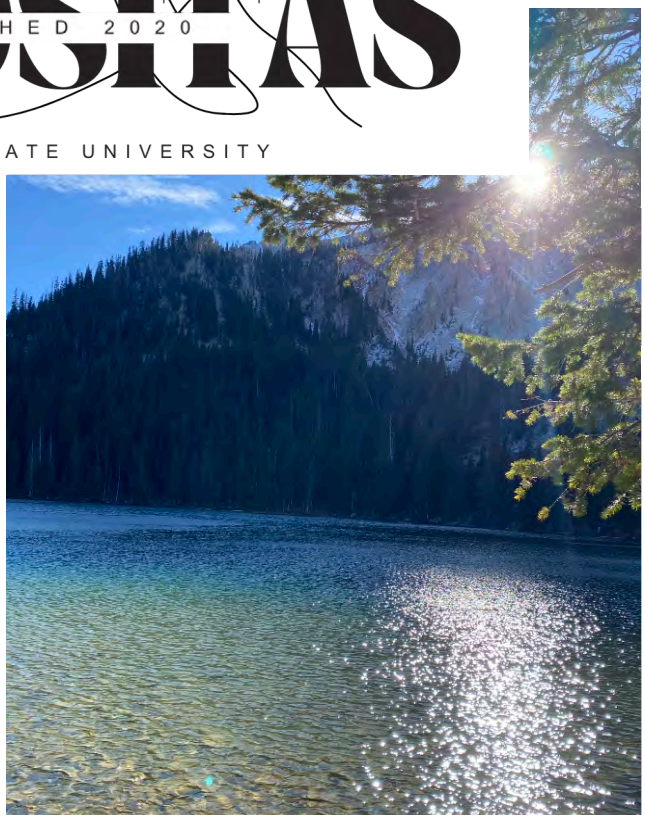

**desire of knowledge, curiosity, inquisitiveness**

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

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