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FOREWORD

Dear Reader,

I am proud to present Volume 7 of Occam’s Razor, which represents a sampling of undergraduate work from the Anthropology, Biology, English, Environmental Studies, and Liberal Studies departments at Western Washington University. As academics, we often spend a great deal of time with individuals from our own fields of study. In contrast, each volume of OR aims to highlight the interdisciplinary nature of a strong academic experience. The editors have the privilege of reading work from a variety of disciplines throughout the submission process and more closely during the collaborative editing process. Now, it’s your turn to step outside of your comfort zone and challenge your perspective.

I am thrilled at the opportunity to showcase the extraordinary work of my peers. I want to thank the seven authors featured in this volume for their time and commitment during the long editing process; getting to pick their brains was a treat. Moreover, I want to wholeheartedly thank the talented editors, designers, and volunteers for making this volume possible.

Please enjoy.

On behalf of the Occam’s Razor staff,

Hannah Lazich
Editor-in-Chief
Ella Higginson’s writing shows us a woman obsessed with the natural world and humankind’s position within it. Displaced to the remote Pacific Northwest at a young age, Higginson had ample time to explore and write about her own relationship with the mostly untouched Nature that surrounded her. As a devout Protestant woman in the late nineteenth and early twentieth centuries, it would be fair to expect the depictions of Nature that arise in her work to reflect a Christian-American worldview.

In “The Greening of Religion Hypothesis (Part One)” and “The Greening of Religion Hypothesis (Part Two),” Bron Taylor discusses how—as far back as the early 1900s—prominent environmentalists identified ways that Christianity in America was at odds with environmentalism, with Sand County Almanac author Aldo Leopold saying that American Christianity was “both a hindrance and essential” to the battle over ecological conservation (“Part One” 283). However, Taylor also notes that, before the mid 1960s, these voices were not necessarily impactful on American Christianity as a whole; religion would “often hinder... pro-environmental values and behaviors” (“Part Two” 348), exacerbating the development of anthropocentric attitudes which kept humans morally separated from and elevated above the nonhuman natural world (“Part One” 274). In this religious framework, a domination-and-submission relationship arose, where American Christianity provoked—at best—total indifference toward the fate of nonhuman natural beings, with complete domination not being uncommon.

Higginson’s poetry espouses a far more radical view. For Higginson, Nature acts as an intermediary presence between the imperfection of postlapsarian

ANTHROPOCENTRIC:
considering human beings to be the most significant entity in the universe
humanity and the eternal perfection of the Christian God. The feminine character of Nature is as central to its essence as is its existence on the material plane. This viewpoint specifically rejects what O. P. Dwivedi and Lucy Reid would later identify as a “destructive, dualistic ordering of the world, where the Masculine is superior to the Feminine, the heavenly to the earthly, the spiritual to the material” (308). By incorporating her Protestant, ecofeministic themes, Higginson's poetry undoes the world's “destructive, dualistic ordering” in three ways: by positioning the Divine alongside the Natural, by placing Heaven on Earth, and by removing Man from the privileged position above Woman, so that the Feminine can inhabit its deserved place as part of this divine Natural, all while attributing a distinctive feminine character to the natural world around her.

We receive the first strong glimpses of Higginson's unique brand of Protestant ecofeminism in her foundational poem “Four-Leaf Clover.” Published in 1890, this piece lays the groundwork for themes that would reappear in more developed ways in her later, explicitly ecofeminist writing. Most striking is the discussion of the inherently divine aspect of the material natural world and the inability of humankind to ever actually take dominion over this divine presence.

“Four-Leaf Clover” begins with a description of where to look for the titular plant, describing “a place where the sun is like gold”, the “loveliest nook, / where the four-leaf clovers grow” (Higginson 59). It appears, at first, that the narrator is simply fawning over a beautiful natural phenomenon and being thankful that she can witness such a moment. However, the stanzas that follow situate the Natural—in the form of the clover—within this place as not only aesthetically pleasing, but divine:

One leaf is for hope, and one is for faith,
   And one is for love, you know,
   And God put another in for luck!
If you search, you will find where they grow. (59)

This stanza moves the “loveliest nook” and its contents from a purely corporeal status to one that is simultaneously natural and of the Divine in a form of Nature-based consubstantiation. What is most important about this stanza is how Higginson, rather than simply saying that these plants were made by God, depicts the four-leaf clover as being intimately constructed by God on an individual basis, emphasizing their importance as self-contained entities in relationship with—but not subordinate to—their human counterparts. God intentionally put the petals of each clover in position with a future purpose in mind for each one. And these purposes—hope, faith, love, and luck—while described in American and Protestant terms, are never stated as being, say, hope for humans or love between humans nor any other similar variation. They were not made for us, but they can be experienced by us.

The final stanza further elevates the clover's position, revealing that in order to even experience these divine creations “you must have hope, and you must have faith, / You must love and be strong” (59). In this passage, the four purposes as-
cribed to the clover’s leaves are revealed not as tools for human use, but qualities that exist within the clovers themselves. Humans must individually come to possess these qualities if they desire to ever find the divine clover’s beatific nook. Here, Higginson explicitly demonstrates what Dwivedi and Reid claim is intrinsic to Christian ecofeminism, that “Heaven can be heaven on earth, and God can be found here and now,” both of which allows us to refamiliarize ourselves with both our physical selves and the material beings around us (315). The goal promoted in “Four-Leaf Clover” is not to find and dominate the clover, nor is it to search for the hope, faith, love, and luck. Rather, it is to enter the presence of the Divine within the clover through one’s own personal realization of hope, faith, love, and luck. The divinity of the clover is represented in its four purposed petals, and this divinity is one that can only be met by humans, not controlled or harnessed.

Higginson’s foregrounding of divinity within the natural world parallel to humans is the first branch of an increasingly radical tripartite thematic refutation of the aforementioned “destructive, dualistic ordering of the world,” with “Four-Leaf Clover” directly attacking the first hierarchical leg; the theological privileging of the human spiritual existence over—and separate from—the material existence of the natural world. Continuing with her attack in an undated, untitled, and (presumably) unpublished handwritten poem (which will hereinafter be referred to as “Untitled”) found in Higginson’s papers at the Center for Pacific Northwest Studies at Western Washington University, Higginson gives us a clear rejection of the second problematic hierarchical positioning she saw affecting both women and the world—the privileging of the space of Heaven over the space of Earth.

“Untitled” begins with the narrator openly lamenting the sectarian nature of Christian denominations on Earth, stating “God I am worn thin with creeds and isms / That weight the brain and heart!” Higginson was a non-denominational Protestant, and it is easy with this knowledge to assume from these opening lines that the narrator is making a case for the privileging of Heaven over Earth. She is openly decrying the central pillar of American organized Christianity at the time—the Christian creeds—and the very concept of religious organization itself, whether that organization (or “-ism”) is, for example, Anglicanism, Lutheranism, or even an all-encompassing Protestantism. However, in the lines immediately following, the narrator does not yearn for an escape from these creeds in Heaven or the afterlife, but asks God to “let us go into the deep wood, / far from the world apart.” The reprieve sought by the narrator, from the spiritual anguish she faces at the hands of the human-made Church, can only be attained by a direct connection with God in the God-made wilderness.

This direct connection is not, however, simply a spiritual one. As we see in the second and third stanzas, it is represented as both a physical and spiritual connection with God the Father, which mimics scenes from the life of Christ as depicted within the Christian scriptures:

Lord God, let us two go alone
into the forest deep,

where the cottonwoods snow noiselessly,
and the drooping willows weep.

There I will kneel me silently,
low at thy white, white feet
and bathe them with my long, soft hair
perfumed and scented sweet. (Higginson)
To fight back against the hierarchical privileging of Heaven over Earth, Higginson places the narrator of “Untitled” in an intimate Heavenly relationship with God on Earth and within the wilderness, simultaneously mimicking two sections of the New Testament; the temptations of Christ as a newly baptized man in the wilderness of Judea and the Anointing of Christ as told in the gospel of Luke.

While the Gospel of Matthew explains that “Jesus was led by the Spirit into the wilderness [of Judea] to be tempted by the devil” (NRSV, Matt. 4:1), “Untitled” begins with the poem’s narrator “so tempted and so torn, / so tortured by these creeds!” that she craves an intimate venture into the wilderness where she hopes God will “Give [her] that high, exalted truth / that like a white light leads” (Higginson). Here the narrator not only mimics the journey of Christ but has Christ fulfill the position of guide, which the Holy Spirit fulfilled in the Biblical narrative. They are walking in Christ’s footsteps, and the force guiding the individual away from temptation for both the narrator and Christ has specifically led to seeking solace in the isolation of the wilderness.

In the biblical narrative, Christ had just been baptized and, despite having been surrounded by fellow followers of God, the Spirit immediately placed him within the isolated wilderness and away from his baptismal river to further affirm his faith by enduring temptation. In the exact same way, our narrator needs to be “far from the world apart” (Higginson), so God himself rejects the manmade world in favor of the divine Natural as a place of ultimate spiritual strengthening and connectedness. The wilderness of Nature is precisely where God leads both the newly baptized Christ and the woman “worn thin” by the Earthly body of believers.

After God has led our narrator into the wilderness we are given the final scene, which elevates Earth to equal footing with Heaven through a reenactment of the anointing of Christ from the Gospel of Luke. Luke 7:37 begins with a description of the unnamed woman who anoints Christ’s feet with her tears. She is “a woman . . . who was a sinner” who “stood behind [Christ] at his feet, weeping, and began to bathe his feet with her tears and to dry them with her hair” (NRSV). In reading this passage from the Gospel of Luke with Higginson’s poem in mind, two things are of vital importance: the fact that Luke identifies this woman as “a sinner” and that Christ rejected the transactional, Pharisaical interpretation of the events.

The nature of the repenting woman’s sin is never explained, which suggests that it is irrelevant. What does matter, however, is that Luke found it necessary to locate this woman centrally as a sinner, meaning that her sinful nature was in some way exceptional. The very foundation of Christianity derives from a belief in the postlapsarian sinful nature of humankind as a whole; when Adam and Eve committed the original sin, human nature changed forever. Therefore, if Luke were to specifically identify the sinful nature of every person that Christ came in contact with, the Gospel of Luke would be less a telling of Christ’s life and more an extended list of names followed by the phrase “who was a sinner.” With
this in mind, we must recognize that by placing her narrator in the position of this woman, Higginson provides a narrator who is not just a sinner, but one of exceptional sinfulness. In this, Higginson’s narrator becomes our nineteenth century version of the Biblical repenting woman, and it is her inherent sinfulness that leads to the interaction they share with Christ.

In both narratives, this action is depicted as an entirely personal and physical act, yet the two interactions occur in vastly different environments. In Luke’s telling, it is within the human-made home of the Pharisee, while in Higginson’s poem the interaction takes place in the God-made divine wilderness. This locational difference—in conjunction with the established connection between the two women—reiterates the importance of the wilderness as an Earthly equal to Heaven, following the allusions to Christ’s own entering of the Judean wilderness.

The story of the Anointing from Luke is often seen as one of simple forgiveness; the woman was a sinner, and Christ forgave her sins due to her kindness to him. However, as Wendy Farley notes in her article “Luke 7:36–50” this is a false and Pharisaical reading:

If we hear in this passage only a message of forgiveness, we remain in the world of the Pharisee: the unrighteous might be forgiven but they remain outside the world of decent behavior; they do not come to our parties. To see with the eyes of Christ, however, we must imagine that before she entered the house, she experienced affliction that is interpreted by the Pharisee as sin. But Jesus sees something else, and in seeing it, awakens in her hemorrhage of love and crazed gratitude. In this “seeing,” he responds poignantly and eloquently to those who are dazed and ground nearly to dust by trauma . . . Jesus sees in [the woman] someone inflamed by love. He recognizes her, just as she recognizes him. In this mutual recognition, the category of sin dissipates like mist in the dawn light. (77)

The Pharisee fails to see the woman Christ is seeing, which is, of course, the true essence of the woman herself; he sees only a sinner, ignoring the material conditions that led to a situation so wrought with sin that Luke felt the need to forefront said sin as an integral part of her identity. In doing so, the Pharisee ignores the full scope of this woman’s actions as well as Christ’s response. Yes, the woman anointed Christ’s feet intimately, and yes, Christ forgave her of her extraordinary sin. However, it is not a simple transactional relationship. Christ saw a sinner so traumatized by the sinful nature of her life that she could not help but weep on his feet and affectionately clean them with her hair afterward. The vitality of this story comes not from the physical acts, but from that shared “seeing”—or sight—where Christ recognizes the woman as a loving child of God and the woman recognizes Christ as a being for whom she has a deep, uncontrollable love. By situating her narrator within this same dynamic, Higginson presents a similarly devoted Christian with a similar desire to see and be seen.

This sight, or recognition of innate nature, as shown in “Untitled,” is what makes the location of the wilderness crucial. Whereas in Luke we are shown the Pharisee’s presence as a representation for the humanly misunderstanding of
what truly goes into that intimate relationship with God, Higginson completely removes humankind from the equation and elevates the Earth to the position of a third player in the intimate relationship. It is not the “creeds and isms” of the human-constructed forms of Christianity that allow the intimate relationship with God, nor is it a separate Heaven. Rather, the Earth—in its natural state, apart from “the world” and “life’s tumultuous mart”—allows for the sight, which is depicted biblically as the true Heavenly relationship with Christ. Higginson moves the Earth from a physical location to the only place where Christians, through true connection with the Natural, can attain the “high, exalted truth” that will lead them to Heaven (Higginson). Just as the Divine and the Natural are not truly separate, Heaven and Earth are not truly separate; both rely upon the other to actualize themselves. We no longer have Heaven over Earth, but rather Heaven alongside Earth. The relationship is both equal and interdependent.

Through her poetic contextualization of Earth and its relationship to God, Higginson’s environmentalism becomes strikingly apparent. However, Higginson is not satisfied with showing the Natural as equal to the Divine or the Earth as equal to Heaven. She actually furthers these radical rejections of typical Christian hierarchies by taking the natural parts of the Earth, which she consistently elevates to the same importance as Heaven, and gendering them as distinctly feminine. For Higginson, Nature—that divine intermediary between humanity and God—not only exists materially on Earth but as an extension and manifestation of femininity and the female sex, removing the Masculine entirely from its typical privileged position.

“Four Leaf Clover” set the foundation for much of Higginson’s ecofeminist thought. In addition to initiating the move of Nature from purely material to simultaneously material and divine, “Four Leaf Clover” also gives us our first strong examples of Higginson’s female gendering of Nature by using rhetorical tools very similar to those utilized in the scriptures. In its opening stanza, this poem lays a framework for the basis of a feminine Nature that Higginson builds the rest of this poem—as well as the remainder of her poetic catalog—upon:

I know a place where the sun is like gold,  
And cherry blossoms burst with snow,  
And down underneath is the loveliest nook  
Where the four-leaf clovers grow. (59)

Higginson uses this nook to illustrate the possibility of the Divine to be experienced by humans but the inability of humans to control said Divine. Additionally, Higginson’s language moves said Divine from a neutral to a specifically feminine position. This transmutes the Feminine—now directly linked with the uncontrollable Divine—from something that can be controlled to something that, like the Divine, can only be experienced.

Higginson provides an introduction into this experiential relationship by weaving not only yonic, but also mammary in-
agery into “Four-Leaf Clover.” This parallel carefully mimics the female form and offers an intimate, literary experience of the feminine Divine built upon floriography reminiscent of that found in the Song of Songs (Tran 113). All of this begins in the poem’s second line, where Higginson chooses cherry blossoms as the plant which will “burst with snow.” Higginson was a white woman, and in a time and culture when non-European depictions of the female form were rare, it is safe to assume that she would primarily orient her understanding of the female form within the context of the form of white women. With this in mind, Higginson’s description of cherry blossoms bursting with white snow evokes the breast of a white woman; the snow through which the blossoms burst serving as the pale skin, the light pink petals of the blossoms serving as an areola, and the role of the nipple being fulfilled by the darker pink center of a “bursted” cherry blossom.

This imagery itself, while strong, is not what confirms this divine Nature as one that is feminine. The confirmation comes from the following two lines and their spatial relationship to the first. After describing the mammary cherry blossoms, Higginson tells us that “down underneath” said blossoms are the “loveliest nook / where the four-leaf clovers grow” (59). The use of “down underneath” and “nook” here constitute the second half of the stanza as yonic while the first half denotes mammary; we are given the image of the cherry-blossom breasts to begin the stanza, and following that we are given the image of a nook spatially underneath said breasts. This nook actually serves as Higginson’s most overtly feminine image. Not only are we provided with a small crevice below flowers that are reminiscent of a white woman’s breast, but we are given a crevice that is abound with clovers. These clovers being, of course, plants which grow in low, dense bushes upon the nook, not unlike pubic hair upon the female pelvis.

What Higginson’s reader is offered is a very clear depiction of the white female form. We have the cherry blossom breasts, with their white skin, light pink areolas, and dark pink nipples, and “down underneath” those we have our vaginal divine nook that abounds with dense, low, pubic-hair clovers. All the while these blossoms are “bursting” and these clovers are “growing”; there is a transformation of the mammary and yonic occurring alongside their description as intrinsically divine. The image Higginson paints is not just a female one, but a pubescent one; it is celebrating the becoming of a woman through puberty. The breasts are enlarging—or as Higginson describes, “bursting”—and the pubic hair is growing. Then, too, with the clovers functioning as the central divine element of the poem, we are shown not only that the Natural is feminine, but that Nature follows the same cycle as female sexual development; the exact cycle that Higginson herself would have experienced. Her understanding of a feminine Divine is not an abstraction but one based on lived, material reality.

Though Higginson would go on to write extensively with a female-gendered Nature, returning often to floriography, one of the most striking examples of her unique ecofeminist thought actually
comes from a poem that not only uses masculine imagery but uses it directly juxtaposed with that of the implicitly feminine Nature. “Midnight on Brooklyn Bridge” does not simply work as a masculine answer to what could be called Higginson’s “nature poetry,” such as “Four Leaf Clover” and “Untitled.” Instead, this poem works within its own subcategory to depict twentieth-century industrial society as both diametrically opposed to Nature and intimately linked with the Masculine.

This poem begins by celebrating her home with the exclamation “Ah me! I know how large and cool and white / The moon lies on the brow of Sehome hill” (72). From the very beginning, Higginson describes longing for a part of Nature, one that has historically been linked to femininity. Similarly, the language used to describe the moonlit night is soft and gentle, describing the moon as “large and cool and white” and later discussing the “luminous background of this soft night” (72). The language continues like this, referring to the sound of crickets as “deep delight.” It is all pretty standard fare for Higginson. However, the second stanza takes both a thematic and lexical shift, moving from the soft, loving descriptions of Nature to the rough, uncomfortable ones of the city. She states at the start of this stanza that “City, a lifetime spent in thee were not / Worth one night in my western solitude!” (72). As with the first stanza, Higginson begins with an exclamation, although this is one of disgust rather than longing. Her unloving description of the city continues with the most damning lines in the poem coming at the end of the second stanza:

Thy pulse is feverish, thy blood is hot,
Thine arteries throb with passion heavily;
But oh, how sweet I hear, in interlude,
The beating, moon-lured tides of Puget Sea. (72)

As one can see, the descriptions of life in the relatively untamed twentieth-century Pacific Northwest are vastly more fond than those of the fully industrialized New York City. What is important about this poem, though, and what situates it within Higginson’s wider set of ecofeminist poetic elements, are not just the depictions of Nature as favorable to the city, but those of the undesirable city as unambiguously masculine.

Higginson had no fear when it came to including feminine and even yonic imagery in her poetry and does so quite frequently. Her masculine imagery is much less common, and phallic language is incredibly rare. “Midnight on Brooklyn Bridge,” however, does not stray from said phallic imagery, even when vulgar. While the feminine Nature experienced on Sehome hill was “cool” and “white” and “soft,” the city is “feverish,” its blood running “hot.” The city itself is, without a doubt, one of the—if not the—most clearly phallic images present in Higginson’s poetry; that of a hot, feverishly pulsing city throbbing with passion. And beyond just being borderline vulgar in its phallic descriptions, “Midnight on Brooklyn Bridge” deprivileges the city and, by extension, the Masculine.

With this final denunciation of mas-
culinity and the phallic, Higginson completes the third branch of her radical restructuring of typical nineteenth and twentieth-century hierarchical structures, both secular and Christian. Higginson has removed all privilege from the phallus and its associated masculinity by connecting it with the inferior, human-made city, all the while maintaining a direct gendering of the superior Nature as feminine. In this reversal of patriarchal literary tropes of the time, Higginson’s entire ecofeminist framework becomes complete; she has successfully gendered Nature as feminine, has shown gendered Nature to be inherently divine, and has elevated divine Nature to a position of spiritual equivalence with Heaven. It is only once all three branches of Higginson’s attacks are realized that the true radical nature of both her Protestantism and ecofeminism can be seen. It is about more than rethinking the role of women within Nature or the role of Nature in our spiritual lives; it is a total rejection of what were, and often remain, fundamental aspects of the dominant Christian and environmentalist ideologies. It is a radical development of the gospel of Luke, wherein the necessary Christian “seeing” is one not only shared with God the Father or Christ the Son but also with Nature and the feminine self.

ENDNOTES
1. Note: Ella Higginson stated, later in life, that the “luck” referred to in this poem is not the typical notion of luck, which caused confusion for some readers. Rather, she uses “luck” as a reference to “industrious hard work,” which she will later rephrase in the same poem as “strength” (Laffrado 60).

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Theatrical performance has survived for thousands of years and is still studied today by millions of aspiring artists. People have always gathered to tell stories and perform their own works in front of an audience. Since 1948, the Tony Awards have provided recognition to exceptionally original playwrights. The script of a play is often the foundation for a Broadway show, making it highly prestigious to be a recipient of the Tony Award for Best Play. The televised award ceremony brings together the most brilliant minds of Broadway for recognition.

Four to five playwrights are nominated per year, but only one wins. Theater enthusiasts have noticed that the Best Play award is mainly bestowed upon white playwrights, causing concern about the types of plays being celebrated—and the types of plays that are not. To date, no Mexican-American has ever been nominated for a Tony Award and all eight of the female recipients have been white. It is not as if Anglo playwrights are naturally more engaging writers or Mexican-Americans struggle to write anything innovative. It is a matter of whose plays are being produced on and off Broadway, and therefore are receiving more mainstream representa-
tion. Without Chicanx playwrights being honored at the Tony Awards, the threat of inequality and misrepresentation remains.

The fact that Mexicans have been on American soil longer than Caucasians makes it appropriate for Chicanx literature to be incorporated into American understanding (Pesquera, 298). For centuries, Mexicans lived in what is now the Southwestern United States. A peace treaty from 1848 converted the land of Northern Mexico into the land of Southern United States; the Mexicans who inhabited that land could either become full citizens of the United States or move further south to Mexico (Pesquera, 298). The majority chose to become citizens to avoid having to relocate their farms and families. The Treaty of Guadalupe Hidalgo of 1848 was designed to include Mexican citizens in American government so they would have the same rights as the white Southwesterners. Unfortunately, the opposite was achieved.

Mexican-Americans were treated like outsiders on the new American soil and were denied equal treatment as Americans. Beatriz M. Pesquera of the University of California, Berkeley writes, “Cultural differences between Anglos and Mexicans became the ideological basis that legitimated the unequal treatment and status of Mexicans in the United States” (Pesquera, 298). While the name of the land may have been Americanized, it should be recognized as a land that many indigenous people built their families upon. Elizabeth Martínez writes, “The Chicanas was raped by the invading gringo both in the literal, physical sense as well as in the sense of those forms of oppression opposed on all our people, both men and women” (Martínez, 32). Yet today there is a population of Americans who believe Anglos were in the United States first, and that Mexicans who are trying to live in America are invading the land. When considering how seldom Chicanx plays are produced, one can see how the remnants of such a mindset are still present in the United States. These Chicanx authors and the people they represent are regarded as the people that don’t belong here, as if they are tainting the land that they held before colonists staked their claim.

The white man had no problem with taking the cultural identity of the Mexicans and denying it the opportunity to flourish. Gerard Navarro is a Chicano playwright who has written “Gitano Fronterizo” and other plays. His works present his perspective as a Mexican man living in the United States. Navarro’s writing expresses the impact of having white Americans assume their race is the superior one that deserves land ownership more than Chicanxs. Kirsten Nigro, a professor of world literature at the University of Texas, El Paso, writes about Navarro’s objectives in his plays; “His politics were more about the degradation that first-world political and economic hegemony have inflicted on third-world spaces” (Nigro, 10). The overlap of white Americans and Chicanxs living in one land has caused a collision of cultural identities that has led to a top dog, underdog dynamic. An interview by Adelaida Del Castillo, the 1974 associate editor of Encuentro Femenil, the first Chicana feminist journal, wondered if the Chicanx movement and the Civil Rights Movement could ever collaborate. Given that these movements both occurred in the 1960s, a partnership would make sense. However, the person who answered this
question, an unnamed Chicana, describes Chicana and Black women as third-world women living in an oppressive state that owes them their own movements due to their different racisms. Partially from racism and partially from ignorance about this history, Anglos do not see the value in representing Chicanx plays. As these writings fail to be produced, they become stories that will be forgotten. If such plays are not taken note of, the trend of Anglos being celebrated and hailed for writing Best Play of the year will continue. Until American theaters produce Chicanx plays, audiences will fail to recognize Mexican-Americans as valid residents of the United States. Their experiences in America are vastly different from what Anglo-Americans have experienced and it is necessary to highlight these different histories.

Luis Valdez began the movement that introduced the working-class Chicanx community to the advantages of theater in expressing political dissatisfaction. Following his lead was the introduction of Chicana playwrights to the Mexican-American theater community. Josefina López and Estela Portillo are Chicana playwrights who paved the road for other Mexican-Americans to write their plays. Ultimately, these women's writings represented feminist concepts such as making money as a woman, supporting another woman's business, and being comfortable with one's sexuality and body type. Plays written by Mexican-Americans are scarcely produced by major theaters and are rarely recognized at award ceremonies like the Tony Awards. Chicanx playwrights tell underrepresented stories that, should those plays be brought to mainstream theater, would educate non-Chicanx Americans about the lives and struggles of these people.

The Chicanx movement of the 1960s and 1970s started from the community of Mexican-Americans who felt their lives were at a disadvantage due to the racism they endured. Female Mexican-Americans dealt with greater discrimination as they were treated with sexism from the government, from their male counterparts, and even the church. The desire to bring the Chicano man to the same level as the white man was born along with the spark that created a political movement. Chicana women supported their men, not only to create better job opportunities for Chicanos, but to later bring Chicanas to the same status as white women. They requested that modern feminism include the needs of mothers, including their right to free bilingual childcare and the right for professional, educated women to have salaries that measured their success more accurately (Nieto Gomez, 56). They wanted freedom from the Catholic Church placing judgment upon the women who chose family planning methods such as birth control pills or who chose to divorce their husbands. They did not see these rights being fought for by mainstream white feminists such as Gloria Steinem (Nieto Gomez, 56). Women like her did not recognize that a
The godfather of Chicano theater is Luis Valdez, a farm worker that wanted to inspire other workers to participate in socio-political protests.

Chicano man is more oppressed than a white woman. Since Chicanx feminism did not directly relate to white feminism, no attention was brought to the Mexican-American movement. The Chicanx community had to take matters into their own hands.

Subsequently, Chicanx could not rely on writing literature alone—they needed a way to perform their frustrations and express the inequalities. In the modern day, Chicanx theaters exist in nearly every major city. However, these theaters are built because there is seldom an opportunity for a Chicanx show to be produced otherwise. If a larger theater does produce a play written by an American of Mexican descent, they are praised for being diverse and representing the so-called minority. Chicanx plays deserve to be a commonplace practice, recognized just as much as non-Chicanx works—not every so often.

The godfather of Chicano theater is Luis Valdez, a farm worker that wanted to inspire other workers to participate in socio-political protests (Huerta, 25). Valdez and other workers performed *actos* in a theater company called the *Teatro Campesino*, which is still active today and has been since the 1970s. The company’s purpose was to demonstrate their frustration with the poor working conditions they faced and to provide a public platform for their life stories to be heard (Huerta, 26). Their intended audiences were other Chicanx farm workers and the white people who needed to see these performances to learn of the hardships Chicanxs face. Teatro Campesino toured the country and “dramatized issues of police brutality, the need for bilingual education, and the importance of voter-registration drives” (Huerta, 32). Their performances also highlighted themes regarding national identity and the need for social equality amongst white people and Mexican-Americans. These workers had basically no knowledge of traditional English theater techniques and instead relied on their passion to create a memorable performance (Huerta, 32). With the help of Cesar Chavez and Dolores Huerta, other Chicanx farm workers, they provided a strong reputation to Chicanx theater.

Decades later, Valdez recounts these memories in an interview and describes his need to write as “Realizing early on that there was no context [in America] for me within which to exist” and recognizing that he had to carve out his own way of being in the U.S. (Valdez). There was a lack of opportunity for Chicanx playwrights to be produced, and he created that opportunity for himself and others through the Teatro Campesino.

Though there were many positive outcomes from this theater movement, Jorge Huerta, a professor at University of California, San Diego, writes about the importance of recognizing the downsides.
to the Chicanx movement and its inclusion of the theater community. He writes that, “...it would be negligent to romanticize the Chicano theater of the 1960s. As current Chicanx and Latina scholars have made clear, the teatros were male-dominated, mirroring the Chicano Movement, and few Chicanas, if any, were in leadership positions in the 1960s” (Huerta, 32). Such leadership positions involved choosing the themes to be presented in their performances and choosing which gender of actors should be featured. Huerta reveals the source of the machismo stereotype amongst male Chicanos. It did not originate out of a desire to oppress females, but because Chicanos were being oppressed by white men. Machismo is a valid concept that Chicanas fought against during the 60s and 70s, as the Chicanx movement primarily validated the needs of the Chicano man. However, female playwrights’ voices did not become prominent until the late 1970s and early 1980s.

To illustrate a strong Chicana’s voice, Josefina López’s play, “Real Women Have Curves,” represents a remarkable accomplishment as she was only 21 years old when it was first performed (López). The play demonstrates that Mexican-Americans are just as capable of writing engaging literature as Anglo-Americans. The play is written in English, with a bit of Spanish woven into each character’s dialogue. This was not so that Anglo audience members could attend a performance and understand the plot. López created her characters to be fluent in English to illustrate her reality. The characters reflect the author’s attempt to dispel the stereotype that all Mexican immigrants speak broken English around Americans but then converse in Spanish in their own space. Considering López did work in her own sister’s factory just like the play’s protagonist Ana, she was very familiar with that work environment and its difficulties. Factory life is not glamorous, nor does it lead to a livable wage. She had no need to embellish or exaggerate any characteristics; she stated the reality about being a factory worker and did not romanticize any aspects of it.

In addition to dispelling stereotypes and depicting everyday life, López’s play is a partial-autobiographical work that discusses struggling body confidence in a skinny-obsessed world, factory workers’ low wages, fears of deportation, and the desire for higher education. Jorge Huerta writes, “The formerly male-dominated Latino theater scene now includes Latina playwrights, directors and producers, women whose voices were basically ignored before the 1980s” (Huerta, 19). Josefina López is not only a Latina, but specifically, a Chicana. Her writing demonstrates the necessity for Americans to not assume that Latinos all come from the same exact background. López intentionally identifies issues that a general Latino audience may not relate to. For example, a person from South America may immigrate to the United States, but they don’t feel an attachment to the land as a Chicanx person would. The history with the land use laws causes Chicanxs to grapple with the idea that this land was taken away from them where a Latinx
would not necessarily identify with that conflict. López moved to the United States when she was young, as did the character Ana, and López had a constant fear as a child that Immigration and Naturalization Service (INS) would catch her as an undocumented person and deport her. It’s ironic that a child of Mexican heritage should fear being deported—her people had been on this land much longer than the government officials who could deport her. The battles a Chicana wages are different from that of any other Latina because she deals with racism in a land that belonged to ancestors but now is not hers. López writes in the preface of her script, “Undocumented people have been used as scapegoats for so many of the problems in the U.S., from drugs and violence, to the economy” (López). Other than all these negative connotations, the Chicanx rarely are recognized for their happier accomplishments as Americans. Increased representation like winning Best Play or being cast in a show that traditionally is for Anglo people would help shift the focus from perceived faults to deserved praises.

López’s play is also revolutionary because Ana is a feminist, even if that word is never specifically used in the script. One of the scenes in the play depicts the factory workers taking off their clothes due to the intense heat. This scene was inspired by Ana’s confident body image, despite her mother’s consistent remarks of Ana’s excess fat. Body image was a major theme in this production. Elizabeth Ramírez, a writer, describes the objective of the play as promoting the idea that, “Women can determine for themselves what they will do with their lives and actively take on the charge of resistance to the inequality and oppressive circumstances surrounding them” (Ramírez). As such, López manages to tackle feminism and racism concurrently by addressing gender equality and the pursuit of independence.

Another aspect the play tackles is spousal abuse. When Ana’s mother claims she is lucky that her husband doesn’t hit her, Ana responds with, “Lucky? Why lucky? It should be expected that he doesn’t. Women have the right to say no.” The other factory workers are shocked to hear this and regard her as a young person that knows nothing about the real world. Mainstream feminism in the 1990s belonged to Anglo women. It was uncommon for a Chicana woman to hold such views, so where did Ana learn that saying “no” is okay? Later on in the play, Ana’s mother describes her reluctance to deny having sex at her husband’s command, resulting in her eight pregnancies. When Ana asks why she just never said no, her mom says, “Because, M’ija, I was never taught how to say no.”

Though the source of Ana’s feelings of value and empowerment aren’t discussed in the play, it seems that her refusal to work in a factory forever is an excellent symbol of female strength that provides a great example to the play’s audience.
López has created a feminist character based off her experiences and the beliefs that mirror the ideologies of progressive people today. Having a strong-minded Chicana star in a production provides the much-needed representation of Mexican-Americans. It further encourages other Chicana playwrights to feature their women and to create more opportunities for Chicana women to have roles.

Other plays by Chicanx writers deal with issues of forbidden love, social class and suicide. The play “The Day of the Swallows” by Estela Portillo, one of the first widely produced Chicana playwrights even before López, deals with challenges of unrequited love, inner struggles with connecting to religion, and the guilt associated with closeted sexuality (Ortego). A young woman, Josefa, kills the person who walked in on her and her female lover; she then must come to terms with the aftermath. She feels guilt that she murdered someone, but also feels upset that the shame of her sexuality has caused her to hide from being herself. The play is a suspenseful drama that could easily fit in at a standard American theater, as it has a balance between entertainment and truth of what shame does to someone. It does not project untrue, negative stereotypes about Mexicans, nor does it handle murder story in a way that might make an audience look down upon Chicanxs. It exemplifies that Chicanxs can be of high social class, but still experience undeniable sadness. A person could have everything going for them and still feel awful, regardless of class, which is a theme all can relate to. From a feminist lens, “The Day of the Swallows” is similar to “Real Women Have Curves,” in that both provide starring roles for Chicanas. They both offer an engaging read at the very least. An opportunity for other memorable performances would arise should a large theater give other Chicanx playwrights a chance.

Despite the excellent aspects of “The Day of the Swallows,” the play did receive criticism for the heterosexual playwright’s choice to have the lesbian protagonist commit suicide as an answer to her wrongdoing. Some viewed it as romanticizing murder and seeing suicide as a healthy, viable option for a closeted individual. It was not an encouraging play for the gay community. Another critique of the play was that a straight woman should not be writing about the struggles of a gay woman since she does not have the proper perspective to make her an authority. Cherrie Moraga, a noted Chicana writer who has written and still writes extensively about feminism, said, “It is a ‘classic’ lesbian work in the worst sense of the 1950s view” (Ramirez). Sue Ellen Case, a theater professor at the University of California, Los Angeles, said that the work was homophobic for its time. In modern theater, it at least acknowledges the existence of gay Chicana women, which few plays do now, even if it does so in a negative light. However, Portillo was still the first Chicana playwright known to the theater community for writing a successful play. The play contained the proper elements of a rising and falling action with an ultimate cliffhanging ending. Her presence created a path for other Chicana playwrights to follow.

In sum, themes of sexuality, immigration, social class and a quest for political change are common themes in Chicanx plays. Promoting the work of these playwrights would create a more realistic understanding of Mexicans living in the United States, which would encourage more opportunities for Chicanxs to excel with their educational and employment opportunities. The farm workers from the 1960s were untrained actors who performed their actos with heart rather than technique, and today, Chicanxs continue to participate in all aspects of theater arts. Jorge Huerta writes, “While professional...
conditions have changed over the past generation, as more actors, designers, directors, and playwrights are trained by and graduate from formal theater programs, the socio-economic condition of the Mexicanos has not improved as much as the pioneers of teatro [theater] would have liked” (Huerta, 32). The Chicano Movement of the 20th century provided a good starting point for Mexican-Americans. An increase in Chicanx representation on stage would remind people of their valuable existence and allow them to share their cultural expressions. Until a Chicanx is nominated for a Tony Award for Best Play, Mexican-American playwrights and the ideas they are striving to share will remain undervalued and overlooked.

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Effectiveness of Chemical Defense in a Tropical Millipede Species on a Potential Predator, the Tarantula *Megaphobema mesomelas*

Maya L. Klem

**ABSTRACT**

Millipedes are known to have a variety of physical and chemical defenses to deter predators. Some species of tropical millipedes have considerably reduced primary defenses when compared to other tropical millipedes, but do retain chemical defense mechanisms. This study uses the tarantula *Megaphobema mesomelas* to test the effectiveness of a secondary defense mechanism, cyanide and benzaldehyde, from a species lacking a robust primary defense. Five tarantulas were found and collected around Monteverde, Costa Rica and brought into the Monteverde Biological Station. They were housed in tanks to allow for controlled feeding trials. Two treatment groups were created: millipedes with cyanide (c-millipedes) and without cyanide (n-millipedes). Each night for 12 nights tarantulas were randomly assigned a treatment and fed a millipede from their corresponding treatment group. It was recorded whether or not the tarantula ate the millipede. It was found that tarantulas had no preference for millipedes with or without cyanide. Tarantulas pounced and began to inject venom into millipedes in less than one second, whereas it took millipedes almost 12 seconds to release cyanide. It appears as though *M. mesomelas* are able to attack faster than the millipedes were able to release cyanide and thus are not exposed to cyanide. For this reason, the millipedes’ chemical defense mechanism was not effective in deterring *M. mesomelas*.

**INTRODUCTION**

Organisms have developed a myriad of defenses to escape predation. In arthropods, there are two categories of defense mechanisms: primary and secondary. Primary mechanisms include passive defenses such as speed, tough exoskeletons, shelters, and camouflage; secondary mechanisms consist of chemical defense (Borror et al. 1989).

Diplopoda, commonly known as millipedes, have evolved a variety of defense mechanisms. There are over 12,000 described species of millipedes in the world (Golovatch & Kime 2009; Sierwald & Bond 2007). As detritivores, these slow-moving creatures live on the forest floors (Brusca & Brusca 1990). Though millipedes lack venom, many species have a variety of primary defenses including a thick exoskeleton and the ability to...
roll into a tight ball (Heisler 1983). Many also have secondary defenses such as the ability to secrete toxic and volatile compounds. Some millipedes contain a non-muscular repugnatorial gland that oozes or secretes irritating or toxic compounds. These compounds are made in vivo, released all at once, and take between two weeks and four months to regenerate; they deter predation in varying ways ranging from irritating the eyes of mammalian predators to burning arthropods’ exoskeletons (Shear 2015).

Most of these 12,000 species are endemic to the tropics (Golovatch & Kime 2009). In Costa Rica, one of the most well studied species of millipede is *Nyssodesmus python*; they possess a very thick, calcified exoskeleton and the ability to roll up into a tight ball. In addition to these primary defenses, *N. python* have the ability to spew hydrogen cyanide and benzaldehyde up to 30 cm to ward off predators. When these defenses are combined, the result is almost no predation of this species. The only common causes of mortality for adult *N. python* are parasites, desiccation, or injury in the delicate post-molting stage (Heisler 1983; Sierwald & Bond 2007). However, other millipede species’ common predators are ants, beetles, predatory arthropods, spiders, slugs, and some visually hunting vertebrates (Shear 2015; Sierwald & Bond 2007). One species of millipede found in Costa Rica lacks *N. python’s* primary defense mechanisms—a thick exoskeleton and the ability to curl into a ball. Despite the appearance of reduced primary mechanisms, millipedes seem to expel a similar secondary compound. The millipedes in this study were experimentally confirmed to contain cyanide, which is produced in a 1:1 molar ratio with benzaldehyde in their repugnatorial glands (Shear 2015). With reduced primary defenses, this smaller millipede species may be more reliant on secondary defenses.

Tarantulas are opportunistic sit-and-wait predators that could potentially prey on millipedes. Additionally, tarantulas have regions on their pedipalps (Fig. 1), a pair of secondary appendages used in feeding, and in some cases front legs that are capable of chemical sensation or taste (Perez-Miles 2005). They rely on this taste mechanism for hunting, which could make their prey’s chemical defense effective. Thus, tarantulas are a good predator to test the effectiveness of a millipede’s secondary defense mechanism.

To explore this, a common tarantula species found in parts of Costa Rica, *M. mesomelas*, were captured and housed in a controlled environment to study their reactions to a millipede’s secondary defense strategy. Five tarantulas were repeatedly fed millipedes (species unknown) with and without their chemical defense intact for a total of 12 days and their feeding choices were recorded.
MATERIALS AND METHODS

Study Site and Organisms

This study took place in July 2016 between 1300–1500 meters in the premontane wet forest of Monteverde, Costa Rica. Approximately 120 millipedes were collected both in the Monteverde Cloud Forest and around the town of Monteverde. After millipedes were collected and brought into the lab, they were placed in an aquarium with dirt, leaf litter, and rotting logs to allow them to eat.

Five Costa Rican Red-Legged Tarantulas, *Megaphobema mesomelas*, were collected along dirt road embankments around Monteverde, Costa Rica. The tarantulas are from the same life zone as the millipedes and have been observed sharing the same microhabitat. These tarantulas were initially found after sunset by locating holes on steep, dirt embankments along roads. After dark, tarantulas can be seen easily as they are at the edge of their holes waiting for prey. A small stick was used to simulate an insect by lightly tickling one of the tarantula’s legs. When the tarantulas felt the stick, they lunged forward. A spoon was then slid behind to simultaneously block their hole and lure them out into a plastic container for transport back to the controlled environment of the lab. The tarantulas were placed in separate aquariums approximately three times the size of their leg span. The aquariums were filled with dirt and each contained a small amount of PVC piping to simulate a hole for the tarantulas (Marshall 2001). Additionally, each tarantula was given a name (Kurt, Zachary, Katti, Demi, and Darryl) for the duration of the study.

Quantifying Millipede Defense

To quantify the primary defense mechanisms of this unidentified millipede species, the mass, length, and width of 25 millipedes were recorded. In addition, millipedes were manipulated to see if they engaged in ball rolling, a common primary defense mechanism in millipedes. To assess secondary defenses, five millipedes were tested for cyanide using sodium picrate test strips. Strips were prepared by creating a solution with 2.5 g sodium carbonate, 1 g picric acid (0.5% w/v, moist), and 100 mL water (Yeh 2014). Filter paper strips (8 cm x 1.5 cm) were saturated in the sodium picrate solution and excess liquid was evaporated. A millipede was then placed in a plastic bag with a sodium picrate test strip and manipulated until it released the chemical; a positive result was indicated by the test strip changing from bright yellow to orange/red, corresponding with the presence of...
cyanide. The test strip was dunked in 5.0 mL of deionized water 30 times and then the diluted solution was transferred to a plastic cuvette. A blank solution (without cyanide) was created by dunking an unused sodium picrate test strip in 5.0 mL of deionized water 30 times. The cuvette was measured in a spectrophotometer against a blank sample at a wavelength of 540 nm to determine the percent transmittance of the sample (Lian & Hamir 1981). The concentrations of cyanide and benzaldehyde were then calculated based on the 1:1 molar ratio of cyanide and benzaldehyde production in millipedes’ repugnatorial glands (Shear 2015).

Feeding Trials
Diplopoda have a gland that secretes many compounds, including cyanide. However, their cyanide is released all at once, after which it takes at least two weeks for the gland to produce more cyanide (Shear 2015). Knowing this, the millipedes were divided into two categories: those with and without cyanide available. The group without cyanide was obtained by inducing cyanide expulsion with the same procedure used to test for cyanide; the amount of time it took for the millipede to release cyanide was recorded. In the second treatment group the millipedes retained their cyanide. Each night at 18:00 the tarantulas were fed a millipede from one of the two treatments. Both the tarantulas’ reactions and whether or not they ate the millipede were recorded. During the 12-day study, each individual tarantula was offered millipedes both with and without cyanide multiple times. If the tarantula did not eat the millipede, they were offered a second meal of a cockroach in order to determine if the tarantula’s rejection was due to a lack of hunger or an aversion to the specific millipede; these reactions were recorded. On July 29, 2016, the tarantulas were released back to their original holes.

RESULTS
 Quantifying Millipede Defense
The millipede species used in this study is smaller in size and lacks the thick exoskeleton of N. python (Fig. 2b). A sample of 25 millipedes were measured to determine their masses, lengths, and widths. Millipede weight ranged from 0.311 g to 0.881 g, length ranged from 32.41 mm to 49.03 mm, and width ranged from 3.90 mm to 7.57 mm (Table 1). The smaller millipede species also did not exhibit the curling defense mechanism that N. python show (Fig. 2c). The sodium picrate test for cyanide had a positive result for all five of the millipedes tested, experimentally confirming that the species of millipede used in the study have a secondary defense mechanism (Fig. 2a). The solution had an average transmittance of 39.8% ± 6.02% at 540 nm in the spectrophotometer. Absorbance was determined (absorbance = 2 - (% transmittance)) and used to quantify cyanide per millipede (y = -1.0110 + 371.4679x + 167.4901x²), where y equals the amount of cyanide in μg and x equals the absorbance. The average amount of cyanide per millipede was found to be 187.25 μg ± 31.94 μg (Lian & Hamir 1981).
FIGURE 2
Comparison of primary and secondary defense mechanisms between *N. python* and the species of millipede used in this study. (a) Sodium picrate cyanide test result of a control strip (bright yellow) and a test strip after being exposed to cyanide released from a millipede (brick orange). (b) Size difference and presence of exoskeleton between the millipede used (left) and *N. python* (right). (c) Example of ball curling as a primary defense in *N. python*.

Feeding Trials
A total of 58 millipedes were offered to the tarantulas: 21 out of the 29 c-millipedes (72%) and 20 out of the 29 n-millipedes (69%) were consumed (Fig. 3). When looking at individual tarantulas, Kurt consumed three of the five c-millipedes and all seven of the n-millipedes offered (Fig. 4). Zachary consumed six of the seven c-millipedes and three of the n-millipedes offered. (Fig. 4). Katti consumed three of the seven c-millipedes and two of the five n-millipedes offered. (Fig. 4). Demi consumed all five c-millipedes and all five n-millipedes offered. (Fig. 4). Darryl consumed two of the four c-millipedes and three of the six n-millipedes offered. (Fig. 4). Demi and Darryl were fed two fewer times because they were captured two days after the other three individuals.

<table>
<thead>
<tr>
<th>Mass</th>
<th>Length</th>
<th>Width</th>
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<tbody>
<tr>
<td>0.5597 ± 0.0400 g</td>
<td>38.5809 ± 1.1448 mm</td>
<td>6.0819 ± 0.2069 mm</td>
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A Wilcoxon paired-sample test was conducted to compare individual tarantula feeding preferences for the five tarantulas fed daily during the study. The tarantulas showed no aversion against millipedes with cyanide (N=5, t=3 z=0 p=1) (Fig. 4).

**FIGURE 4**
Percent of millipedes, with and without cyanide, eaten by each individual *M. mesomelas*. Twelve millipedes were fed to Kurt, Zachary and Katti over 12 days and 10 millipedes were fed to Demi and Darryl over 10 days.

**FIGURE 3**
Percent of 118 millipedes consumed by five *M. mesomelas* based on cyanide presence.
Tarantulas rejected the millipedes 19 out of the 58 feeding trials. Furthermore, 50% of the time tarantulas ate the second meal after rejecting the initial c-millipede and 50% of the time did not eat the second meal after rejecting the initial c-millipede (Fig. 5). By contrast, 11% of the time tarantulas ate the second meal after rejecting the initial n-millipede and 89% of the time did not eat the second meal after rejecting the initial n-millipede (Fig. 5).

If a tarantula pounced on a millipede, it occurred in less than one second (Fig. 6). On average it took millipedes between 1.4 and 79.2 seconds to release cyanide (11.67 ± 2.60 sec) (Fig. 6). If the tarantula did not pounce and attack upon the initial touch of the millipede, it did not consume the millipede. When this happened, the tarantula either had no reaction or backed away from the millipede.
Additional Observations

On July 25, 2016 the millipede fed to Zachary released cyanide, which appeared to injure him. He did not move for many hours, even when prodded. The following day, when the millipede was presented to him he pounced and then immediately retracted, which was abnormal behavior for him. The same millipede was presented one more time to him on July 26, 2016 and he once again pounced and retracted. When presented with a second food option, a cockroach, he immediately pounced and consumed it. It should also be noted that Katti is a brooding female who had her egg sac in the tank with her for the study. Due to time constraints, the tarantulas in this study were fed more frequently than they would eat in the wild. All five tarantulas maintained a strong appetite despite their increased food intake. As mentioned in the methods, steps were taken to determine if a tarantula was not eating the millipede or was simply not hungry.

DISCUSSION

The results of this study show that the reduced primary defense mechanisms, such as a thin exoskeleton or the inability to roll into a ball, make millipedes vulnerable to predation. In addition, though they possess a secondary defense, the millipedes are unable to expel cyanide quickly enough to deter sit-and-wait predators such as *M. mesomelas* tarantulas. It appears as though these tarantulas are able to pounce, attack, and inject their venom into the millipedes before they are able to react. Tarantulas pounce quickly to deliver a lethal dose of venom to their prey, which are then liquefied, sucked, and digested (Kosiba et al. 2014). Spiders, including *M. mesomelas*, do have the ability to sense chemicals using patches on their pedipalps (Perez-Miles 2005). This suggests that tarantulas can detect chemicals such as cyanide if they are present. However, the tarantulas ate 72% of millipedes with cyanide and 69% of millipedes without cyanide. Additionally, the tarantulas often did not eat the millipedes from either treatment simply because they were not hungry. When they ate, *M. mesomelas* pounced and began injecting their venom in less than one second. However, the millipedes took on average 11.67 seconds to release cyanide. Logistically, this explains why the tarantulas seemed to be relatively unphased; millipedes did not have enough time to expel cyanide.

The millipedes used in this study were found to contain approximately 187.25 μg of cyanide. This is equivalent to the lethal dose for a 25 g mouse and nearly six times the lethal dose for a 300 g pigeon (Shear 2015). Most likely, the millipedes used in this study also produce benzaldehyde. The gland that produces cyanide has two chambers; one chamber contains mandelonitrile, which is catalyzed to produce benzaldehyde and hydrogen cyanide in the second chamber (Shear 2015). These two chemicals combined are known to be an almost perfect pair in defending millipedes. Hydrogen cyanide does not appear to repel many arthropods, such as ants, whereas benzaldehyde does. Cyanide appears to be an effective deterrent of vertebrates but not of arthropods (Shear 2015). However, these chemicals are essentially useless if there is not enough time between threat arrival and paralysis/death to release them, such as with *M. mesomelas*.

Millipede secretions are known to cause eye irritation or blindness in vertebrates and burn arthropod exoskeletons (Shear 2015). However, tarantulas have a chitin layer covering their eyes that could potentially protect them from these chemical irritations (Pérez-Miles 2005). It is possible that tarantulas are less likely to be affected by these toxic chemicals due to their pedipalps and protective eyes. Noting the instance of cyanide exposure for Zachary, their defenses appear to be insufficient. He retracted from the millipede upon exposure and did not move for multiple hours even when poked, and he appeared to be afraid of the next mil-
lipede offered to him. This seems to indicate that if millipedes did have enough time to release chemicals it would likely be effective against *M. mesomelas*.

A similar study conducted on *M. mesomelas* found that they did not have an apparent aversion to a toxic stick bug species. These bugs also spray a toxin, limonene, which can be fatal to insects in as little as 15 minutes. Koranda hypothesized that this was due to the overall larger size of *M. mesomelas* (Koranda 2013). The findings of this study suggest that it is not only the larger size of the tarantula that allows them to eat prey containing poisonous chemicals but also their speed. The Koranda study should be repeated while taking time of attack into account.

Five nights were spent at the beginning of this study finding and capturing tarantulas in Monteverde, Costa Rica. During this period only five *M. mesomelas* were discovered. This indicates that there does not appear to be many *M. mesomelas* in the area. Although these millipedes and tarantulas share the same habitat, it is logical to believe that these millipedes do not come into contact with *M. mesomelas* often. If this is true, there have most likely not been significant evolutionary pressures for these millipedes to evolve a mechanism to evade tarantulas.

**CONCLUSIONS**

The reduced primary defense mechanisms in this species of tropical millipede, combined with a delayed chemical secondary defense mechanism, does not appear to be effective in deterring *M. mesomelas* predation. However, it is hypothesized that this is due to the incredibly fast attack time of *M. mesomelas* rather than the chemicals not being effective. It is likely that if the millipedes were presented to a slower predator, their chemical defense would be effective, as it is with other animals of similar or larger sizes than *M. mesomelas* (Shear 2015).

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**BROODING:**
when a female animal is caring for her egg sac

**CHITIN:**
a fibrous compound used for protection and support in many arthropods


Americans today wear a thin, green cloak of environmentalism, evidenced by our recycling efforts, energy conservation attempts, and sporadic forays into “green consumerism.” We spend time carefully sorting our discarded paper, plastic, and glass, turn off the lights whenever we leave rooms, and make product choices based on a company’s environmental reputation, or a product’s purported “sustainability” or “eco-friendliness.” Professor Magali Delmas of the UCLA Institute of the Environment and Sustainability has been studying the motivations behind these environmentally beneficial, “green” behaviors over the last decade and has found that considerations of health, higher product quality, functionality, convenience, and status weigh more heavily in consumers’ decision-making than concern for the environment (Hewitt 2015). The revelation that environmentally supportive behaviors are easily attributable to other motivating factors is not, however, proof that American environmental public opinion lacks depth and strength of conviction. For that, one only needs to examine the polling data.

For more than 30 years, the nonpartisan and data-driven news organization Gallup has been asking Americans whether environmental protection should be prioritized “even at the risk of curbing economic growth” (Swift 2014). The majority of Americans, over the course of those decades, have answered yes. In 1984 61% of Americans agreed that environmental protection should be given priority over economic...
growth and, although support peaked at 71% percent in 1990 and has slowly declined since, the environment remained a priority though 2014 except during several years of economic downturn (Swift 2014). In light of this data, one might presume a translation to the voting booth in support of both environmental issues and pro-environment candidates, but there is a punchline that precludes that prediction: Americans also do not list environmental protection among their top political issues.

Polling data, summarized from 1990 to 2010, reveals a decline in general concern for environmental problems; from 2007 to 2010, concern for global warming decreased specifically (Guber 2013). A Gallup-compiled summary from 2001 to 2016 reveals an American public that, in 9 out of 15 years, was most concerned about the economy over all other problems; the environment never made our self-identified “top four problems” list during that timeframe (Smith 2016). Moving into the 2016 Presidential election, climate change remained a below average concern for the majority of Americans, Democrats and Republicans alike (Newport 2016).

Given the responsiveness of most politicians to public opinion, and Americans’ confusing and conflicting poll responses, it is no surprise that little progress has been made in the last 30 years at the federal level to address climate change and curb the primary culprit, carbon dioxide emissions (Houghton 1996). However, in light of the fact that anthropogenic climate change is arguably the most pressing environmental issue at hand today—in terms of our health, safety, and national security—it is surprising that such negligible progress does not cause greater concern (Presidential Memorandum 2016; US EPA 2017). The United Nations’ Intergovernmental Panel on Climate Change (IPCC) initially warned of the potential dangers of the greenhouse effect in 1990, it declared that global warming was “unequivocal” in 2007 (Rosenthal and Revkin 2007), and it has generated successive reports that provide increasing corroboration of human causation, as well as extrapolation of “potentially disastrous climatic changes later in the century” (Gillis 2014). Countries the world over have taken heed and purposeful steps to reduce their atmospheric greenhouse gas contributions. The United States, however, has recently gone backwards.

In spite of our individual dedication to recycling, energy conservation, and green product purchasing, how Americans vote sends a direct message that the environment is not our top priority. In March 2016, Americans’ concern about global warming peaked; 64% of Americans reported being worried, ranging from “a great deal” to “a fair amount” (Saad and Jones 2016). Just months later, in November 2016, Americans elected climate change skeptic Donald J. Trump as President of the United States. Clearly, tertiary “green” behaviors and environmentally supportive polling responses should not be used to predict elections. Just as clearly, American environmentalism is sorely shallow—a skin deep cloak, insufficient to convince politicians of the urgent need to act on climate change.

Certain clues as to why this contemporary, shallow affect has permeated American environmentalism can be extrapolated from both our superficial green behaviors and our confusing poll responses.
some of the blame; it is an expansive problem that lacks a visceral, immediate presence. Both first and second generation environmental issues—comprising the limited contaminations of air and/or water leading up to the 1960s, and “cross-media” (but still spatially limited) hazardous and toxic waste pollution in the 1970s, respectively—were comparatively easy to target and address. Third generation issues like acid rain, ozone depletion, and climate change, in contrast, have the potential to cause adverse effects at regional or even global scales, with origins much more complex and equivocal (Ringquist 1993). Finally, politicians and policymakers own another portion of the blame. American environmentalism is only skin deep, not because we lack the information necessary to understand and address environmental problems today, but because we are subject to cognitive limitations and the increasingly partisan identification of environmental issues.

EVERY LITTLE BIT HELPS?
One aspect of our surface-level environmentalism could be the reinforcement of shallowness in a negative feedback loop. Our superficial green behaviors may serve to discourage us from greater, more meaningful actions on behalf of environmental causes in a phenomenon known as single action bias. Coined by Elke Weber, Professor of Psychology and Public Affairs at Princeton University, this term describes a cognitive limitation whereby a single action (e.g., choosing to walk to the store rather than drive, composting food waste at home, or buying an energy efficient appliance) serves to satisfy our perceived worry about the environment even as we perform an action we believe to be mitigating. Single action bias theory suggests that people are much less likely to take additional steps or prolonged actions that would result in incremental protection from future harm (Weber 2006).

Another cognitive limitation that contributes to our shallow environmental outlook is attribute substitution (Li, Johnson, and Zaval 2011). This theory suggests that people tend to rely heavily on personal experiences when deciding how to perceive and interpret the surrounding world, while also forming layman’s opinions regarding correlation and causation. Climate change is a complex environmental issue that provides sparse signals, or attributes, to most people around the world. However, daily and seasonal temperature variations are readily and easily substituted—problematically—as evidence for, or against, climate change.

A Columbia University study exemplifies such attribute substitution, revealing a positive correlation between fluctuation in local temperature and reassessment of beliefs about global warming, especially among those with less education and weak attachment to political parties (Egan and Mullin 2012). It is unlikely that incidental weather events, especially daily temperature changes, could be signals of anthropogenic

Climate change is a complex environmental issue that provides sparse signals, or attributes, to most people around the world.
climate change. Still, this cognitive limitation is evidenced by formal studies, casual conversations, and the media, promoting a wavering and uncertain support for issues like climate change on the basis of what is, effectively, illusion. By revisiting past environmental movements, we can gain understanding of the power that personal experience commands over our response to environmental problems.

WHERE THERE’S SMOKE...
In the decade leading up to the first Earth Day—April 22, 1970—it was increasingly evident that the environment was in trouble. Americans were outraged by disturbing news reports of the killer smog event on Thanksgiving Day 1966 in New York City, responsible for the deaths of at least 169 people, the 1969 Santa Barbara oil spill off the coast of California—which fouled miles of beaches and killed thousands of seabirds and marine mammals—and the burning of the severely polluted Cuyahoga River in Ohio that same year. These environmental disasters were widely publicized, including visceral details and powerful, complementary photography. When coupled with the first image of the Earth from space in 1968, these events arguably gave birth, in large part, to the environmental movement (MacDonald 2003).

An examination of cognitive risk assessment methods helps explain why we were moved to action on environmental issues in the 70s, and why the so-called “salience slope” has been increasingly steeper since; those early issues created “smoke” we could smell, whether by personal experience or by well-documented and vividly descriptive reporting and imagery. This evoked our primitive risk response, motivating us to take steps to put out the environmental “fires” across the country, like passing the National Environmental Policy Act and establishing the Environmental Protection Agency, both in 1970. In contrast, today’s primary environmental issue, climate change, is left to our analytical risk response, in which costs and benefits are considered very carefully (Weber and Stern 2011). Global warming represents “a creeping problem . . . remote in space and time” (Jamieson 2006). As such, Americans are wont to give prece-
Americans with little to do but make their political choices based on other factors. In their seminal 2004 essay “The Death of Environmentalism,” Michael Shellenberger and Ted Nordhaus exhort fellow progressives for their continued narrow and inflexible definition of environmentalism as a special interest. As such, they suggest, the environmental cause should die, in order to be reframed as an American value, tasked with solving human—and not “environmental”—problems.

AN INCONVENIENT TRUTH
In light of the IPCC reports in 1990, 1992, 1995, and 2001, climate policy advocates presumed that lack of support for climate change response and legislation was due to an information gap suffered by the American public during this time frame (Guber and Bosso 2013). Former Vice President and unsuccessful presidential candidate, Al Gore, was the self-nominated educator. His presentations, and especially his 2006 documentary movie An Inconvenient Truth on the topic of anthropogenic global warming, have been credited with raising knowledge about the issue of climate change worldwide. Surprisingly, American concern about global warming began to drop soon after its release. The presumption was precisely wrong, that an increase of information about global warming and its mechanisms was all that was necessary to push public opinion to a tipping point on the issue. Instead, detailed information about global warming and climate change may be a contributor to skin deep environmentalism. Guber and Bosso put the situation succinctly in their 2013 review of the rise and fall of climate change policy hopes post-2006: the American public, knowing more than ever about climate change, also cared less. This seems to be another case of our cognitive limitations at work. The higher our awareness of the gravity and complexity of a situation the less power we feel we have to address it, and therefore we take less responsibility for the solution. It is inconvenient, but true, that a lack of information or depth of understanding on the topic of climate change is not a contributing factor to our less-than-deep environmental support; what we know is simply not provocative enough to make us want to change.

THE WIND IS BLOWING
Our cognitive limitations and increasingly polarized stance on environmental issues leaves America sweating under our thin green cloak of environmentalism. As a nation, our support for the environment is broad but shallow, not directly cognizant of where the danger is coming from but aware of its basic premise. Nevertheless, we perfunctorily perform superficially green behaviors, easing our heavy concerns, with mostly ineffectual actions. We can be hopeful that further research into our cognitive limitations and the psychology of risk response will inform environmental policy advocates and climate change scientists alike of the best ways to present messages that we can fully receive and respond to in a deeper, more meaningful way. If not, the winds of climate change threaten to blow off the cloak and leave us suddenly exposed to a clear and present danger that we can no longer ignore.

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References


CO-EVOLUTION OF CALCIUM HOMEOSTASIS AND LACTASE PERSISTENCE: Implications for Treatment of Degenerative Bone Diseases in the 21st Century

Ryan J. Glendenning and Aaron J. Williams

ABSTRACT

Recent research on the relationship between osteoporosis and lactase persistence has revealed that these two factors are positively correlated. There is existing evidence that shows the domestication of cattle was a selective force for the lactase persistence allele. We hypothesize that this genetic change caused a shift in the ancestral physiological mechanism for calcium homeostasis, resulting in a derived calcium homeostasis. Consequently, individuals with this derived calcium homeostasis are more susceptible to degenerative bone diseases, such as osteoporosis. Osteoporosis is a topic of major health concern in the United States, considering that it is responsible for more hospital stays for women aged 45 or older than any other disease in America. Geriatric populations are the demographic most heavily affected by osteoporosis—particularly postmenopausal women. Research has also indicated that roughly 20 percent of elderly patients die within the first year of a hip fracture and less than 50 percent return to their previous lifestyle. The health concerns associated with osteoporosis along with the expensive costs of treatment place a priority on alternative ways to treat and prevent this disease. We review the development of lactase persistence along with important biological molecules involved in calcium homeostasis. We also discuss the physiology behind the ancestral calcium homeostasis and the derived calcium homeostasis, as well as potential paths for further research.

INTRODUCTION

Osteoporosis is a degenerative bone disease recognizable by a loss of bone mass density (BMD). Dual-energy X-ray absorptiometry (DXA) is a diagnostic technique used to evaluate the BMD of a patient.1 While a DXA scan can assess BMD of the whole skeleton, it is usually focused on the hips and spine of a patient when searching for osteoporosis.1 The results of a DXA scan are then measured against a reference
populations of young, healthy individuals. This comparison against the reference population is widely referred to as a \( T \)-score. The \( T \)-score measures how many standard deviations away from the reference population the patient’s BMD is. A diagnosis of osteoporosis occurs when a patient’s \( T \)-score is -2.5 or lower, i.e. 2.5 standard deviations below the reference population.\(^2\) Elderly women are the most likely demographic group to develop the disease, although it can develop in anyone at any point in life.\(^3\),\(^4\) Osteoporosis accounts for more hospital stays for women aged 45 or older than any other disease in America and treatments cost Americans over $22 billion per year.\(^5\),\(^6\) For this reason, a drug that can effectively treat or even prevent this disease is a priority in the pharmaceutical community. Historically, osteoporosis was thought to be rather simple. However, new research has increased our understanding of the complex immunological and physiological systems behind the disease.\(^7\),\(^8\)

Recently, a team of researchers led by Dr. Constance Hilliard from the University of North Texas ran a comparative study between West and East Africans. West Africans have some of the lowest rates of osteoporosis in the world, with around 3 hip fractures per 100,000 postmenopausal women, while East Africans have high rates of osteoporosis, with around 243 hip fractures per 100,000 postmenopausal women.\(^9\) The fracture rates were positively correlated \( (r = 0.841) \) with milk consumption and positively correlated with lactase persistence \( (r = 0.735) \).\(^7\) East Africans adopted cattle domestication between 2,700–6,800 years ago, and have been consuming milk from cattle ever since.\(^9\) Milk contains lactose, a sugar only digestible by people who produce the lactase enzyme. The domestication of cattle created a selective pressure for people who have the lactase persistence (LP) allele.\(^10\),\(^11\)

Current guidelines on osteoporosis encourage maximum calcium consumption.\(^14\) However, Dr. Hilliard’s study contradicts this suggestion. According to Dr. Hilliard, the incidence of osteoporosis increases with calcium and milk consumption. The implications of these findings are critical to understanding the etiological processes of osteoporosis. Identifying risk factors in patients earlier, and more accurately, could prevent injuries and hospital stays. Based on Dr. Hilliard’s conclusions, we hypothesize the domestication of cattle was a selective force for the LP allele. This genetic change caused a shift in the ancestral physiological mechanism for calcium homeostasis, resulting in susceptibility to developing degenerative bone diseases like osteoporosis.

**Osteoporosis accounts for more hospital stays than any other disease in America, and treatments cost Americans over $22 billion per year.**
small intestine in its natural form. However, lactase cleaves lactose into glucose and galactose, two monosaccharides capable of providing calories. Mutations in the lactase (LCT) gene, located on chromosome 2, allowed humans to successfully digest milk through adulthood.\textsuperscript{10,11,15}

Upon the domestication of cattle, milk became an easy source of calories for those who could digest the lactose sugar.\textsuperscript{18} Consuming lactose in the absence of lactase can create painful abdominal cramps and gas, discouraging those who are lactose intolerant from consuming milk.\textsuperscript{18} Those who had the LP mutations in milk-consuming populations possessed a selective advantage over those who did not, since only LP individuals could benefit from the high nutritional content of milk.\textsuperscript{19} This selective advantage allowed those who expressed the LP trait to pass on their genes.\textsuperscript{20} This selecting force, along with other cultural and environmental factors, allowed LP to replace lactose intolerance in certain parts of the world.\textsuperscript{10,18} In populations with European ancestry, the T-13910 allele on the LCT gene is responsible for the expression of lactase. The T-13910 variant is only present at significant levels in populations with European ancestry.\textsuperscript{10,11} In Africa, several other variants of the LCT gene have been identified as causes of LP trait expression.\textsuperscript{10}

Individuals selected for the LP trait shifted away from the ancestral state of LNP. This shift resulted in LP individuals consuming high levels of milk and thus a high intake of dietary calcium. It was this continuous high intake of dietary calcium, made possible by a naturally selected genetic change, that led to a physiological change in the calcium homeostasis for LP individuals. That change will be referred to as the derived calcium homeostasis. LNP individuals did not have access to excess calcium from milk and retained their ancestral calcium homeostasis.

**IMPORTANT BIOLOGICAL MOLECULES INVOLVED IN CALCIUM HOMEOSTASIS**

Calcium is an element found in plants and animals. It is classified as a micronutrient and a mineral, meaning it is needed in small amounts to sustain life. In humans, calcium serves three important functions of normal physiology: muscle contraction, cellular signaling, and blood clotting.\textsuperscript{21} Humans have more hormones that raise blood calcium levels as opposed to hormones that lower blood calcium levels, indicating that adequate calcium is necessary for maintaining many cellular processes.\textsuperscript{21} One such hormone is parathyroid hormone (PTH).

PTH is synthesized in the parathyroid glands located posterior to the thyroid gland in the lower neck.\textsuperscript{22} This hormone has direct effects on bones and kidneys. It binds to cell surface receptors on certain bone cells to increase the ratio of bone resorption to bone building.\textsuperscript{22} PTH also binds to cell surface receptors on the kidney tubules to cause reabsorption of calcium into the plasma.\textsuperscript{22} Reabsorption of calcium from the kidneys helps to minimize the loss of calcium through excretion. The last function of PTH is indirect. PTH causes cellular modifications of Vitamin D\textsubscript{3} in the kidney to turn Vitamin D\textsubscript{3} into its biologically active form, 1α,25-dihydroxyvitamin D\textsubscript{3}, also known as calcitriol. PTH accomplishes this by increasing production of the enzyme 1-α-hydroxylase, which converts 25-hydroxyvitamin D\textsubscript{3} into calcitriol. Calcitriol increases plasma calcium by absorbing it from the small intestinal lumen. It also acts to cause bone resorption by increasing osteoclast production.\textsuperscript{23} In a correctly functioning calcium homeostasis, average bone building rate roughly equals average bone resorption rate. This maintains BMD.

Bones release and sequester calcium based on their anatomical composition. The hard part of bone is made of a calcium phosphate crystal known as calcium hydroxyapatite.\textsuperscript{24} These crystals are built by bone building cells, osteoblasts, and are broken down by bone dissolving cells, osteoclasts. Osteoblasts form these hydroxyapatite crystals by combining water with secreted calcium and phosphates.\textsuperscript{24} The
bone matrix is maintained by osteoblasts trapped within the bone matrix known as osteocytes. When these crystals are broken down by osteoclasts, calcium leaves the bone and enters the bloodstream.25 Once in the bloodstream, the body utilizes this calcium for life sustaining functions.21 Bones serve as storage banks for calcium in this homeostatic mechanism. Proper regulation of osteoblasts and osteoclasts is necessary for bones to effectively serve this purpose.

Receptor activator of nuclear factor kappa-B ligand (RANK-L), receptor activator of NF-κB (RANK), and osteoprotegerin (OPG) are key signaling-proteins involved in osteoblast and osteoclast regulation.26 When calcitriol binds to osteoblasts, RANK-L is released into the extracellular environment. RANK-L then binds RANK on osteoclast precursors, causing production of osteoclasts by a process called osteoclastogenesis.26 OPG is a signaling-protein that functions as a RANK receptor. It binds to RANK-L with a high affinity and prevents RANK-L from binding to RANK, therefore inhibiting osteoclastogenesis and conserving BMD.26 OPG is vitally important in maintaining a healthy BMD.

THE EVOLUTION OF THE DERIVED CALCIUM HOMEOSTASIS

Preagricultural diets had extremely low dietary calcium levels, which can be partially attributed to the absence of milk.27–29 Therefore, this ancestral calcium homeostasis would have been extremely advantageous for our early ancestors before dairy agriculture was present. We theorize that the ancestral calcium homeostasis is defined as having chronically high PTH and OPG levels that are necessary to efficiently utilize the low levels of dietary calcium.

High PTH levels in the presence of low dietary calcium is beneficial for the ancestral calcium homeostasis because PTH allows for maximum absorption of calcium through the small intestine via calcitriol and the maximum reabsorption of calcium from the renal tubules.22 The calcium conserving purposes of PTH in the ancestral calcium homeostasis allows individuals to maintain a healthy BMD. The high presence of OPG mediates the negative bone resorption associated with PTH and conserves BMD by inhibiting osteoclastogenesis.22 This ancestral calcium homeostasis allowed our ancestors to maintain bone health despite having a low dietary calcium intake. Research shows that having high levels of OPG and PTH present at the same time significantly increases bone mineral density.22, 30, 31 Further studies have shown that the body can adapt its calcium homeostasis physiology in the presence of low calcium levels without compromising bone health in the process.32

The introduction of dairy agriculture along with the selection for LP genotypes allowed individuals to consume high amounts of dietary calcium in the form of milk.18 This large influx of dietary calcium led to high levels of calcium in the bloodstream, which would decrease the relative amount of PTH.22, 33, 34 With PTH levels decreased, osteoblastic OPG production would also decrease in an effort to conserve energy. This would create a new calcium homeostasis setpoint for LP individuals where both PTH and OPG levels are low. Although this high calcium intake leads to

**LIGAND:**
a molecule that binds to another molecule

**CALCITRIOL:**
the biologically active form of vitamin D

**DECOY RECEPTOR:**
a receptor that can recognize and bind cell-signaling proteins as an inhibitor to prevent normal binding
to energy conservation, the derived calcium homeostasis is also susceptible to dysfunction. In times of stress, such as low calcitriol production or low calcium consumption, PTH levels rise and cause bone resorption. Without the protective effects of OPG, osteoclast activity is minimally inhibited and outpaces osteoblast activity. More simply stated, the breakdown of bone via PTH would go unchecked and bone health would suffer. Due to the decrease in estrogen production levels associated with the postmenopausal stage of life, postmenopausal women with this calcium homeostasis are at a high risk for developing osteoporosis. Estrogen has been seen to provide a protective effect against osteoporosis since it positively regulates OPG expression.

FIGURE 1
Figure 1. The diagram above shows the divergence of the derived calcium homeostasis from the ancestral calcium homeostasis along with the basic functions of each homeostatic mechanism. Parathyroid hormone (PTH) binds to surface receptors on osteoclasts to increase bone resorption activity. PTH also causes resorption of calcium into blood plasma by binding to receptors on kidney tubules. Osteoprotegerin (OPG) inhibits the bone degrading effects of PTH. In the derived calcium homeostasis, low PTH and OPG levels increase the risk for osteoporosis development since PTH levels can rise with inadequate calcitriol or calcium. With PTH levels raised, bone resorption increases. In the ancestral calcium homeostasis, high OPG levels inhibit the bone resorption aspect of PTH and therefore decreases the risk for osteoporosis development.
IMPLICATIONS FOR THE TREATMENT OF OSTEOPOROSIS

Current guidelines for osteoporosis prevention from the National Osteoporosis Foundation (NOF) suggest “get enough calcium, eat a well-balanced diet, engage in regular exercise, eat foods that are good for bone health such as fruits and vegetables, and avoid smoking and limit alcohol to 2–3 drinks per day.”14 These guidelines are insufficient for prevention and treatment of osteoporosis under our model of the derived calcium homeostasis. Studies have shown that dietary calcium and vitamin D supplements alone have mixed results in their effectiveness to reduce fractures.36–38 Current treatments for osteoporosis do not take into account this difference between an ancestral and a derived calcium homeostasis. These treatments include supplementing with calcium, vitamin D, estrogen, calcitonin, and/or bisphosphonate derivatives. While bisphosphonate derivatives have been shown to effectively treat osteoporosis, there have been major concerns regarding long-term safety of their use.39, 40

The drug known as denosumab targets the RANK-L–RANK-OPG pathway, a key aspect of the derived calcium homeostasis, and provides ample evidence to support an effective treatment of osteoporosis.39 The derived calcium homeostatic mechanism needs to be considered in order to develop more effective treatments and preventions for osteoporosis. Sampling serum biomarkers from a large population of diverse individuals would allow for further evidence to support our hypothesis. Specifically, research might include looking at the serum levels of PTH and OPG in lactase persistent and lactase non-persistent individuals.

Genetic screening for the presence of the LP allele, as well as sampling PTH and OPG serum levels, could be an important step in the prevention and treatment of osteoporosis. This method would identify risk factors for young patients and could lead to the early implementation of preventative treatment for osteoporosis. Currently, US health insurance companies will not cover the use denosumab derivatives for patients.41, 42 In order for insurance companies to cover this preventative treatment, studies need to be conducted to determine if this type of preventative treatment would save them money.

Recent research suggests that mortality rates for hip fractures in North America alone are between 14 percent–36 percent within 1 year of surgery and less than 50 percent of patients return to their previous lifestyle.43, 44 Hip fracture surgery has also been shown to be associated with an increase in dependency on long-term institutional care, an increased incidence of entering a low-income status, an increased risk of coronary heart disease and other postoperative complications like perioperative anemia, gastrointestinal anemia, cognitive alterations, and embolisms.45–47 These potential health and lifestyle consequences combined with the immense cost of treating osteoporosis indicate the dire need for future osteoporosis-related research.

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Healthy and open communication about the dynamics of domestic violence and patriarchy are essential to dismantling the roots and causes of abuse. To examine these two stigmatized concepts, definitions must be established; for this paper, patriarchy will be defined as an ideological and social position where men hold power over all other identities (Jackson 2003). The term domestic violence will be used to describe the assertion of power and control over another person through repetitive abuse and manipulation (Kelly 2016). While patriarchy may not be the issue at hand, it has propelled domestic violence to impact the way American society views abuse against women, as well as within and against the LGBTQ community. Advocates can learn to identify violence and abuse during tension, post tension, and reconciliation stages (Kelly and Westmarland 2016); consider why survivors choose to stay; and change the language surrounding survivors.

There have been several moments in legislative history that have reshaped the way society approached issues pertaining to domestic violence. Up until the late 19th century, a man could choose any object of his choice to abuse his wife—as long as the object was no bigger than his thumb (Walker 2002, 85). When instances of physical injury were deemed detrimental...
to the woman’s health and were brought before the court (nine stitches often being the medical standard), male judges typically sided with their male counterparts (Walker 2002). Although this “rule of thumb” was to act as a limitation of abuse, it provided no protection and instead promoted the acceptance of violence against women in the name of patriarchy (Walker 2002). It is important to note that this was also during a time when there was no account for protection from domestic violence for LGBTQ identifying individuals (Walker 2002). The culturally-deemed invalidity of their relationships made seeking help difficult; the heterosexual-man-abuses-wife dynamic was the unspoken standard, thereby dismissing the wide variety of other relationship dynamics that may be experiencing the same abuse. Jumping forward two centuries, great improvements have been made in legal support for those experiencing violence. Social services now exist to assist individuals in filing for protection orders, providing safe housing, and facilitating positive discussions of healthy relationships. Society has also witnessed the national legalization of homosexual marriages.

Too long has our culture relied on the precedence of partnerships being between a man and a woman. By doing this we eliminate support to a monumental group within our society. In “Transgender People, Intimate Partner Abuse, and the Legal System,” Leigh Goodmark presents two case studies of trans-women who were murdered by their partners and the way in which the court handled it (Goodmark 2013). Had these individuals been cis-women, the situation would have been labeled as domestic violence without question. However, both instances were instead ruled as hate-crimes (Goodmark 2013). By mislabeling abuse, we misunderstand proper avenues for relief. For example, one implication of mislabeling a crime as a hate-crime instead of domestic violence is the decreased resources for survivors. Like the “rule of thumb” back in the 19th century, we again can carefully assess the role of legal protection in terms of domestic violence. The progress made to protect female survivors has yet to extend itself to the LBGQT community (Goodmark 2013). By removing the generalization of identity as a source of crime and focusing on the abuser’s role, as we would in a cis-heterosexual relationship, average citizens can begin to take the necessary steps in supporting individuals of all identities experiencing violence. Moreover, true support cannot be achieved until we fully understand the complexity and diversity that is relevant in every intimate partner relationship. As a first step, we—as active members in our community—can educate ourselves on red flags to better identify instances of abuse.

Liz Kelly and Nicole Westmarland lay out these red flags in three stages: tension, post-tension (or often called “outburst”), and reconciliation (Kelly and Westmarland 2016). During the tension stage, the survivor is experiencing, at minimum, emotional battering by their abuser, which typically causes the survivor to experience guilt, nervousness, and/or agitation. An abuser may begin to capitalize on these emotions to retain their status of power. Over time—whether hours or days—there comes to be an acceptance of abuse where the survivor does not reach out for help but rather strategizes ways to keep themselves safe within the relationship. This stage is very fragile because the survivor’s understanding of trust is skewed. They accept the perpetrator’s truth as the sole truth, which thereby alienates them from other relationships in their life (Kelly and Westmarland 2016). Caroline Clements and Daljit Sawhney explain in “Coping with Domestic Violence” how hopelessness relates to emotional battering, and how it pertains to the persistence of violence. They argue, “individuals who
develop negative expectations about the occurrence of highly desired outcomes, who also feel helpless about changing the likelihood of these outcomes, are likely to develop a more generalized expectation of hopelessness” (Clements 2000). When an abuser convinces their victim that they are unworthy of relief, the hope for such relief diminishes.

By manipulating survivors in such a way, abusers can maintain control and power within their relationship. This makes the survivor malleable and predictable in the eyes of an abuser, who is then capable of acting and reacting in certain ways to attain a desired result. An example of this may be a partner asking their significant other to stop talking to one of their friends. They may say, “You know, they don’t like you anyway. They’re only using you because you drive them to work when they need it. I don’t use you like that. I’ll never use you like that. Cut them out of your life and you’ll be better off.” Here, the abuse has already begun.

Furthermore, another way abusers maintain control within relationships is by acting sporadically and unpredictably. By being unable to anticipate forthcoming trauma, a survivor’s emotions begin to mirror the lack of stability in the relationship (Clements 2000). To illustrate this, imagine an individual perceiving a threat and preparing to be attacked without the ability to avoid it, but then suddenly receiving care and sympathy from their abuser. The survivor’s tension is met with comfort, instilling a lack of trust in their own perception of the situation. An abuser can utilize this destabilizing technique to make the survivor feel unstable and paranoid, like they were prematurely nervous for nothing. In “Feeling Bad about Being Sad” Brock Bastian explains, “…reflecting negatively on the self in response to negative emotional experiences has been shown to further aggravate those same emotions” (2012, 70). In other words, when an abuser convinces their victim that they are being melodramatic and overly sensitive, the survivor will soon come to believe it themselves. The abused individual may begin to blame themselves for the abuse, accepting that the trauma is caused by their supposed wrong-doings and negative reactions (Clements 2000).

Following the tension stage, the post-tension stage ushers in the physical outburst of assault (Kelly 2016). Physical trauma comes in many forms: some abusers may target the rib, abdomen, or other hidden areas to avoid discovery of the abuse, while others have been known to mainly target their victim’s face and neck areas (Karakurt, Patel, Whiting, and Koyutürk 2016, 84). Strangulation can also be intensely detrimental to a survivor’s health (Domestic Shelters 2016). It has been well documented that if the brain goes without oxygen for more than two seconds, long term cognitive disabilities, loss in vision, and seizures can result (Domestic Shelters 2016). Traumatic brain injuries resulting from strangulation have a prevalence rating of 30–74% in intimate violent relationships (Karakurt et al. 2016, 84).

To determine the long-term effects of abuse, Karakurt and her colleagues searched through testimonies from women who claimed to have experienced domestic violence and by those who have not. They were attempting to find correlating symptoms associated with domestic violence, and how acknowledging these symptoms may better help medical practitioners to detect abuse. Throughout their research, they found many correlations between PTSD and reactions to violence; one specific reaction has been termed the “learned fear response” (Karakurt et al. 2016). When a survivor is experiencing an assault, they may have physical reactions such as shaking, rapid heart rate, nausea, and shortness of breath; in subsequent instances of conflict, a survivor can re-live these physical reactions without any direct contact from their abuser (Karakurt et al. 2016). This magnifies the experience of abuse even when physical trauma is not present. This can be representative of the long-term impacts from instances of abuse—whether it occurred ten minutes or ten years ago, the impact of trauma is not only long lasting but deeply suppressed.
The final red flag is the reconciliation stage. An example of this would be an abuser apologizing profusely, promising the abuse was situational, perhaps due to an action committed by the survivor. The abuse and exploitation has dropped by this third stage, but eventually tension rises again (Baker 1997). Domestic violence is never an isolated incident. Though one particularly frightening incident may stand out above the rest, it stems from—and is fueled by—the systematic oppression of power, control, and patriarchy.

Ultimately, individuals who have survived domestic abuse exhibit a wide variety of coping strategies. While onlookers may criticize someone’s choice to stay in an abusive relationship, it is important to acknowledge the complexity of this decision. Phyllis Baker explains the multitude of coping forms that are practiced by survivors of domestic violence in her ethnography "And I Went Back: Battered Women’s Negotiation of Choice" (2009). She conducted sixteen in-depth interviews with women who spent an extended amount of time in domestic violence shelters, many of whom sought out formal networks for assistance, such as crisis centers and law enforcement. Despite these resources, many of these same women also returned to their abuser. This, like fleeing or seeking legal support, is a way to cope. Baker explains this coping strategy as a direct opposition to the “dominant culture script,” which is a largely over-generalized solution to fleeing domestic violence: pack your bags, get a lawyer, and remove all ties with the abuser (2009, 56). Although this solution may be
applicable to certain cases, there is no “one size fits all” approach. Various factors such as financial needs, child care assistance, and threat of injury are relevant when making the decision to leave or mend a relationship. Whether maintaining the relationship or fleeing the violence, every survivor is actively using their agency and coping techniques to properly serve their situation-specific needs.

By the same token, a survivor may abandon the dominant culture script and exhibit what Clements and Sawhney call “emotion-focused” coping (2000). An example of this is safety planning, where a survivor has a hidden bag containing survival items in case they need to flee a highly violent situation. Another technique is placating, where the survivor tends to their abuser’s needs during the tension stage to avoid an outburst. As human beings, we make autonomous decisions to keep ourselves safe in traumatic situations. The careful consideration and discussion of deeply rooted patriarchy can be practiced every day by a change in our vocabulary. Advocates can replace the term “victim” in their discourse. Baker continually emphasized that by labeling someone as a “victim,” they are stripped of their agency (2009). Instead, survivors of domestic abuse can be referred to as just that: survivors. It is important to not demoralize the various strategies used by survivors but rather explore them to develop a wider understanding of the complexity of domestic violence.

To summarize, relationships are complex and consist of many different identities. Whether cis, trans, or something in between, violence expands well beyond the male-female dichotomy and therefore demands our attention. Too often are non-binary conforming individuals at a disadvantage because of their identity. We all have the capability to play an active role in identifying domestic violence and we all have the power to be advocates for justice in our community. Advocates can learn to help identify the three stages of domestic violence, educate themselves on the various coping mechanisms used by survivors, and change the discourse surrounding intimate partnerships and those experiencing abuse. By understanding that these people battle their trauma as autonomous, strong, and competent beings, we are able to validate the agency lived by these people.
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