

# SURJ

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The mission of the Stanford Undergraduate Research Journal is to encourage, recognize, and reward intellectual activity beyond the classroom, while providing a forum for the exchange of research and ideas. SURJ encourages students to become interested in research by displaying examples of what is studied and by offering the means of communicating knowledge between these disciplines to achieve an holistic effect.

# A Letter from the Editors

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Dear Reader,

It is with great excitement that we present you with this twelfth volume of the Stanford Undergraduate Research Journal. We are proud that this journal is a fitting testament to the vibrance of undergraduate research, at Stanford and across the globe.

This year, out of an unusually strong pool of submissions across a wide range of disciplines, we have selected 17 exceptional papers to share with you. These papers represent some of the very best undergraduate research in their respective disciplines. We encourage you to explore rocky intertidal zones with Matthew Higgins ('14), understand pilgrimages with Taylor Winfield ('13), examine British genre painting with Judith Pelpola ('15), and (copy) edit Wikipedia pages with Caitlin Colgrove ('12), Julie Tibshirani ('12), and Remmington Wong ('11). These papers represent a fraction of the research that lie in the following pages. We hope you enjoy engaging with the brilliant young minds of these authors.

Each year, we strive to increase SURJ's impact and further our mission of celebrating undergraduate research. This year started with a brand new website for SURJ where all past articles published by SURJ are available individually. Our outreach team, led by James Nie ('15), started a series of online features sharing undergraduate research stories on campus, called Spotlight on Research. We have also initiated communication with undergraduate research journals across the country, and we are delighted to announce the first outcome of these efforts: a journal exchange program with The Harvard Undergraduate Research Journal. This was in addition to revamping our editorial process courtesy of review coordination officers Devan Diwanji ('15) and Laurie Rumker ('15).

This journal would not have been possible without the incredible dedication and enthusiasm of this year's SURJ staff. In addition to those already mentioned, we would particularly like to mention the following members of staff for their executive leadership roles: production leads Susan Tu ('15) and Catherine Dong ('16); Natural Science section editors Eric Liaw ('14) and Evelyn Chang ('15); Humanities section editors Mark Bessen ('15) and Aldric Ulep ('14); Social Science section editors Jodie Ha ('14) and Julia Turan ('14); and Engineering section editors Arzav Jain ('15) and Isaac Madan ('15). We are constantly impressed by the maturity and drive of our staff across all fronts, and are eager to see what the future holds for SURJ in the hands of these incredible leaders, editors, designers, and journalists.

We are also indebted: to Dr. Shay Brawn of the Hume Writing Center, who guided our staff through the editing and production processes with wisdom, grace, and good humor; to the guidance of the Office of the Vice Provost of Undergraduate Education; and to the ASSU Publications Board for advising and financial support.

Again, our most heartfelt thanks go to all those who made this journal possible. We hope you enjoy this volume of the Stanford Undergraduate Research Journal.

Sincerely,

Daniel Ibarra, Class of 2012  
Bryce Cronkite-Ratcliff, Class of 2013  
*Editors-in-Chief*

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# Homogenizing Community, Homogenizing Nature: An Analysis of Conflicting Rights in the Rights of Nature Debate

Laurel Fish

Stanford University

## Abstract

In less than half a decade, the idea that nature possesses inalienable rights akin to human rights has gone from a strictly theoretical concept to the basis for policy changes in several countries and U.S. municipalities. This paper explores the tensions between community decision-making and the rights of nature by focusing on how the implementation of these theories has played out in Ecuador and how similar laws might function in the city of Spokane, Washington.

On one hand, the laws assume that local communities will act in the best interest of society and the environment, without acknowledging the heterogeneous interests and power dynamics within communities and between non-locals and a given community. On the other hand, the laws assume that nature's needs are always compatible with community needs and that nature itself is a homogenous entity rather than a complex ecosystem of competing interests. Together, these bifurcated oversights represent the existential tension of rights discourse in which community, societal, and environmental needs come into conflict. This paper seeks to explore the tensions of current initiatives and inform alternative framings for future initiatives in Spokane and elsewhere.

In less than half a decade, the idea that nature possesses inalienable rights akin to human rights has gone from a strictly theoretical concept to the basis for policy changes in several countries and U.S. municipalities. In 2008, Ecuador became the first country to constitutionally guarantee the rights of nature. Attempting to use this momentum, a community group in the city of Spokane, Washington has put forth three voter initiatives that include provisions granting rights to nature—the first was soundly rejected by over 75 percent of voters, the second was voted on in November of 2011 and missed passing by less than one percent, and the third will be on the 2013 ballot [i]. The recurrence of these initiatives and similar proposals in other cities presents a unique opportunity to explore the implications of rights of nature initiatives, their potential, and the unproductive contradictions inherent in their current framing.

This paper will focus on the tensions between community decision-making power and the rights of nature in the context of rights of nature initiatives in Spokane and Ecuador. On the one hand, the laws implicitly assume that local communities will act in the best interest of society and the environment, without acknowledging the heterogeneous interests and power

dynamics within communities and between non-locals and a given community. This oversight reinforces power disparities by facilitating claims that are disconnected from broader societal needs and obscuring potential ulterior motives of lawsuit plaintiffs. On the other hand, the laws assume that nature's needs are always compatible with community needs and that nature itself is a homogenous entity rather than a complex ecosystem of competing interests at different scales. This misunderstanding undermines the very principle that nature possesses inalienable rights by naturalizing human culture as harmonious with nature and romanticizing nature itself. Together, these bifurcated oversights represent the existential tension of rights discourse in which community, societal, and environmental needs come into conflict. While there are continuous tensions between the full expression of universalized rights, recognizing these points of conflict is the starting point for a thoughtful and contextualized prioritization of diverse rights. This paper seeks to explore the tensions of current initiatives and to inform alternative framings for future rights of nature initiatives in Spokane and elsewhere.

## Human Rights and Rights of Nature in Ecuador

The expansion of the human rights framework has occurred at an astounding pace over the 21st century. While many national constitutions (especially in the West) historically recognized certain human rights, such as the first-order rights to life and liberty, the concept of human rights exploded internationally in the post-World War II era with the emergence of post-colonial nation-states and the 1948 United Nations Universal Declaration of Human Rights. Since then, the recognition of rights has grown exponentially to encompass prisoner's rights, religious rights, voting rights, disability rights, and more [ii].

While international bodies and individual nation-states have quickly jumped on the human rights bandwagon, they have been extremely hesitant in granting rights to nature. The movement to guarantee legally enforceable rights of nature has come mainly from the United States, yet draws inspiration from indigenous paradigms of the relationship between humans and the environment. Since the 1940s, scholars such as Aldo Leopold, James Lovelock, and Arne Næss have developed the framework for the recognition of rights that acknowledged human interdependence with the environment [iii]. In 1972, Christopher Stone proposed the first mechanism for codifying nature's rights in an essay titled "Should Trees Have Standing?." That same year, Supreme Court Justice William O. Douglas entertained Stone's concept in his dissenting decision in *Sierra Club v. Morton*, stating outright that "the critical question of 'standing' would be simplified and also put neatly in focus if we fashioned a federal

rule that allowed environmental issues to be litigated...in the name of the inanimate object about to be despoiled, defaced, or invaded by roads and bulldozers, and where injury is the subject of public outrage” [iv]. Rights of nature advocates have wistfully held up Douglas’ dissenting opinion for multiple decades as a representation of what might be possible.

However, only over the last four years have rights of nature moved from theory to practical recognition and enforcement. The 2008 Ecuadorian Constitution was a bold and exceptional affirmation of both nature’s inherent value and indigenous worldviews. It recognizes rights belonging to Pachamama (the Quechua world correlating to Mother Earth) including those to “integral respect for its existence,” “maintenance and regeneration,” and “restoration.” In addition, Article 73 states that “the State shall apply preventive and restrictive measures on activities that might lead to the extinction of species, the destruction of ecosystems and the permanent alteration of natural cycles.” Article 74 states that “persons, communities, peoples, and nations shall have the right to benefit from the environment and the natural wealth enabling them to enjoy the good way of living [life in harmony]” [v].

While these provisions are certainly significant, there are several important subtexts to the Ecuadorian case. First, the rights of Pachamama are surrounded by a laundry list of other rights, including those to “nutritional food, preferably produced locally,” “universal access to...communication technologies,” “the practice of sports and free time” “tax exemptions for elderly persons,” and the free “develop one’s personality” [vi]. The inclusion of such a wide spectrum of rights risks a complete inability to prioritize the enforcement of these rights, diminishing the urgency of the entire list. The fact that most of these rights are being violated in continual and significant ways suggests that the list is more of a national vision statement than a State obligation. Second, the new constitution is Ecuador’s twentieth since its independence in 1822. The rapid turnover rate suggests that each constitution is given relatively less significance and that the current version may not last past the current presidential term [vii].

### **Community Rights and Rights of Nature in Spokane, WA**

Emboldened by the recent constitutional changes in Ecuador, the movement in the U.S. to add rights of nature to city and town charters is growing. Spokane, Washington is an interesting case study as it has attempted to pass several different rights of nature proposals [viii]. As the result of a multi-year partnership between neighborhood advocates, labor union locals, and community activists, a group called Envision Spokane placed the first Community Bill of Rights (titled Proposition 4) on the 2009 municipal ballot. The initiative, though not quite as expansive as the Ecuadorian Constitution, had nine main provisions including the subordination of corporate rights to community rights, rights for nature, and enhanced rights to neighborhood decision-making. In respect to the rights of nature, the initiative included a fairly expansive definition of nature and its rights:

Ecosystems, including but not limited to, all groundwater systems, surface water systems and aquifers, have the right to exist and flourish. River systems have the right to flow and have water quality necessary to provide habitat for native plants and animals, and to provide clean drinking water. Aquifers have the right to sustainable recharge, flow and water quality... Enforcement actions shall [include] restoration of a damaged ecosystem. [ix]

The long list of rights without any clear plans for enforcement and the broad definition of ecosystem mirror the expansiveness of the Ecuadorian Constitution. Despite its lofty goals, or perhaps because of them, Proposition 4 was soundly defeated at the polls by over 75 percent of voters.

Envision Spokane put forth their next attempt in November 2011. The 2011 Community Bill of Rights (Proposition 1), was much more focused than the previous version and included only four provisions: the right of neighborhoods to approve all development-related zoning changes, the right to healthy water systems, the subordination of corporate rights to community rights, and worker’s rights to constitutional protections in the workplace. The first three provisions are the most salient to the current discussion. In regards to environmental rights, the provision was significantly narrowed: “The Spokane River, its tributaries, and the Spokane Valley-Rathdrum Prairie Aquifer possess inalienable rights to exist and flourish, which shall include the right to sustainable recharge, flows sufficient to protect native fish habitat, and clean water.” The latest version of the bill, which will be most likely be on the 2013 ballot, has no significant changes, except for adding language that guarantees the right of Spokane residents to sustainably use water resources [x].

The limitation to particular water systems, the removal of the right to restoration, and the elimination of several provisions were probably factors in the relative success of Proposition 1 and explain why is being introduced with very few changes in 2013. This accomplishment is even more surprising given that Proposition 1 (as with Proposition 4) was supported by only two businesses in Spokane and that opponents of the initiative outspent the proponents by over 5 to 1 [xi,xii]. Even the campaign director for the initiative said that he was expecting to receive only 35 percent of the vote (Huschke K, personal interview, Nov 22, 2011). Although there are certainly many factors that may have affected the bill’s surprising success, the increasing support for the initiative indicates that the concepts of nature’s rights and community-based decision-making are gaining ground. However, as these ideas become more mainstream, it is important to look not only at the underlying objectives, but also at how these provisions play out in the real world.

### **Not In [Nature’s] Back Yard: NINBYism as a cover for NIMBYism**

One of the most pressing practical conundrums in implementing rights of nature proposals is who should act as nature’s representative, given that nature cannot represent itself in the legal system. As rights of nature have gone from theory to practice [xiii], the trend in Ecuador and Spokane has been to grant standing to everyone, regardless of whether or not they suffered direct harm (the typical standard in a lawsuit), while naively assuming that the provisions will be used primarily by idealized communities that have nature’s best interest at heart [xiv]. However, open standing (*actio popularis*) is not as democratic or unequivocally good for an ecosystem’s best interests as it may seem. Because anyone, including foreigners, people unfamiliar with the local environment, and corporate interests can sue on behalf of nature under an open standing doctrine, there is the possibility that claims supposedly based on nature’s rights will be used to further the personal interests of those people in power. This not only reinforces existing political and economic

disparities, but also permits claims that are disconnected from local needs and obscures ulterior motives of lawsuit plaintiffs. In part, the idealization of a homogenous community serves to hide disparities and conflicting interests within the community, as well as between the community and society more broadly.

The first (and so far, only) case where the courts have recognized the rights of nature, already shows signs that the law obscures resource disparities and conflicting interests between different community groups. The case was presented to the Loja Provincial Court of Justice in Ecuador in March of 2011, on behalf of nature, specifically the Vilcabamba River, and against the Provincial Government of Loja. The suit sought to stop the widening of the Vilcabamba-Quinara road that runs past the river. The plaintiffs, Richard Frederick Wheeler and Eleanor Geer Huddle, argued on behalf of nature that new construction was adding debris to the river, thus “increasing the river flow and provoking a risk of disasters from the growth of the river with the winter rains, causing large floods that affected the riverside populations who utilize the river’s resources” [xv]. Environmental groups applauded the courts for allowing Wheeler and Huddle to file a lawsuit on behalf of the river rather than out of direct personal harms.

On an environmental level, the suit may prevent a minimal amount of environmental damage, but further investigation indicates that the case was primarily a victory for Wheeler and Huddle, two American residents who live part-time in Ecuador and own property downstream of the road construction. According to their website, the couple have plans to develop a “Garden of Paradise Healing and Retreat Center” outside of Vilcabamba, with plots along the river selling for \$30,000 to \$150,000 [xvi]. The land slated for development was most likely that which was flooded by the new road construction—one of the reports from the Global Alliance for the Rights of Nature states that the 3.7 acres that flooded as a result of the road construction were “of the most valuable land in the Uchima Neighborhood” and that approximately 15,404 feet of the Wheeler-Huddle land was affected [xvii]. To be sure, the case most likely did prevent a minimal amount of erosion in the Vilcabamba River, but it is questionable whether the construction of a full-scale retreat center and multiple houses along the river that cater to Western tourists, will not have an equal or greater impact on the river and surrounding environment.

While the true environmental impact remains ambiguous, the suit had clear social implications that were not taken into account. Basing the claim on nature’s rights sidestepped the issues of resource disparities and competing rights claims between foreign interests and the local community. The case briefly mentions the impact on the surrounding community that uses the river, but it appears that no local people were asked to testify, and local perspectives were not a major part of the judge’s decision. Furthermore, there is no evidence on how the development affected the lives of local people. What was the economic impact of the road construction on surrounding communities? Were local people supportive of the lawsuit? Did the road increase mobility and access for local people? These questions become irrelevant when the rights of nature provisions are examined in isolation, without regard to provisions that guarantee the human right to benefit from the environment (such as Article 74) and to lead productive and meaningful lives. In fact, the Vilcabamba case generated absolute, unadulterated

praise from environmental organizations, with no one bothering to examine the motives behind the suit or consider how the road might benefit the surrounding communities [xvii]. Organizations such as the Global Alliance for the Rights of Nature specifically praised the Loja court for focusing exclusively on the violation of nature’s rights rather than comparing the competing interests of the river and surrounding communities [xix]. This praise not only overlooks any potential ulterior motives of the plaintiffs, but also neglects a discussion of the comparative value and risks of development and conservation. Even if the suit had a net positive impact for the Vilcabamba River, it shows the risks of overlooking tensions between the rights claims of humans and nature.

While Ecuador certainly faces unique problems such as instability and corruption within its court system and large wealth disparities between foreigners and citizens, which would enhance the possibility for successful personal interest claims, the threat of NIMBYism also applies to the United States [xx]. It is easy to imagine situations in which a proposed development would be in the best interest of society as a whole, but have some negative impacts for nearby residents. Schools, light rail lines, halfway houses, and waste treatment facilities are all necessary, but create some annoyances for residents in the immediate vicinity. The risk is that claims on behalf of nature—cutting down trees, clearing brush, impinging on animal habitat—would be used by more powerful groups to simply relocate development to poor neighborhoods, where the environmental impact could be equivalent or even greater.

Proponents of granting rights to nature envision the laws being used to assist communities in fighting back against corporations and developers, and largely deny the possibility of personal interest claims. For example, when asked if individuals could use their advocacy for nature to advance their own interests, the Envision Spokane campaign director indicated that communities are less likely than corporations to make self-interested claims. He did not take other possibilities seriously, saying only that democracy is almost necessarily “messy” (Huschke K, personal interview, Nov 22, 2011). Even Thomas Linzey, one of the main people involved in drafting the provisions for U.S. municipalities and Ecuador, admits that the laws make it possible for a developer to argue that it is in the “best interest of the river to be diverted, or used, or put to some other ‘higher and better’ purposes.” Linzey’s proposed resolution is to trust that the laws’ true intent will be “vindicated” by well-meaning communities [xxi]. However, the cases above suggest that local communities may not have the resources, power, or even desire to uphold the best interests of the local environment. While combating the threat of corporate power is certainly one application of the proposed laws, it is likely not the only—the lack of attention to local resource disparities and heterogeneous interests within a community threatens to silence certain perspectives and even well-meaning communities may not act solely in nature’s best interest.

### **Nature’s Rights as Human Rights and Nature as Homogenous**

The homogenization of divergent interests within a community parallels the assumptions that nature’s needs are inseparable from those of the community and that nature is a homogenous entity with only a single set of needs. These assumptions naturalize human culture (and especially indigenous cultures) as existing in harmony with nature and

romanticize the environment as a homogenous, harmonious entity. While both the naturalization of indigenous culture and the anthropomorphization of nature is more direct in Ecuador, much of the same framework is appropriated in spirit, if not in direct wording, in the Spokane rights of nature provisions. This rhetoric undermines the very premise of ecocentric policies, and fails to acknowledge competing interests within an ecosystem and between ecosystems of different geographic scales.

Most prominently, rhetoric in the Ecuadoran constitution and some United Nations documents fails to make distinctions between the rights of nature as a separate entity and the indigenous right to culture, which not only undermines the principle of nature's rights, but also glosses over the potential for conflict between human rights and nature's rights. The Ecuadorian constitution uses multiple indigenous Quechua words interchangeably with Spanish terms when referring to environmental issues, including Pachamama for Mother Nature, or nature more broadly, and *sumak kawsay*, meaning the good way of living or life in harmony [xxii]. While these terms partly affirm indigenous cultures and worldviews, worldviews are not simply transferable to a static and legalistic framework of inalienable rights for nature—closing the gap between a particular worldview and its enshrinement in national law necessitates a conflation of the indigenous right to culture and nature's rights as a separate entity. For example, the United Nations "Study on the rights of Mother Earth" contends that nature is so intertwined with humanity in the indigenous worldview that "Nature, of which mankind is a part, is Pachamama." Thus, "the rights of Pachamama could be inherent in the rights of humankind, human rights" [xxiii]. While humans certainly depend on the environment and can have deep connections to land, the idea that nature's rights are subsumed under human rights seems to weaken the very principle of distinct rights for nature. In addition, the conflation of humans and nature as the same entity glosses over the difficulty in presuming that humans (indigenous or not) know what is best for the environment. Even if humans could know what would be best for an ecosystem, the conflation assumes that people would always act in nature's best interest, even when it went against their own self-interests.

The rhetoric of nature's rights in Spokane parallels that of Ecuador in some ways, but is also unique in that it is framed in a historical context of extending rights to different human groups. In an adaptation of Pachamama as a member of the human community, all three initiatives in Spokane included the rights of nature as part of the Community Bill of Rights—the right to a healthy Spokane River and Aquifer is subsumed under the Community Bill of Rights, but also includes the rights of the Spokane River and Aquifer. This framing can be extrapolated in several ways: that nature is a part of the community (presumably the community that is geographically nearby), that humans are inseparable from nature (in the sense of an ecosystem), or that a community has the right to nature's existence. The fact that the propositions do not acknowledge or delineate between these different possibilities suggests that perhaps all three are intended or cannot be separated from one another [xxiii].

The anthropomorphization of nature and conflation of human rights with nature's rights has several implications. First, the slippage undermines the very premise of ecocentric policies—nature is conserved not for its own inherent value, but for its value to cultures and societies. This justification then legitimizes

the conservation of only the elements of nature that humans value, rather than those most important to the functioning of the ecosystem. Although many of the potential cases may directly benefit the environment and preserve parts of nature that people value for cultural, spiritual, economic, or other reasons, not recognizing the slip between these two sets of needs allows a dangerous type of anthropocentrism to continue. As Myrl Duncan argues, the anthropocentric model is less damaging than a purely egocentric (self-centered) model, but it is more "insidious" as it "permits us to think we are protecting 'the environment' when we are primarily protecting human beings" [xxiv]. As Proposition 1 shows, groups have already begun to focus on granting rights to parts of nature that "resonat[e] with folks" (Huschke K, personal interview, Nov 22, 2011). While this may be a strategic decision for the time being, it also opens the door to only preserving the elements of nature that appeal to humans—jungles that are useful for bioprospecting, the endearing panda bear, waterfront ecosystems frequented by tourists—rather than protecting endangered fish species or desert wildlife that are harder to capture in a postcard image.

Second, the homogenization of nature ignores questions about what actually counts as "nature" and fails to grapple with the divergent needs within a single ecosystem—just as a human community is not a homogenous entity with a single set of needs, the Western conception of nature implies a false sense of homogeneity. Under the Ecuadorian constitution for example, "nature" is not defined explicitly, meaning that it could reasonably include "entities like pests, viruses, bacteria, tornadoes, and intangible entities like climate" [xxv]. Within the concept of nature, there is no way to mediate between competing claims. For example, how should judges weigh the loss of wetland habitat with the potential for the restoration of fish habitat in a dam removal project? What if overpopulation of an individual species threatens other elements of an ecosystem [xxvi]? According to the legal scholar, Michelle Bassi, this lack of specificity then creates the potential for judges and legislators to define nature in "anthropogenic" terms, which might also allow "corporate interests... [to] define nature in ways that would justify destruction in the name of defending other "rights of nature" [xxvii].

Lastly, the local character of legislation in Spokane and the romanticization of nature in both Ecuador and Spokane overlook the potential for conflicting interests between ecosystems of different scales. While local ecosystems are valuable, the localized rhetoric of Proposition 1 obscures the fact that the rights of local ecosystems may conflict with broader environmental rights. For example, given that hydropower can substitute for fossil fuel use, how should a court balance the right of a river to not be dammed versus the harms caused by air pollution and oil extraction from fossil fuels? These conundrums are especially acute when only certain elements in an ecosystem have rights. Proposition 1 only gives rights to the water systems in the Spokane area, but what happens when the rights of the Spokane River to not be dammed conflict with the non-legislated right of the Alaskan wilderness to not be drilled for oil? If only some rights are protected, how should courts mediate a case if proposed development would negatively affect a watershed area but moving it would have a greater negative impact on a nesting ground for endangered birds? Rather than grappling with these questions, rights of nature proposals assume that nature is a single and homogenous entity.

## Conclusion

As with any other ballot initiative or constitutional amendment, the full significance of rights of nature laws will have to be clarified and defined over time through judicial review. Nevertheless, future rights of nature laws anticipated from Spokane to Bolivia can adapt both their wording and their framing to the successes and failures of existing laws. Rather than *actio popularis*, the judicial system must hold plaintiffs accountable to truly acting in nature's best interest as defined to the best of human capabilities. In practice, this means that judiciaries should adopt a "liberal interpretation of sufficient interest" guideline, meaning that a plaintiff must have "knowledge of the injured community or ecosystem,...genuine interest, and [be able to] accurately represent nature in litigation" [29].

While a different standing doctrine would resolve some of the problematic aspects of enforcing nature's rights, policymakers and judges will inevitably have to make tough decisions about how to prioritize rights in different contexts. Primarily, there must be recognition that local communities do not always represent the best interests of the environment and that even the vision of well-meaning communities can be undermined by personal interest claims. Perhaps also, the flaws of localist rhetoric in Spokane can help problematize this same rhetoric in talking about indigenous Ecuadorian communities or even raise the question of whether U.S. organizations writing and advocating for provisions in the Ecuador constitution is its own sort of NIMBYism—the West experimenting in the Global South with policies that they are not yet ready to try on themselves. As currently framed, rights of nature laws risk undermining both community interests and environmental interests, by letting non-locals and privileged interests exploit nature's rights to promote their own interests. Prioritizing rights will entail inevitable sacrifices, but is a necessary mode of resolving tensions that exist whether or not they are acknowledged.

## End Notes

- [i] "2011 Washington General Election: Spokane Proposition 1, Community Bill of Rights" (2011, Nov 14). The Spokesman-Review Election Center. [Online]. Available: <http://www.spokesman.com/elections/2011/washington-general-election/measure/citytown/city-of-spokane/46/>.
- [ii] Stacy H, *Human Rights for the 21st Century: Sovereignty, Civil Society, Culture*. Stanford, CA: Stanford U Press, 2009, pp. 5.
- [iii] U.N. Economic and Social Council, "Study on the need to recognize and respect the rights of Mother Earth," report to Permanent Forum on Indigenous Issues 9th Session held in New York, April 2010, pp. 15.
- [iv] *Sierra Club v. Morton*, 405 U.S. 727 (1972).
- [v] Constitution of the Republic of Ecuador, art. 71-74. Available: <http://pdba.georgetown.edu/Constitutions/Ecuador/english08.html>.
- [vi] Constitution of the Republic of Ecuador, art. 13, 16, 24, 37, 66. Available: <http://pdba.georgetown.edu/Constitutions/Ecuador/english08.html>.
- [vii] Ecuador ranks fourth in the world for the number of different constitutions it has had. Cordeiro JL, "Latin America: Constitution Crazy," *Latin Business Chronicle*. Oct 2008. Available: <http://www.latinbusinesschronicle.com/app/article.aspx?id=2799>.
- [viii] The city also has noteworthy connections to Ecuador given that Thomas Linzey, the founder of the organization that helped Ecuador craft the articles about rights of nature, lives in Spokane (Huschke K, personal interview, Nov 22, 2011).
- [ix] The excerpted wording is from the proposition itself as included in the news story. Brunt J, "Prop 4 supporters, opponents make cases; Point by point arguments on proposed community bill of rights," *The Spokesman-Review*, online edition 11 Oct 2009. Available: <http://www.spokesman.com/stories/2009/oct/11/defining-community-rights/>.
- [x] "Proposition 1 - Community Bill of Rights," *Envision Spokane*, Available: <http://envisionspokane.org/2011/08/17/proposition-1-community-bill-of->

rights. The 2013 version of the initiative made no significant changes, except for adding the right of Spokane residents to use water resources: "All residents of Spokane possess fundamental and inalienable rights to sustainably access, use, consume, and preserve water drawn from natural cycles that provide water necessary to sustain life within the City." See "Community Bill of Rights: Initiative 2012-13," *Envision Spokane*, Available: <http://envisionspokane.org/2011/08/17/community-bill-of-rights>.

- [xi] It is worth mentioning that of the two businesses listed as endorsers, one is a Fair Trade import business and the other is a non-profit community kitchen. *envisionSPOKANE*, Spokane: Envision Spokane. Available: <http://envisionspokane.org>.
- [xii] According to Public Disclosure Commission, the Envision Spokane Political Committee spent \$18,344.57, while the opposition PAC, the Jobs and Opportunities Benefiting Spokane Political Committee spent \$104,730.60. "Cash Contributions for: ENVISION SPOKANE POLITICAL COMM," Public Disclosure Commission," Available: <http://www.pdc.wa.gov/MvcQuerySystem/CommitteeData/contributions?param=RU5WSVNQIDIwMg===&year=2011&type=single>; and "Cash Contributions for: JOBS & OPPORTUNITIES BENEFITING SPOKANE POLITICAL COMM," Public Disclosure Commission Available. <http://www.pdc.wa.gov/MvcQuerySystem/CommitteeData/contributions?param=Sk9CU09CIDIxMw===&year=2011&type=continuing>.
- [xiii] In *Should Trees Have Standing?*, Stone asserts that trees themselves should have legal standing, but he breezes over the difficulty of who should advocate for the trees (and the rest of the ecosystem), arguing that nature's inability to speak should not be grounds for denying nature standing. He points out that many other entities including, "corporations...states, estates, infants, incompetents, municipalities [and] universities" cannot speak for themselves, yet are represented by lawyers. However, the difficulty is not who will represent nature in the courtroom, as the majority of legal cases are argued by lawyer. Rather, it lies in who should be able to hire legal council on behalf of nature, who is recognized as having nature's best interests at heart, and what parts of "nature" deserve rights when rights conflict with each other. Stone CD, "Should Trees Have Standing--Toward Legal Rights for Natural Objects," *Southern California Law Review* vol. 45, pp. 454, 1972.
- [xiv] The Ecuadorian constitution, for example, states that "each person, community, neighborhood and nationality shall have the power to enforce the rights [of nature] before the public authority." Most scholars agree that this language correlates to the legal concept of *actio popularis*, under which any of "nature's millions of potential representatives can earn standing," regardless of whether or not they have been directly harmed. Proposition 4 in 2009 was similarly broad, stating that "any person seeking to enforce the rights of ecosystems, may enforce these rights." The 2011 and 2012 version significantly limited who had standing to enforce nature's rights to only people living within the City of Spokane, but did not place restrictions on the motives of those bringing cases. They both state that: "the City of Spokane and any resident of the City or group of residents have standing to enforce and protect these rights."
- [xv] Greene N, "The first successful case of the Rights of Nature implementation in Ecuador," *The Global Alliance for the Rights of Nature*. Available: <http://therightsofnature.org/first-ron-case-ecuador/>.
- [xvi] Richard Wheeler seems to be the quintessential new-ager, his personal website describes him as a "multi-talented artist whose visual & musical creativity was irrevocably influenced in the famous '60s by immersion in the psychedelically-enhanced Sensory Isolation Tank." Wheeler R. (2006). *WheelerWhirled I* [Online]. Available: [http://www.tarpitboss.com/tarpitboss.com/WheelerWhirled\\_I.html](http://www.tarpitboss.com/tarpitboss.com/WheelerWhirled_I.html)
- [xvii] Greene, "The first successful case of the Rights of Nature implementation in Ecuador."
- [xviii] Daly E, "Ecuadorian Court Recognizes Constitutional Right to Nature," *Widener Environmental Law Center: The Blog*. 12 July 2011. Available: <http://blogs.law.widener.edu/envirolawblog/2011/07/12/ecuadorian-court-recognizes-constitutional-right-to-nature/>.
- [xviii] The logic here is a little hard to follow as it seems as though any rights claim would have to balance different interests claims. The text is excerpted below for analysis. "The Provincial Court of Loja... establishes:...That the argument of the Provincial Government that the population needs roads does not apply because there is no collision of constitutional rights of the population, nor is there any sacrifice of them, because the case does not question the widening of the Vilcabamba-Quinara road, but the respect for the constitutional rights of nature." (Greene, "The first successful case of the Rights of Nature implementation in Ecuador.")
- [xx] Whittemore ME, "The Problem of Enforcing Nature's Rights under Ecuador's Constitution: Why the 2008 Environmental Amendments Have No Bite," *Pacific Rim Law & Policy Journal Association* vol. 20, no. 3, pp. 671-675, 2011.

- [xxi] Linzey T, "The Implementation of Rights for Nature," 2008.
- [xxii] Constitution of the Republic of Ecuador, art. 71, 275.
- [xxiii] U.N. Economic and Social Council, pp. 14.
- [xxiv] When asked about this issue during an interview, Kai Huschke replied that "it's really about nature having the inalienable right to exist in and of itself... exclusive really of human beings...It is our responsibility to be stewards of those natural systems, for them, but also understanding that we're linked to the natural system as well"
- [xxv] Duncan, ML, "The Rights of Nature: A Triumph for Holism or Pyrrhic Victory," *Washburn Law Journal* vol. 31, pp. 67, 1992.
- [xxvi] Whittemore ME, "The Problem of Enforcing Nature's Rights under Ecuador's Constitution: Why the 2008 Environmental Amendments Have No Bite," *Pacific Rim Law & Policy Journal Association* vol. 20, no. 3, pp. 669, 2011.
- [xxvii] One example of this type of scenario come from Kenya's Amboseli National Park where elephants in a park are destroying a woodland ecosystem that also had a right to exist. See Thompson C, "Competing Philosophies of Nature," in *Complexities: Social Studies Knowledge*, Eds. A Mol and J Law, Durham, NC: Duke U Press, 2002, pp. 167-190.
- [xxviii] Bassi M, "La Naturaleza O Pacha mama de Ecuador: What Law Should Grant Trees Standing?," *Oregon Review of International Law* vol. 11, pp. 468, 2009.
- [xxix] Bassi M, "La Naturaleza O Pacha mama de Ecuador: What Law Should Grant Trees Standing?," *Oregon Review of International Law* vol. 11, pp. 473, 2009.

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- Constitution of the Republic of Ecuador. Available: <http://pdba.georgetown.edu/Constitutions/Ecuador/english08.html>.
- Cordeiro JL, "Latin America: Constitution Crazy," *Latin Business Chronicle*. Oct 2008. Available: <http://www.latinbusinesschronicle.com/app/article.aspx?id=2799>.
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Laurel Fish is a junior from Spokane, WA majoring in anthropology. Her academic interests include human relationships with the natural environment, immigration politics, and the study of social movements. Her fieldwork this summer will focus on Latino immigrants in the San Francisco Mission District. Alongside her academic interests, Laurel is passionate about backpacking, gardening, and activism that creates the conditions for social justice.



# Community-Based Management of Multidrug Resistant Tuberculosis in Rural Kwazulu-Natal

Michael Celone

Tulane University

## Abstract

Multidrug Resistant Tuberculosis (MDR-TB) is a significant health burden in South Africa, and it is particularly problematic in the region of KwaZulu-Natal. MDR-TB is not susceptible to most first-line medications, and anti-bacterial treatment for resistant bacteria may take up to 24 months to complete. The majority of this treatment process occurs outside the confines of the MDR-TB ward – in the community. This project examines the provision of community-based care to MDR-TB patients in a rural area of Northern KwaZulu-Natal, and attempts to understand the multifaceted system of MDR-TB control.

Community-based care is one of the essential steps in the treatment of MDR-TB due to the lengthy treatment process and the potential for adverse side effects. Without a comprehensive system of community-based care, MDR-TB has the opportunity to proliferate and to amplify its resistance. This project explores the roles, motivations, and skills of various community caregivers who are responsible for treating and overseeing MDR-TB patients in the community, such as the TB tracers, injection nurses, home assessors, and community health workers who all play integral roles in managing MDR-TB. Participant observation and informal conversations with these hospital personnel allowed for a comprehensive understanding of the management of MDR-TB in the community, and to assess the obstacles to care posed by a rural environment. This experience led to the conclusion that a comprehensive, community-based strategy is necessary for the containment of MDR-TB and that significant funding should be allocated for strengthening MDR-TB control systems.

**T**uberculosis (TB), caused by the *Mycobacterium tuberculosis* bacilli, is a disease that dates back as far as 500,000 years [1]. TB is particularly problematic among poor and marginalized populations in resource-poor areas, and it remains endemic in many low-income countries in Africa, Asia, Europe, and South America. It is estimated that one third of the world's population (2 billion people) is infected with the bacillus, although the majority of these cases are latent or asymptomatic [2-4]. TB usually attacks the lungs but can affect other areas of the body as well, such as the spine, kidney, or brain. When people have an active infection cough, they propel TB bacilli into the air, spreading infection. South Africa has the third highest prevalence rate of TB in the world, lagging behind only China and India [5]. Tuberculosis is a major source of morbidity and mortality in South Africa, causing 5.5% of total deaths and posing

a significant hindrance to the development of the country [6].

Over the past several decades, a new threat has emerged: Multi-Drug Resistant Tuberculosis (MDR-TB), defined as any strain of TB resistant to the most efficacious first line drugs isoniazid (INH) and rifampin (RIF) [7]. Cases of MDR-TB are inordinately concentrated in resource-poor areas of Africa, Eastern Europe, Asia, and South America. Unfortunately, medical facilities in South Africa are not sufficient to treat the growing number of MDR-TB cases. In 2010, the amount of new MDR-TB cases in the province of KwaZulu-Natal exceeded the number of available beds in MDR wards by 352 [5].

While studying abroad for four months in South Africa, I had the opportunity to conduct a research project focused on the recent epidemic of drug resistant TB in KwaZulu-Natal, South Africa, a province that has the highest burden of drug resistant TB in the country. Treating MDR-TB is an 18-24 month process, and the majority of this process occurs outside of the hospital. I explored the various services that have been established to manage MDR-TB in the community and the workers who provided these services and analyzed the findings in a rural context to determine the difficulties associated with providing care. Drug resistant TB is a growing epidemic that shows no signs of receding. To address this epidemic and reduce MDR-TB globally, it is imperative that health systems invest in the support structures responsible for managing MDR-TB at the community level.

## Literature Review

Those who decide to meditate in silence for six days or hike across Northern Spain for five weeks are not average individuals. Most are too busy with the activities of daily life, work, and family to be willing to undergo this experience. Hence, this paper is not about how spiritual practices will affect anyone, because not everyone would be drawn to this experience. My findings, however, are relevant for those who want to increase their spirituality but do not have the resources to undergo a retreat.

I propose that when seekers embark on a spiritual journey, they expect a higher state of well-being. However, is it possible to achieve a higher sense of well-being? Or are changes seekers feel a result of their desire to feel different? Evidence suggests that well-being levels, as measured by a number of scales, can increase – at least in the short term – through intentional actions.

The scale I found most useful is Sonja Lyubomirsky's Subjective Happiness Scale (SHS), which determines subjective well-being levels through four questions with rankings 1-7 (Lyubomirsky 1999). The scale is closely correlated with other happiness measures. Results from SHS and other similar scales suggest that activities like expressing gratitude, compassion, and



forgiveness (Emmons and McCullough, 2003; Lyubomirsky et al., 2005), performing service, acts of kindness, and generosity, (Sheldon et al., 2008), employing one's strengths and pursuing goals (Seligman et al., 2005; Sheldon et al., 2010), and spiritual practices (Koenig et al., 1988; Meisenhelder and Marcum 2004; Hartmann 2006) increase well-being.

Increasing numbers of studies are also touting the benefits of spirituality. While medical researchers were once skeptical that religion might influence mental or physical health, this topic has become well received (Ellison, 1998). One psychologist defines spirituality as a dynamic construct that involves the "internal process of seeking personal authenticity, genuineness, and wholeness" and "deriving meaning, purpose and direction in life" (Astin, 2011). Astin argues that spirituality is a source of inner strength, moral orientation, and connection that brings faith, hope, peace and empowerment. Lyubomirsky uses the research of Myer (2000), Ellison (1998), Pollner (1989) to demonstrate that spiritual people are generally happier, have superior mental health, cope better with stressors, have more satisfying marriages, use drugs and alcohol much less, are physically healthier and live longer than non-spiritual people. Others suggest that spirituality is a significant indicator of well-being because spiritual communities create peer support systems and teach practices and principles that cultivate peace of mind (Keyes, 2002; Lyubomirsky, 2008).

Some researchers have found that spiritual practices, such as meditation, are also related to well-being on numerous scales. Meditation is what positive psychologists refer to as a "flow activity," which is distinguished by a complete immersion in a present task (Csikszentmihályi, 1991). Foster and Hicks find that through flow activities, individuals can further appreciate and enjoy their lives, as "happiness is all about living in the present" (Foster 1999). For example, practicing mindfulness meditation (a Buddhist technique) for as little as eight weeks can measurably change parts of the brain associated with improved memory, sense of self, and empathy and decreased stress (Hölzel 2011). Hartmann adds a new dimension of walking meditation as compared to traditional sitting meditation in his analysis of bilateral therapy. Hartmann discusses how the alternating stimulation of the right and left lobes of the brain "while thinking of a problem or issue" (such as in REM sleep) is potentially healing for emotional trauma (Hartmann, 2006).

Foster, Hicks, Csikszentmihályi, Lyubomirsky, and numerous other psychologists agree that more information on the influence of spiritual relationships and activities on well-being is needed. My work will contribute to this literature through exploring whether spiritual communities and practices influence individual well-being on retreats. It will focus on how the collective experience shapes individual emotions in order to bridge the gap between social theory and positive psychology. The paper will also examine whether the effects of the process last after the end of the experience.

## Methodology

This project was conducted over a 3-week period in the catchment [1] area of a rural hospital in northern KwaZulu-Natal, where a variety of community-based activities that contribute to the surveillance, control, and treatment of MDR-TB were observed. Primarily, qualitative data was gathered through numerous informal conversations with health professionals.

This was supplemented with a variety of secondary sources from academic journals and websites. The hospital and all hospital personnel will remain anonymous throughout this paper to protect their integrity and privacy. The hospital will be referred to as Hospital X. Hospital X is a 280-bed district hospital, belonging to the KwaZulu-Natal Department of Health. It serves a predominantly Zulu population, with some patients crossing the border from Mozambique to receive care.

## Results and Discussion

### Home Injections

An effective treatment regimen for a patient that presents with MDR-TB typically lasts between 18 and 24 months, and this necessitates the provision of injections directly to the home [8]. Those who test positive for MDR-TB are hospitalized in the MDR-TB ward and immediately started on injection therapy with either amikacin (AMK) or kanamycin (KM). This injection is administered to the patient six days a week for approximately two months in the hospital ward. Each month, patients must provide a sputum sample to test for the presence of bacilli. Typically the patient's sputum (mucus from the lower airways) will convert to negative after a period of two months on injections (Nurse 1, Personal Communication, November 8, 2011). According to Department of Health policy, "patients who have negative sputum microscopy and who are clinically not too ill may be initiated on MDR-TB treatment as outpatients if access to daily injections can be organised." [2]

MDR-TB patients should be visited at home by a mobile team five days a week for the duration of the injectable phase of treatment. During visits, the team will administer injectable drugs, monitor side effects, provide health education, and assess household infection control practices [2]. This constant maintenance is essential, because the interruption of injection treatment may amplify the already resistant bacilli, leading to extensively resistant bacteria.

Hospital X has implemented a community-based program to ensure that all MDR-TB patients adhere to the 6-month injection regimen even after discharge from the hospital ward. One nurse from the HAST (HIV, AIDS, and Sexually Transmitted disease) ward has the sole responsibility of driving to the homes of MDR-TB patients and administering injections. It is impractical to assume that the patients or their family members are capable of providing injections due to the difficulty of such a procedure. It is also unrealistic to keep MDR-TB patients in the ward for the duration of the 6-month injection treatment, as resident patients must be discharged to make room for new ones. Therefore, community-based injection treatment is an essential aspect of a successful MDR-TB treatment program.

It is also important to consider the impact of injection treatment on children infected with MDR-TB. Six months of injections place a heavy burden on both the child who must endure the painful procedure and the healthcare professional who must administer the treatment. As one nurse stated, "Another challenge is treating the children with injections. Children normally cry when you give them immunizations, so imagine giving injections for six months? It's not easy to be their enemy" (Nurse 1. Personal Communication. November 8, 2011). In some situations, the injection nurse may be forced to administer treatment while the child is at school, which may reinforce the stigma surrounding TB

and exacerbate the emotional strain for the child. The injection nurse at the hospital commented on this scenario: "Sometimes I must give injections at school and when the other children see them [the patients] getting the injections they will make fun of them [the patients] and isolate them because they think they [the patients] are sick" (Nurse 1, Personal Communication, November 8, 2011). Therefore, community support structures must be established for children who are subjected to treatment for MDR. It is also essential that the patients' peers are educated about the condition so misconceptions are not perpetuated and children are not ostracized as a result of their condition.

### Linking Patients with a DOT Supporter

DOTS (directly observed therapy short-course) has been the cornerstone of TB treatment regimens since it was established in the 1980s by a doctor in Tanzania, and successful treatment outcomes are predicated from the implementation of an effective DOTS program [7]. DOTS is a comprehensive program that relies on government support, a steady supply of antituberculosis drugs, a successful monitoring system, and diagnostic capabilities. The central tenet of DOTS is that all doses are taken under the direct supervision of another individual (a DOT supporter), in order to ensure patient compliance [4].

Directly observed treatment takes on a greater significance in the context of MDR-TB due to the duration of treatment and the complications associated with treating drug resistant strains. The 24-month treatment regimen increases the probability of interruption or default in comparison to the six month, short-course regimen (Nurse 3, Personal Communication, November 14, 2011). In addition, adverse reactions to treatment are increasingly likely with second line drugs. Many countries have adopted a DOTS-Plus program to combat MDR-TB, which is more complex than the traditional DOTS strategy.

The nurses at Hospital X must ensure that every MDR-TB patient is linked with a DOT supporter as soon as they are discharged from the hospital. The DOT supporters will supervise the ingestion of treatment in the community and monitor any adverse effects that develop. DOT supporters must watch the patients take their medication and record that they have done so on a card that is turned in at the monthly clinic appointments. At Hospital X, there is no specific DOT protocol but it is the responsibility of hospital personnel to link patients with a DOT supporter in the community (Nurse 3, Personal Communication, November 14, 2011). In the majority of situations, the DOT supporter is a family member, but community health workers, neighbors, or home-based caregivers may also serve this role. When the patient is first registered in the MDR-TB ward at the commencement of treatment, he is required to provide the name of someone who will serve as the DOT supporter for the duration of his treatment in the community (Nurse 2, Personal Communication, November 14, 2011). For example, one patient who was to be discharged from the MDR-TB ward lived with two sons, both of whom were teenagers. While conducting the home assessment, the nurse was concerned that the older son would not be a suitable DOT supporter due to his age and demeanor. However, the nurse located a nearby family member who was willing to supervise the patient during the treatment regimen. The nurse deemed this woman better suited to the responsibility of a DOT supporter in this situation, and he proceeded to educate

her about her role in the patient's treatment regimen. The nurse discussed the duration of the treatment and the importance of patient compliance. Due to the remote location of many homes and the lack of health facilities in rural settings, family members are usually the only option for DOT support. As one tracer stated "there is no other way around" (TB Assistant, Personal Communication, November 3, 2011). However, according to Department of Health policy, "Family members should be used only as a last option [for DOT] because they may be coerced by other family members, making them less objective as community caregivers." [2]

It is essential that hospital personnel develop a system for linking MDR-TB patients with DOT supporters if the patient lives alone or does not have an adequate support system at home. In this situation, home-based caregivers may be the only option for DOT support. Occasionally, community health workers may act as a DOT supporter, but this is rare due to their heavy patient burden. "It is difficult for us to provide DOT," lamented one community health worker. "The patient must be observed every day and we have too many patients to see so it [the DOT supporter] is usually a family member." (Community Health Worker 1, Personal Communication, November 9, 2011)

Therefore, it may be necessary to employ home-based caregivers in the provision of directly observed treatment in the community. A community health center, located just outside the Hospital X gates, is an NGO that trains home based caregivers in the provision of DOT. These caregivers differ from community health workers in that their services are completely voluntary. The NGO employs 130 such community volunteers who reach into 45 of the 48 tribal areas in the Hospital X catchment area (NGO Personnel, Personal Communication, November 15, 2011). If MDR-TB patients cannot locate a DOT supporter to supervise their treatment regimen, the NGO is able to provide this service for the duration of the treatment regimen (Nurse 1, Personal Communication, November 8, 2011). It is evident that the successful treatment and surveillance of MDR-TB in the community is heavily reliant on community caregivers; the impact of these non-professional health workers in maintaining patient compliance cannot be understated.

### Preventing Interruption and Default: TB Tracers

The interruption and default of treatment among MDR-TB patients is usually caused by the lengthy and grueling treatment regimen associated with the condition. 'Interruption' is defined as a failure to take treatment for two months or less, while 'default' is a failure to take treatment for over two months (TB Assistant, Personal Communication, November 3, 2011). The factors that lead to default among TB and MDR-TB patients are poorly understood but often include personal stresses, such as alcoholism, pessimism, previous negative experiences with TB treatment, health care service limitations, and the need to earn money [9].

One of the most apparent reasons for the interruption of MDR-TB medication is the potential appearance of side effects (Nurse 3, Personal Communication, November 14, 2011). All TB drugs have been reported to cause adverse reactions and one of the most common side effects is progressive hearing loss [10]. Other common side effects range from mild (dizziness, headaches, fatigue, nausea, diarrhea, anxiety, etc.) to severe (depression,

seizure, peripheral neuropathy, psychosis, suicidal ideation, etc) [10]. According to the audiologist at Hospital X, approximately nine out of ten MDR-TB patients experience some level of hearing loss (Hospital Audiologist, Personal Communication, November 8, 2011). Another common reason for default is that patients start to feel better before the treatment is complete. According to the injection nurse at Hospital X, many patients stop their treatment prematurely when their symptoms are alleviated. “When we ask the reason [for defaulting] it was that the patient was feeling well. They decided to stop treatment because they are no longer coughing, they are no longer sweating at night, they think they are fine” (Nurse 1, Personal Communication, November 8, 2011). However, patients are not fully recovered at this point and must follow through with their drug regimen to ensure a positive treatment outcome. Another nurse echoed these sentiments, attributing this behavior to a lack of proper patient education.

I think the people don't understand why they have to be treated for so long when immediately they convert. With TB, one becomes very sick, very quickly, and then immediately they commence the treatment they feel much better and then they stop, and 3 or 4 months down the line they are completely better but they have to continue with the treatment. If they're not properly health-educated they will default with the treatment (Nurse 2, Personal Communication, November 14, 2011).

According to Department of Health policy, one key element for a successful MDR-TB program is the establishment of “functional defaulter tracing teams that conduct home visits, identify contacts and trace defaulters.” [2] The tracing team at Hospital X are nurses associated with the HAST unit. Following discharge from the MDR-TB ward, patients must travel to a hospital or clinic for a monthly review, which includes a sputum test, determination of weight and vital signs, monitoring of side effects, and collection of treatment (which is provided in tablet form) (Nurse 2, Personal Communication, November 14, 2011). When patients fail to appear for their monthly appointments, tracer teams are sent into the community to locate them and bring them to the hospital. In addition, if the monthly sputum test shows that a patient has converted from negative to positive, the tracers are immediately sent into the community to locate the patient and inform him to return to the hospital. Efficient and well-organized tracing can prevent the transmission of bacilli among family members of infected patients. In certain situations, if the tracer believes a patient's condition is too severe for home-based care, he may determine that the patient requires further hospitalization and return him to the ward, despite the fact that he has been discharged by a physician (TB Assistant, Personal Communication, November 3, 2011). This prevents further transmission between those in the patient's household.

Tracers may also be utilized to locate patients who have interrupted their injection treatment. Although it is rare, patients who are still on injections may interrupt their drug regimen for various reasons. For example, some patients experience noticeable pain during injections. One man was not present for his injection, and the nurse attributed this to his reluctance to endure the pain (Nurse 1, Personal Communication, November 8, 2011). As a result of the pain associated with the treatment, some patients will flee their home when they see the hospital personnel arriving



Fig. 1. An example of a rural road in the Hospital X catchment area. (Photo taken by author)

to administer injections. In this case, tracers will be sent to find them and encourage them to adhere to the treatment.

### Home Assessments

After the conversion of sputum to negative, MDR-TB patients will be released from the hospital ward to return to their homes. It is imperative that health workers facilitate the transition from hospital to home for MDR-TB patients. If a high quality of home life is not maintained, there could be deleterious results for the patient and the patient's family. In order to make certain that MDR-TB patients are being released to a home environment that is conducive to their medical situation, TB tracers, nurses, or community health workers will conduct a home assessment. Department of Health policy dictates that home assessments include the following:

Ensuring adequate ventilation/open windows, isolating patient (own bedroom where possible), promoting cough hygiene, ensuring that patients use surgical mask during waking hours while at home or when meeting with others; refraining from close contact with children; maximising time in open-air environment (e.g., receiving visitors outside) [5].

The first consideration is often the patient's sleeping situation: the patient must be isolated during the night to prevent further transmission of bacilli to family members. It is also essential that the patient sleeps alone and that the sleeping room is well-ventilated (Figure 1 for an example of a poorly-ventilated house). This may prove difficult if the patient lives in an overcrowded home. According to the TB tracer, “there may be a family of 9 living in one room and when they are sleeping they are all breathing the same oxygen” increasing the probability that the infection will spread. If the patient cannot be isolated during the night, the health worker must find other sleeping arrangements

with a neighbor, family member, etc. (TB Assistant, Personal Communication, November 3, 2011). If alternative arrangements cannot be coordinated, the patient's discharge from the MDR-TB ward will be delayed.

The assessment also serves as an opportunity for the health personnel to educate family members about the complexity of the MDR-TB treatment process. It is important that both family members and patients thoroughly understand the importance of adhering to treatment and the potential consequences if treatment is interrupted. As one nurse stated, "One of the most difficult things about MDR is properly educating the patient and making him understand the severity of the condition" (Nurse 1, Personal Communication, November 8, 2011). If patients and families are properly educated, the probability of patient noncompliance is decreased and family members gain the knowledge they need to protect themselves. When I observed the education of a family during one home assessment, the tracer surveyed the family about their knowledge of MDR-TB, including symptoms and modes of transmission. He also emphasized the importance of adhering to the treatment, and described the potential consequences of patient noncompliance. Another aspect of the home assessment is determining the patient's proximity to a nearby clinic, which is essential in a rural environment like the Hospital X catchment area, where MDR-TB patients may live significant distances from the hospital. As a result of the isolated and distant location of many patients, the hospital injections nurse may be unable to reach all patients to administer injection treatments. Therefore, the home assessor must determine the closest clinic or hospital where the patient can receive injections.

Finally, the home assessor must ensure that the patient has a stable living situation, with some level of familial support, and a form of income. As one tracer stated, "The patient may have his own room, but is there anyone looking after him, is there any DOT supporter?" (Nurse 1, Personal Communication, November 8, 2011). If the patient's living situation is not conducive to his continued improvement and overall wellbeing, interventions from social workers may be necessary. For example, the social worker may take measures to ensure that adequate food is available, as many patients in resource-poor areas may not have any means to generate an income and to maintain a balanced diet (Nurse 3, Personal Communication November 14, 2011). If the home assessor determines that patients cannot maintain an adequate standard of living they may choose to consult a social worker, who can travel to the home of the patient and conduct his own assessment to determine the appropriate course of action. If necessary, the patient may receive government nutritional assistance. The federal government has established grant programs to provide food to those who cannot afford a sufficient diet. In addition, many MDR-TB patients may qualify for federal grants to supplement their income and aid in their continued recovery (TB Assistant, Personal Communication, November 3, 2011).

### Difficulties of Providing Care in a Rural Area

A rural environment poses many significant obstacles to the provision of quality healthcare to MDR-TB patients. In the Hospital X catchment area, homes are dispersed over a wide geographic area, and many people reside a significant distance from any type of medical facility or clinic. This is problematic



Fig. 2. An example of a rural road in the Hospital X catchment area. (Photo taken by author)

during the months following discharge from the MDR-TB ward, when a health worker must travel to the home of the patient to administer injection treatment. For a four month period, MDR-TB patients must receive injectable second line drugs while they are living in the community, but if patients do not live in close proximity to the hospital, it may be necessary to travel to a nearby clinic to receive injections. The hospital has established relationships with local clinics in order to link MDR-TB patients with these healthcare facilities. However, in certain situations, even clinics are not able to provide MDR-TB patients with the care that they require. It is evident that some patients simply reside too far from an established medical facility or a qualified medical professional who is capable of administering injections. As a result, they are not able to receive their required four-month regimen of injections (Nurse 1, Personal Communication, November 8, 2011).

In some instances, MDR-TB personnel may find themselves in the rare situation where it is simply infeasible to provide injections in the community. In this case, it may be necessary for the patient to remain in the MDR-TB ward for six months or the duration of the injection treatment course. This is highly discouraged due to the limited space in the MDR-TB ward and this option should only be pursued if absolutely necessary (Nurse 3, Personal Communication, November 14, 2011). I observed this phenomenon during one home assessment in a village approximately one hour from the hospital. In a village located approximately one hour from the hospital, it was unrealistic to expect an injection nurse to deliver injections directly to this patient due to the sheer distance. However, the patient's home was located several kilometers from the nearest clinic, a location that was simply not walkable. According to the patient, travelling to the clinic six times a week for four months to receive injections would be a R 1200 (USD 135) expenditure, a cost that was unaffordable (TB Assistant, Personal Communication, November 3, 2011). The home assessor did not have a solution to the situation and he stated that the only option was to keep the patient in the MDR-TB ward for a six-month period (TB Assistant, Personal Communication, November 3, 2011). Scenarios like this demonstrate that it is necessary to weigh the probability of patient default against the personal and economic burden associated with six months of isolation in the MDR-TB ward.

The impact of the rural environment on MDR-TB management was very apparent in other ways. As mentioned, homes are dispersed over a wide geographic area with no sense of organization. Many of the homes are makeshift or informal huts with no address (See figure 1). As such, it is imperative that those involved in the treatment and surveillance of MDR-TB in the community are familiar with the area and can locate the many homes found only by driving down unmarked dirt roads through dense bush and shrubbery (See ). Various landmarks like trees and rivers were the only means of distinguishing specific locations. Therefore, familiarity with the terrain is a must for health workers in rural areas. Another obstacle posed by the rural setting lies in linking patients with DOT supporters. Ideally, all MDR-TB patients would be linked with a community health worker, nurse, or other medical personnel for the provision of directly observed treatment. Because healthcare workers are familiar with the severity of MDR-TB and the importance of compliance to treatment, they are very effective as DOT supporters [4]. However, due to the remote location of many rural homes and the lack of healthcare facilities in such an environment, it is simply impossible to link all patients with a healthcare worker for DOT support (Nurse 2, Personal Communication, November 14, 2011). Therefore, family members have emerged as the only option for directly observed treatment. Based on these observations, it is imperative that the impact of a rural environment is considered when implementing community-based programs for MDR-TB control. Otherwise, the obstacles and limitations posed by a rural setting could have disastrous effects for MDR-TB healthcare personnel.

## Conclusion

MDR-TB is a complex problem placing a significant financial burden on an already struggling healthcare system. In KwaZulu-Natal, MDR-TB has emerged as one of the most critical health concerns, and the incidence of new MDR-TB cases over the last several years is greater than that of any other South African province [2]. There is a great need for medical facilities and personnel for the treatment and surveillance of MDR-TB patients, as many MDR-TB treatment centers remain overcrowded, understaffed, and simply unable to care for all infectious disease patients. Therefore, community support structures must be in place to maintain patient adherence to therapy during the long and arduous treatment regimen. If the management of MDR-TB in the community is not a priority, patient noncompliance may result in the development of extensively resistant strains of TB.

This project allowed for a comprehensive understanding of MDR-TB control in one rural community. Although some

observations may not generalize to all communities dealing with MDR-TB, they can certainly be applied in a variety of settings. All health personnel consulted for this project -- nurses, TB tracers, doctors, and other health workers -- are essential in developing a community-based program for managing MDR-TB. These individuals are interconnected in a complex system of treatment and control, and their importance cannot be understated. It is important that South Africa and other nations with a significant MDR-TB burden invest in the training of these personnel in order to manage this growing epidemic and prevent further morbidity and mortality. Experiences with these individuals have reinforced the point that MDR-TB patients cannot be neglected when they leave the hospital. Health personnel must take the proper measures to ensure that patients receive sufficient care during the duration of their treatment including education, symptom management, DOT support, etc. Government health authorities must prioritize MDR-TB diagnosis and treatment and allocate sufficient resources to ensure that this epidemic is contained. The successful management of MDR-TB at the community level is imperative in the global fight against TB and it cannot be neglected, especially in resource-poor countries where the burden is greatest.

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Michael Celone will be graduating in May 2013 from Tulane University with a Bachelor of Science in Public Health. He has already been to South Africa and Ghana and hopes to work in East Africa for a year after graduating. In the future, he will pursue a Master of Public Health degree to explore his interest in neglected tropical disease control. In addition to his academic interests, Michael enjoys African languages, Arrested Development, playing the drums, and exploring the New Orleans music scene.



# The Seekers: Do Spiritual Practices Lead to a Sense of Well-being?

Taylor Winfield

Stanford University

## Abstract

This past year, I joined participants of spiritual retreats in India and Spain. I was surprised to discover that in each location individuals who had undergone some sort of spiritual process (a process through which one discovers a sense of self or “spirit”) reported similar emotional and behavior changes from the experience – particularly individuals who walked the Camino de Santiago, a Catholic pilgrimage in Northern Spain, and those who completed intensive, silent meditation retreats in India. My paper will explore similarities and differences between the Art of Silence meditation retreat and the Camino de Santiago and participants’ emotional outcomes. I will use both qualitative and quantitative data to document how practitioners changed during the processes and identify what community dynamics, interactions, and individual behaviors contributed to their developmental process. I hope to answer my research question of how spiritual processes influence emotion and behavior.

This past year, I joined participants of retreats to explore the effects of spiritual practices on well-being. I was skeptical of testimonials that these experiences lead to improved well-being and was eager to investigate this first hand.

My research examines seekers in two very different contexts: the Art of Silence, a meditation retreat in India, and the Camino de Santiago, a Catholic pilgrimage route in Spain. I chose these particular experiences because of their distinct locations (India versus Spain), religions (Hinduism versus Catholicism), and types of practices (sitting versus walking meditation). I was curious who was drawn to each one and how the type of practice and community influenced emotional development.

While remaining skeptical of the role of cognitive dissonance and group persuasion in reported effects, I hypothesized that spiritual processes have a “three-pronged” impact on well-being. (1) Spiritual processes give individuals a sense of purpose and belonging to a community. Although practitioners may enter the experience alone, the processes are communal and depend heavily on social influence. (2) Group dynamics during spiritual processes create norms where members are expected to value their spiritual growth and follow spiritual principles. (3) The taught techniques increase the practitioner’s perceived level of well-being and resilience. My work aims to illuminate the interplay between social and psychological processes on spiritual retreats and the impact these have on a searching individual.

## Literature Review

Those who decide to meditate in silence for six days or hike across Northern Spain for five weeks are not average individuals.

Most are too busy with the activities of daily life, work, and family to be willing to undergo this experience. Hence, this paper is not about how spiritual practices will affect anyone, because not everyone would be drawn to this experience. My findings, however, are relevant for those who want to increase their spirituality but do not have the resources to undergo a retreat.

I propose that when seekers embark on a spiritual journey, they expect a higher state of well-being. However, is it possible to achieve a higher sense of well-being? Or are changes seekers feel a result of their desire to feel different? Evidence suggests that well-being levels, as measured by a number of scales, can increase – at least in the short term – through intentional actions.

The scale I found most useful is Sonja Lyubomirsky’s Subjective Happiness Scale (SHS), which determines subjective well-being levels through four questions with rankings 1-7 (Lyubomirsky 1999). The scale is closely correlated with other happiness measures. Results from SHS and other similar scales suggest that activities like expressing gratitude, compassion, and forgiveness (Emmons and McCullough, 2003; Lyubomirsky et al., 2005), performing service, acts of kindness, and generosity, (Sheldon et al., 2008), employing one’s strengths and pursuing goals (Seligman et al., 2005; Sheldon et al., 2010), and spiritual practices (Koenig et al., 1988; Meisenhelder and Marcum 2004; Hartmann 2006) increase well-being.

Increasing numbers of studies are also touting the benefits of spirituality. While medical researchers were once skeptical that religion might influence mental or physical health, this topic has become well received (Ellison, 1998). One psychologist defines spirituality as a dynamic construct that involves the “internal process of seeking personal authenticity, genuineness, and wholeness” and “deriving meaning, purpose and direction in life” (Astin, 2011). Astin argues that spirituality is a source of inner strength, moral orientation, and connection that brings faith, hope, peace and empowerment. Lyubomirsky uses the research of Myer (2000), Ellison (1998), Pollner (1989) to demonstrate that spiritual people are generally happier, have superior mental health, cope better with stressors, have more satisfying marriages, use drugs and alcohol much less, are physically healthier and live longer than non-spiritual people. Others suggest that spirituality is a significant indicator of well-being because spiritual communities create peer support systems and teach practices and principles that cultivate peace of mind (Keyes, 2002; Lyubomirsky, 2008).

Some researchers have found that spiritual practices, such as meditation, are also related to well-being on numerous scales. Meditation is what positive psychologists refer to as a “flow activity,” which is distinguished by a complete immersion in a present task (Csikszentmihályi, 1991). Foster and Hicks find that through flow activities, individuals can further appreciate and enjoy their lives, as “happiness is all about living in the

### Subjective Happiness Scale

Instructions to participants: For each of the following statements and/or questions, please circle the point on the scale that you feel is most appropriate in describing you.

1. In general, I consider myself:
 

1	2	3	4	5	6	7
not						a very
a very						happy
happy						person
person						
2. Compared to most of my peers, I consider myself:
 

1	2	3	4	5	6	7
less						more
happy						happy
3. Some people are generally very happy. They enjoy life regardless of what is going on, getting the most out of everything. To what extent does this characterization describe you?
 

1	2	3	4	5	6	7
not at						a great
all						deal
4. Some people are generally not very happy. Although they are not depressed, they never seem as happy as they might be. To what extent does this characterization describe you?
 

1	2	3	4	5	6	7
not at						a great
all						deal

Fig. 1. Survey used to rate subjective happiness

present” (Foster 1999). For example, practicing mindfulness meditation (a Buddhist technique) for as little as eight weeks can measurably change parts of the brain associated with improved memory, sense of self, and empathy and decreased stress (Hölzel 2011). Hartmann adds a new dimension of walking meditation as compared to traditional sitting meditation in his analysis of bilateral therapy. Hartmann discusses how the alternating stimulation of the right and left lobes of the brain “while thinking of a problem or issue” (such as in REM sleep) is potentially healing for emotional trauma (Hartmann, 2006).

Foster, Hicks, Csikszentmihályi, Lyubomirsky, and numerous other psychologists agree that more information on the influence of spiritual relationships and activities on well-being is needed. My work will contribute to this literature through exploring whether spiritual communities and practices influence individual well-being on retreats. It will focus on how the collective experience shapes individual emotions in order to bridge the gap between social theory and positive psychology. The paper will also examine whether the effects of the process last after the end of the experience.

## Methodology

During my research I employed both qualitative and quantitative methods to capture the stories of the seekers. I utilized the ethnographic qualitative research methods of participant observations and interviews. Sections (1) and (2) of this Chapter explain the exact methods on each trip.

(1) Art of Living: My field site was the Art of Silence at the international Art of Living headquarters in Bangalore, India. The Art of Living (AOL) is an international non-governmental organization (NGO), focused on building “a global society that is free of stress, violence, and misery and full of service, wisdom, and celebration” (AOL 2011). Among its many projects, AOL utilizes breathing techniques, meditation and yoga in their silent

retreats to provide practitioners with, “tools to eliminate stress, heighten awareness, and increase mental focus” (AOL 2011). The Art of Silence (AOS) lasts five days, during which eight hours a day are dedicated to sitting meditation. The Art of Living states that the retreat provides the optimal conditions, “for going deep within, quieting our mental chatter, and experiencing deep rest and inner peace” (AOL 2011). Although the guru, or teacher, Sri Sri Ravi Shanker, has roots in the Hindu tradition, the practices are considered secular.

During AOS, I followed specific ethnographic research techniques to analyze how the teacher taught novices and shaped individual behavior and development. I conducted seventeen interviews chosen by convenience sampling and later sent out a quantitative survey. The survey included the SHS along with follow up questions for ranking the importance of various spiritual and religious activities in their daily life. AOL organization also sent the survey to centers all over the United States and Latin America. I collected 116 interviews in total, 76 of which were by AOS participants. Although the data was collected by convenience sample, I believe that the sample is reasonably representative of the different populations that take the course because it represents individuals from a large range of nationality and ages.

When analyzing practitioners from AOS, I was skeptical of the efficacy of the practices because individuals were taught exactly how each practice should make them feel. It was an expectation to feel better after the course, and dissent was not accepted at the ashram. Although the retreat contains many components that the literature suggests is conducive to well-being, these effects may be exaggerated because people believe they are supposed to feel a certain way. While the surveys were sent out anonymously, people may have felt a pressure to say positive things about the experience since the organization helped circulate the surveys. Moreover, there may have been selection bias if people with a positive experience were more likely to fill out the survey.

(2) Camino de Santiago: The Camino de Santiago is a Catholic pilgrimage that leads to the shrine of St. James in Santiago de Compostela, Spain. Pilgrims walk from 15 to 40 kilometers per day, through forests, mountains, and valleys. I formally interviewed nineteen people along the Camino through convenience sampling, and spoke in detail with many more. Along the way, I collected the email addresses of every individual I encountered, to later send the quantitative survey. I also posted the survey on Camino de Santiago’s forum online, where experienced pilgrims answer questions for incoming pilgrims. I had 63 respondents. The pilgrims who filled out the survey from the Camino de Santiago forum most likely represent the most involved pilgrims, who have walked the route several times. I believe that the sample is reasonably representative because it includes individuals from a number of nationalities and religious backgrounds. Since the Camino does not have the institutional persuasive power of the Art of Living, I was less concerned about the bias in the survey results. However, there is most likely a selection bias. Those who filled out the survey were more likely to have had a positive experience. Moreover, cognitive dissonance says that if the seekers are taking the walk for spiritual fulfillment then they will be more like to report this outcome.

## Results

### The Art of Silence

The Art of Silence is an intensive, five-day meditation retreat, during which individuals learn techniques and information meant to improve their state of mind. During the course there is substantial pressure to participate in all the meditations and have show an emotional response. The expectation of a result is especially relevant because many individuals undergo the experience to cure personal and psychological ailments. Among my participants, mental health, spiritual search, and stress were the most common reasons to undergo the AOS. Tejashree took her first silence course at age eighteen after she had fallen into a deep depression. Mark took the course after he had a breakdown because of work stress. Haava took and continues to take the courses because being close to the guru allowed her to escape depression and suicidal thoughts. As such, the participants had the expectation that their distress would decrease after the course. Participants also devoted immense amounts of time and money to the experience. Individuals had traveled from around the world to take a course with their guru, Sri Sri Ravi Shanker. Their decision to undergo the experience with their guru— instead of taking a less expensive course at their local center – suggests that they believe in the power of the guru and his teachings. Finally, there seems to be an addictive component to the course. For eight participants it was their first course, eleven had taken five-ten courses, and ten had taken more than fifteen. Haava has completed 48 courses. Due to these strong external factors, I was skeptical that the benefits participants reported from the experience were a result of the practices rather than the strong desire to feel a change. However, the AOS course utilizes several techniques: (1) a supportive community; (2) yoga and mediation practices; (3) service work; (4) song and dance; (5) a guru; and (6) peer reinforcement that have found to be conducive to well-being. This section will outline these components of the course and how participants reflected on their importance.

1. Community: Before going into silence, participants partook in a number of activities to create solidarity between group members. As an introduction, individuals were required to shake hands or hug and say, “sangachadwam” to each other, which means “let’s journey together” in Hindi. The first afternoon was spent sharing “life stories” in order to prepare the participants before going into silence. These rituals helped create trust and a sense of belonging that lasted through the retreat. Haava noted that, “We entered the class as strangers, but emerged as long time friends. This never happened before. Usually when you want to be that close, you need much more than five days.” That evening, participants took a vow of silence. For the rest of the course, the group meditated together in the same room.

2. Yoga and Mediation: The days began at 6 AM with morning yoga and Kriya. The Kriya is the technique used on all Art of Living courses. There are similarities between the Kriya and other breathing exercises. Both create an ecstatic state through irregular breathing patterns. The breathing cycles during the Kriya parallel breaths that occur in different emotional states to create bodily harmony. Participants reported powerful effects from the Kriya: “It was like I felt heaven...It was so exciting I did not want to get out of it,” said Tejashree. Meditation was like “merging yourself with the divinity,” she continued. For others the experience was less pleasant. Julianna’s first experience with the Kriya was not

positive: “after Kriya...my whole head, my eyes blocked, and my whole body was shivering. But I am very persistent and consistent person, so I continued to do the daily and group practice.” There are two versions of the Kriya: the long version which lasts about an hour which is done weekly, and the short version that lasts about twenty-five minutes that is done daily. While the long Kriya must be done together with the group, it is also recommended that participants do the short Kriya in a group, because, “the effects become stronger in groups,” says Ravi Shanker. Practicing in a group also insures that individuals will continue to do their practice and will not fall out of the routine.

3. Service: When practitioners were not engaged in meditation, they did seva (selfless service). Participants who stay at the ashram are given kitchen or manual labor seva tasks. Women help cut vegetables and wash dishes, while men spend most of their time lifting hot and heavy pans. It is a widely held belief that seva will deepen meditation: “If you are not having good experiences in meditation, then do more seva...when you bring some relief or freedom to someone through seva, good vibrations and blessings come to you” (Ravi Shanker). Participating in seva is a cultural expectation at the ashram. During seva, individuals are kind and compassionate toward others. It also helps practitioners savor the present moment, as they can not distract themselves with words during the activity.

4. Devotional Song and Dance: After a full day of meditation and seva, the participants gathered for satsung (a time for devotional song and dance). Participants were encouraged to sing loudly in order to let go of any energy that might have built up after staying silent for so long. Sri Sri Ravi Shanker ended the evening answering questions from the participants and teaching a lesson. Ravi Shanker employed the technique of “democratization of suffering” that can be found in many guru talks (Kakar, 1972). Gurus tell their disciples that their suffering does not connote any individual failure or deficiency – that suffering is part of the “nature of things,” the divine plan (Kakar 1972). For a devotee in pain, the realization that s/he is not alone in her/his suffering and that everyone else is also an actual or potential sufferer rids her/him of self-blame and feelings of hopelessness. During these talks the guru also stresses the benefits of the practices. During one satsung, I asked Ravi Shanker, “What if a practitioner is doing all the practices but is still unhappy?” His answer was simple, “Then the person is being selfish, thinking too much about himself or herself. He or she needs to do more seva.” Unhappiness was not an option at the ashram.

5. The Guru: One of the most important parts of taking the Art of Silence course at the ashram was the presence of the guru. At the Art of Living ashram, Ravi Shanker’s face was plastered everywhere. Walls were covered with pictures of him laughing and dancing. His face graced computer screens, calendars, and even newspapers.

Participants had a relationship with the guru – one that often paralleled their relationship with a higher power. “He is my father. He is my mother. He is my G-d. He is everything to me right now. I feel happy, I am happy, and I will be happy only because of him and his blessings,” said Tejashree. She believed that Ravi Shanker has a role in her fate and can control outcomes in her future: “with his blessings I finished my graduation with 92% marks... Whatever I ask him for, he gives me...once you ask with him full of faith, he never lets you down.” Mary also believed that Ravi Shanker is divine and has control over miraculous events: “Guruji



fixed my son's heart so he did not have to get surgery, pulled my other son out of a car so he did not get into an accident, and kept my car on the road in Afghanistan after it was almost pushed off. We all should have been killed but nothing happened... who knows what else he has taken care of." Mary's belief in Ravi Shanker's power and omnipresence gave her a sense of security and the ability to surrender her problems to him.

Not all participants feel comfortable with the idea of Ravi Shanker as divine. Mark did not like this guru-mania, "I don't think he is G-d. He just happens to be a teacher, a very special guy." Mark viewed Ravi Shanker as a teacher, and utilized the guru's philosophies to decrease his anxiety.

6. Peer Reinforcement: After five days of silence, the course comes to a close. The participants sat down in a circle and shared their first words. Participants were eager to describe the benefits they received from the course and practicing with the Art of Living in general. Many commented on how "beautiful" and "peaceful" the course was and how "grateful" they were for taking it. After completing the course, practitioners describe a number of outcomes including increased awareness, calm, compassion (in particular self-compassion), decrease in stress, and an increase in joy. Not a single negative comment was expressed. It is difficult to determine whether no one had a negative experience, or because saying a negative comment could have resulted in a loss of status or membership to the group.

## The Camino de Santiago

There are so many ways to walk the Camino de Santiago that many disagree on where it actually begins. Some say it starts when the pilgrim first has the idea to walk the ancient path, and others believe it is when one starts to walk towards Santiago de Compostela. Nevertheless, the importance of the experience for the pilgrim is the journey and how one reaches the shrine. Unlike other Catholic shrines, the ritual act on the Camino de Santiago does not occur within the bounded sacred space of the shrine of St. James. The healing shrine consists of the physical and often internal (spiritual, personal, religious) journey that the pilgrim undergoes to reach Santiago de Compostela. Modern pilgrims often choose to travel the routes in the same way as medieval pilgrims – walking the entire path on foot. They carry all that they need on their back in a mochilla (backpack). For Catholics, the suffering that pilgrims undergo along the difficult path is penance for one's sins, a purification of the body. For others, it is a way to get in touch with their spirituality or take a vacation in nature (Frey 1998).

Similar to the Art of Silence course, pilgrims invested significant time and energy into the journey – to walk the whole pilgrimage can take between four to six weeks. There is pressure for the trip to be successful because of the large investment. These factors may influence how the pilgrims feel about the journey after arrival. However, there are several common themes that manifest along the pilgrimage that suggest elevated levels of well-being: (1) the performance of democracy; (2) minimal material items; (3) time for reflection; (5) community; and (6) sharing.

1. Equality: When one begins along the road, one enters into a liminal space (Turner 1971). People say that traditional roles lose meaning, and distinctions are eliminated. The pilgrim is in a state of transition, without a distinct identity. Distinctions between age, gender, and social status disappear, as pilgrims walk together: "We are ageless," said Conrad, "[Although] the

American man is seventy-seven-years-old, we really connected. That wouldn't really happen in normal life... You want to have a relationship with people from other age groups but it is pretty rare... you are supposed to be with people of your own kind, of your own age." Pilgrims could be recognized by their large backpack with a scallops shell and walking stick. Some say one can detect an "authentic" pilgrim by his smell - rich from weeks without proper laundry and sufficient bathing. The equality among pilgrims allowed individuals to develop friendships that may not exist in the outside world.

2. Minimal Materials: Pilgrims carried only the essentials they needed to survive. For many this was liberating because they did not have to worry about superficial aspects of life (Martha). For others it was freeing because they realize how little they needed to survive: "I just learned to stay in the present and that we make all these things big in our lives that really aren't important and that as you long as you have something to eat, and something to drink, and somewhere to sleep - which can be outside in a haystack, you're fine" (Erika). Those who brought too much quickly got rid of the excess weight - both literally and figuratively. They threw it into the garbage or sent it all the way to Santiago de Compostela.

3. Time for Reflection: On the road, pilgrims restructured their lives. This gave them space and time to think about things they usually ignore (Conrad). Pilgrims were able to find peace in solitude and appreciate the moment (Raul). Despite the pain of walking for so many miles, many pilgrims encountered pleasant emotions, and a sense of a deeper meaning. Finding the fatigue meaningful lead them to a place of personal, physical, and spiritual renewal. They felt purpose, because their only job was to arrive at the next albergue (shelter) (Jungyoung). They felt optimistic that they would arrive. There were many moments of joy as pilgrims connect with nature, and were free from modern technology (Sebastian). Many mentioned the ability to find time to think thoughts that they have been avoiding for some time, and dip into their "calling," or purpose. For example, Alejandro decided that he wanted to open up his own hotel. Suffering was also often mentioned as powerful emotion on the Camino – "it is part of redemption, penance" (David). Suffering helped pilgrims feel compassion for others. Jungyoung mentioned that it helped her connect more with Jesus and understand the pain that he must have felt on the cross. Suffering allowed pilgrims to stay in the moment, as they felt the immense pain in their feet with each step.

4. Community: Pilgrims spent the day on the road, only to reconnect with others during the night at the albergue. Several pilgrims I spoke with mentioned that the desire to meet new people was one of the reasons they decided to walk the Camino. While some pilgrims walk in pairs, it is preferable to walk alone. Andre shared, "To do the Camino, it is the best on your own. If you walk with a group, you are talking with the group. Your world is only your group, if you go alone, your world is the people you meet... People talk quicker to you because you are alone, and you talk quicker back. You are different: nice, more adventurous, more interesting." Similarly, Sebastian said, "There are more relationships between those who go alone. Those who go in pairs... continue leading the life of the city. When you go alone, you can become someone else, you can change yourself when you get to an albergue... When you go with a friend, you feel a bit shy to say some things." Once relationships began between individuals, they deepened immediately: "personal relationship develop without

Table 1: Art of Living Life Practice	Mean Frequency of Life Practice	Correlation with Well-being, p-value	Table 2: Camino Life Practice	Mean Frequency of Life Practice	Correlation with Well-being, p-value
Loving others	5.842	0.29, 0.011**	Expressing Gratitude	5.651	0.412, 0.001**
Meditation	5.816	0.287, 0.012**	Self-Reflection	5.651	-0.048, 0.71
Self-reflection	5.789	0.287, 0.012**	Feeling compassion for others	5.556	0.213, 0.097
Expressing Gratitude	5.737	0.358, 0.002**	Loving others	5.524	0.392, 0.002**
Feeling compassion for others	5.671	0.291, 0.011**	Connecting with nature	5.508	0.081, 0.531
Practicing acts of kindness	5.605	0.28, 0.014**	Practicing optimism	5.460	0.499, 0.000***
Forgiving others	5.592	0.297, 0.009**	Savoring the present moment	5.41	0.349, 0.005**
Having a life guide	5.592	0.329, 0.004**	Practicing acts of kindness	5.30	0.249, 0.050*
Doing compassionate things for others	5.566	0.287, 0.012**	Giving to others	5.29	0.125, 0.331
Belief in higher power	5.553	0.058, 0.166	Spending time with friends and family	5.29	0.398, 0.001**
Giving to others	5.553	0.266, 0.020**	Doing compassionate things for others	5.267	0.235, 0.067
Practicing optimism	5.434	0.371, 0.001**	Forgiving others	5.238	0.354, 0.005**
Spending time with friends and family	5.395	0.293, 0.010**	Committing to goals	5.190	0.126, 0.331
Savoring the present moment	5.368	0.394, 0.000***	Finding purpose daily	5.143	0.226, 0.078
Connecting with nature	5.342	0.25, 0.03**	Meditation	4.222	0.103, 0.428
Committing to goals	5.211	0.246, 0.032**	Belief in higher power	4.175	0.049, 0.705
Finding purpose daily	5.132	0.241, 0.036**	Communicating with a higher power	3.746	0.098, 0.447
Communicating with a higher power	4.882	0.2155, 0.062	Having a life guide	2.714	-0.035, 0.790
Attending services regularly	3.921	0.2972, 0.009*	Reading religious texts	2.476	0.115, 0.372
Reading religious texts	3.368	0.1869, 0.106	Attending services regularly	2.429	0.048, 0.709

Note: N= 76; \* P< .05; \*\* P< .01;\*\*\* P<.001, two tailed tests

Table 1. Frequency of life practices among student cohort

falsity within the first or second day” (David). Pilgrims were not afraid to bear their souls along the road, especially because they might never see this person again: “They talk about important things. They talk about their reasons for making the journey, and speak of themselves. They arrive at the importance of life, and exchange knowledge...these people are not going to meet again, and enjoy the moment to talk about important things” (Ama). Pilgrims did not become attached to the others they meet along the way, because everyone has his/her own rhythm.

6. Sharing: Although pilgrims did not stay together for long, they learned how to “give and take” (Alejandro). Sharing is an essential part of the journey. Many were struck by receiving unexpected gifts and were left wanting to give to others. Conrad explained the phenomenon in his statement, “it’s just kind of like ‘what the hell have some of mine, have some of this. A really open, sharing atmosphere...When someone starts sharing it is really like a domino effect, more sharing follows. Someone just has to start. It is easier to start on the Camino, somehow.” King hit the heart of what is occurring on the Camino when he stated, “you depend on the kindness and acceptance of others. You can’t live in a bubble on the Camino...you kind of reconnect with humanity and the spirit.” The Camino gave individuals the time to realize their potential and the time to realize the good in others.

7. Arrival: After weeks of walking along the Camino, pilgrims develop a way of life. The arrival to Santiago comes as a shock. Frey finds that participants refer to it as la gran depression del Camino (the great depression of the Camino) (Frey 1998). Although the energy of the pilgrims rises as they get closer to the destination, after the initial excitement of arriving to the cathedral, emotions plummet. Pilgrims have little time to adjust and have to immediately figure out their plans for the future and how they will return home. Many pilgrims described a feeling of “emptiness” in a moment that they thought they would feel joyful. Participants reveal a slight fear as well: a fear of the future, and a fear of falling back into old habits. To deal with this stark contrast, many pilgrims continue to walk to Finisterre or to Muxia. They, however, can not continue to walk forever.

## Quantitative Analysis

It is interesting to compare how lessons from the Art of Living and the Camino de Santiago are reflected in practitioners’

Table 2. Frequency of life practices among pilgrim cohort

life practice and well-being levels once they return home. Surveys were collected between two and six months after the experiences. A sample of 105 Stanford University students who did not undergo a spiritual retreat serve as the control.

Sonja Lyubomirsky finds that in over 2,732 participants, the average score on the Subjective Happiness Scale (SHS) runs from about 4.5 to 5.5. College students tend to score lower than working adults and older, retired people (5 versus 5.6). Art of Silence practitioners had an average subjective happiness score of 5.65. This is significantly different from those who did the Camino (5.25,  $p=0.046$ ). When compared with Stanford students’ average score (4.93), AOS participants’ score is significantly different ( $p=0.000$ ) but Camino’s is not ( $p=0.09$ ). In these samples, subjective happiness is not correlated to education levels, gender, income, race, or religious association.

To analyze the data, I first calculated the average frequency of various life practices in order to understand if practitioners were integrating what they learned on the experiences into their daily lives. I was also curious which practices correlated with well-being. Tables 1 and 2 show the frequency of practice within each group and which are correlated with well-being. Table 1 demonstrates the almost all the life practices were correlated with well-being for AOS participants – except for belief in a higher power, reading religious texts, and communicating with a higher power, which were not highlighted in the course. The close relationship between what was taught in the course and what participants are practicing suggests that the AOS was successful in teaching students effective strategies to promote well-being. Table 2 shows that the practices on the pilgrimage are not correlated to well-being for the pilgrims: self-reflection, giving to others, feeling and doing compassion, connecting with nature, committing to goals, and finding purpose are not correlated with well-being. It is interesting how many fewer items are correlated to well-being for the Camino pilgrims than the AOS pilgrims. Since the AOS ranked almost everything higher on the survey, it is possible that this created more correlations.

Next, I examined whether or not frequency of practice was significantly different between groups. Table 3 demonstrates that despite the distinct nature of the experiences, the average frequencies between groups are surprisingly similar. The only

Frequency of Life Practices	1.Camino Average	2.AOS Average	3.Stanford Average	P value 1&2	P value 1&3	P value 2&3
Belief in a higher power*	4.174	5.553	3.354	0.001**	0.043*	0.000***
Communicating with a higher power*	3.746	4.882	2.781	0.007**	0.012*	0.000***
Reading religious texts*	2.476	3.368	2.260	0.008**	0.467	0.000***
Attending services regularly*	2.429	3.921	2.448	0.000***	0.953	0.000***
Feeling compassion for others	5.556	5.671	5.969	0.686	0.038*	0.192
Doing compassionate things for others	5.27	5.566	5.531	0.298	0.207	0.886
Loving others	5.524	5.842	6.063	0.258	0.008*	0.329
Practicing acts of kindness	5.302	5.605	5.78	0.298	0.028	0.448
Giving to others	5.286	5.553	5.49	0.367	0.347	0.795
Savoring the present moment	5.413	5.368	5.263	0.891	0.577	0.698
Spending time with friends & family	5.286	5.395	5.854	0.723	0.01*	0.049*
Practicing optimism	5.460	5.434	5.427	0.932	0.899	0.979
Expressing Gratitude	5.651	5.737	5.729	0.762	0.712	0.975
Forgiving others	5.238	5.592	5.49	0.233	0.27	0.669
Self-reflection	5.651	5.789	5.9791	0.616	0.107	0.419
Meditation	4.222	5.816	3.531	.000***	0.038*	.000*
Committing to goals	5.190	5.211	5.208	0.947	0.944	0.993
Finding purpose daily	5.143	5.132	5.031	0.972	0.682	0.726
Connecting with nature	5.508	5.342	4.323	0.595	0.000***	0.001**
Having a life guide	2.714	5.592	2.844	.000***	0.696	0.000***

Note: Data gathered from 3 separate convenience sample surveys, of Camino (N=63), Art of Silence (N=76), and Stanford Students (N=105). \* P< .05; \*\* P< .01;\*\*\* P<.001, two tailed tests

Table 3. Life practices frequencies summary statistics

behaviors correlated to well-being that differ between the Camino and Art of Silence individuals are meditation and having a life guide – disparities that likely stem from the emphasis on meditation and the guru in AOS. Stanford students differ from both Camino and Art of Silence practitioners when it comes to belief in a higher power, communicating with a higher power, spending time with friends and family, meditation, and connecting with nature. Of these differences, only meditation and spending time with friends are correlated with well-being. The similarity suggests that the other behaviors correlated with well-being in Tables 1 and 2 are not a result of the retreat or pilgrimage. They are common practices among many individuals. It is interesting, however, that Camino individuals are more likely to meditate than Stanford students. The difference in meditation frequency could be because Camino individuals rank spirituality as more important in their lives than Stanford students; therefore, they are more likely to try out spiritual techniques, such as meditation.

If frequency of life practices does not drastically vary between activities, what is causing the significant difference in SHS scores? To answer this question, I ran a linear regression, controlling age, gender, importance of religion, importance of spirituality, meditation, and satisfaction with spirituality. Table 4 demonstrates that activity is important up until I added importance of spirituality to the regression analysis. When I controlled for likelihood to use meditation as a coping strategy, importance of spirituality lost its significance. This finding suggests an individual's values are not as important as his/her life practice. This hypothesis is furthered when meditation became insignificant after I added satisfaction with spirituality into the analysis. Meditation is just one tool individuals use to become satisfied with their spirituality. Satisfaction with spirituality also controls for the impact of expressing gratitude, feeling and doing compassion for others, loving others, connecting with nature, savoring the present moment, giving to others, committing to goals, finding purpose daily, and having a life guide. The only three behaviors correlated with well-being that were insignificant when regressing with satisfaction with spirituality were optimism, spending time with friends and family, and self-reflection (which was not correlated for Camino individuals). Additionally, the difference between the well-being level of AOS individuals and Stanford students became insignificant when controlling for satisfaction with spirituality ( $p=0.055$ ).

These findings suggest that an individual's ability to practice spirituality in a meaningful way to increase subjective well-being. There is no single tool that will work for everyone. Merely

Subjective Happiness	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Activity	.401 (.201) [ 1.99*]	.445 (.204) [ 2.18*]	.440 (.206) [ 2.13*]	.440 (.207) [ 2.13*]	.214 (.216) [ 0.99]	-.005 (.228) [ -0.02]	.023 (.219) [ 0.10]
Age		.007 (.007) [ 1.03]	.007 (.007) [ 1.03]	.007 (.007) [ 1.02]	.005 (.007) [ 0.67]	.008 (.007) [ 0.71]	-.001 (.007) [ -0.13]
Male			-.053 (.211) [ -0.25]	-.054 (.212) [ -0.25]	-.011 (.207) [ -0.05]	.015 (.203) [ 0.07]	.002 (.195) [ 0.01]
Importance of Religion				.005 (.046) [ 0.11]	-.032 (.046) [ -0.69]	-.014 (.046) [ -0.30]	-.011 (.044) [ -0.25]
Importance of Spirituality					.164 (.058) [ 2.84 ***]	.085 (.064) [ 1.32]	.012 (.07) [ 0.18]
Meditation						.161 (.063) [ 2.57*]	.062 (.067) [ 0.93]
Satisfaction with Spirituality							.285 (.083) [ 3.45***]
Constant	5.254 (.149) [ 35.20***]	4.92 (.348) [ 14.15***]	4.941 (.358) [ 13.81***]	4.924 (.389) [ 12.67***]	4.318 (.434) [ 9.94***]	3.97 (.446) [ 8.91***]	3.50 (.449) [ 7.79***]
Unweighted N	136	136	136	136	136	136	136
Adjusted R-squared	0.021	0.025	0.018	0.010	0.061	0.01	0.17

Note: Data gathered from 3 separate convenience sample surveys, of Camino (N=63), Art of Silence (N=76), and Stanford Students (N=105)  
Regression Coefficient  
(Standard Error)  
[T-statistic] \* P< .05; \*\* P< .01;\*\*\* P<.001, two tailed tests

Table 4. Regression model descriptions

going on a spiritual retreat or pilgrimage will not create lasting emotional change unless one learns how to practice spirituality daily. The benefit of going to a course like the Art of Silence is that participants learn specific tools, like meditation, that they can implement upon return. While most individuals went on these activities because spirituality is important to them (especially for AOS people who scored it at 6.447, as compared to Camino individuals at 5.03, and Stanford Students at 4.257 ( $p=0.000$ )) the data suggests that heightened well-being occurs if one is able to learn how to be more satisfied with their overall spirituality level.

There are several limitations to this statistical analysis. First, Stanford students are not perfect controls for AOS and Camino individuals as they differ in terms of age and spiritual interest. There are also many cultural differences between the Camino and AOS that may attract people who have various spiritual needs. Moreover, it is difficult to control for cognitive dissonance and normative pressure to report positive results. While I do not have before and after data for the groups, when I examine individuals who did the basic Art of Living course (the prerequisite for AOS), I found more evidence that the practices are what make the difference for well-being. I found that importance of spirituality is not statistically different between the groups (basic=6.526 and AOS= 6.447,  $p=0.775$ ), but subjective happiness is (basic=5.032 and AOS= 5.655,  $p=0.014$ ). When I controlled for meditation practice, differences between subjective happiness disappeared ( $p=0.166$ ). This suggests that people who have done the course might have boosted their subjective well-being levels through meditation practices.

## Discussion

Comparing the Art of Silence and the Camino de Santiago sheds light on how spiritual retreats can make a lasting impact on behavior. In both experiences, the seeker leaves his/her community to embark on a spiritual journey. In these communities, individuals dress similarly and report that age, gender, and class are not barriers. People are taken out of their social category and

reintegrate as equals. The community that forms during these experiences is based upon acts of kindness. In both processes, there is a culture of giving and receiving. Surprisingly, neither group reports statistically higher frequencies of giving than Stanford students. This finding implies that while sharing may be augmented on the retreats, participants do not continue with these elevated levels upon reintegration into society.

Both groups reported some sort of emotional response to the practice. One emotional response is the cleansing or catharsis that occurs in meditation or along the walk. When combining this finding with the survey data, I found that AOS and Camino individuals do meditate with a higher frequency than Stanford students. However, meditation is only correlated to well-being for Art of Silence practitioners. Camino individuals' meditation practice, connection with nature, and self-reflection are not correlated with well-being. It is possible that they do not receive significant benefits from these practices because they are doing them alone, and spending time with others is highly correlated to well-being for them.

While there are similarities between the experiences, attainment of knowledge on each retreat is distinct. Art of Living is a course, a formal learning experience where individuals are brought through various types of meditation with the expectations of results. There are specific techniques and a teacher. In contrast, the pilgrims learn lessons on the Camino in an informal manner. Knowledge is attained through conversations with other pilgrims and the personal experience on the road. Pilgrims tend to follow the other pilgrims' lead when it comes to certain behaviors (how fast to walk, where to eat, where to stay, etc). They model each other's behaviors and habits. There is no authority figure. The quantitative data reveals that having a life guide is beneficial for the Art of Silence participants. When subjective-happiness levels between AOS and the Camino are controlled for the frequency of having a life guide, there is no longer a significant difference in subjective happiness ( $p=0.675$ ). This finding suggests having a life guide is beneficial for both groups and has the potential to make benefits longer lasting.

Additionally, the way participants reintegrate the practices from the retreats and reconnect with their experiences varies between groups. While both lifestyles are unable to continue upon reintegration, since the Art of Living exists in 152 countries, AOS participants are more likely to find other centers to repeat the course or connect with others who have undergone it. In fact, the Guru recommends that participants undergo two to four silent retreats per year in order to maintain effects. This could be why the participants are able to integrate more of the learned behaviors into their daily life. The Camino, on the other hand, is a process that takes far more time and is often a once in a lifetime experience. Outside of Europe, the population of individuals that has walked the Camino is minimal. There are websites and Camino Federations, but for the average individual who walks the path, when s/he arrives at Santiago, s/he will be thrust back into the real world without tangible lessons to hold onto. While pilgrims want to reincorporate the positive experience into their real lives, it is difficult to maintain the reality of the Camino when it exists so far away and there are no nearby pilgrims. Pilgrims

who come alone (as is recommended) do not have the ability to replay the experience with anyone when they return home and often suffer from the "post-Camino blues" (Camino de Santiago forum).

The data suggests that without clear practices to reintegrate into real life, a spiritual guide, and/or individuals to reconnect about the experience, behavioral changes from the experience will not be sustainable. This is not to say that pilgrims do not receive any long-term benefit from the pilgrimage. Indeed, they practice many behaviors with a similar frequency as AOS individuals. Their ability to retain specific practices, however, appears to diminish.

## Conclusion

Seekers set out on spiritual experiences for a reason – whether it is an escape a stressful job, secular life, or negative thoughts. They have goals for the journey, and expect to feel a certain way at the end. The well-being outcome on the Art of Silence retreat and on the Camino de Santiago pilgrimage can be seen as a result of mixing certain practices, principles and community. The quantitative data shows that higher levels of well-being are correlated with: savoring the present moment, remaining optimistic, feeling grateful, loving others, practicing acts of kindness, forgiving others, some sort of self-reflective processes, and spending time with friends and family. While the qualitative data reflects all of these aspects of the experience, it reveals that personal practices could become more sustainable and powerful through practice with a community.

While researchers have long known that loneliness is detrimental to health, it is not often discussed that relationships can also be the preserver of good memories and practices. Although some may consider it better to walk or meditate alone, the data shows that in order to maintain the benefits of the experiences it is imperative to travel or reconnect with a companion who can reinforce the behavior in the future. This practice could close the gap between the Camino pilgrims, who feel joy along the way that usually fades when they return home, and Art of Silence participants, who have an infrastructure of an organization to return to. In short, I encourage possible spiritual pilgrims to do the experience with someone they can continue to share the experience with in the future or keep in touch with the friends s/he meets along the way.

For those who want to increase their well-being but do not have the time or resources to go on an elaborate journey, this research provides insight into practices that could help elevate well-being. The research suggests that it is important to cultivate time with friends and family in order to build a support system. Community will also provide one with the opportunity to practice the other principles that are correlated with well-being with higher frequency, such as practicing acts of kindness. This topic requires future research regarding how people make the benefits of a spiritual practice long lasting, and further investigations into the claim that people are happier undergoing processes when they can reconnect with a community at home. Research along these lines has the potential to teach individuals tools they can use in their daily lives to help improve their quality of life.

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Taylor Winfield is a recent graduate from Stanford University with Honors in Sociology and a Minor in Anthropology. Her research focuses on the intersection between positive psychology, sociology, and spirituality. Ms. Winfield has collected data in India, Spain, and South Africa and will spend next year investigating the experience of ultra-orthodox women in Israel. During her time at Stanford, Ms. Winfield was involved with student mental health promotion. She served as the ASSU Chair of Health and Wellness 2010-2012 and the wellness consultant for Stanford Dining and Vaden Health Promotion Services. She hopes to continue this work in the future.

# The Experience of Normative Development: Land Access and Retention in City Heights, San Diego

Tarangini Saxena

University of California, San Diego

*“Because people embody lives as if living free, power often gets in the way but seems unable to become an absolute force.” – La Paperson*

## Abstract

This study of development in a small yet densely populated San Diego neighborhood, City Heights, leads a critical environmental discussion on the legislative, institutional, and local influences on access and retention of local land. Through qualitative research, it is argued here that the cultures of privatization and assimilation operate the misappropriation of “development” and “progress,” enabling a capitalist hegemony of land under the pretense of community benefit. Further, a survey of antithetical forces expands knowledge of community self-determination, while evaluating the very ways in which knowledge is produced.

In the context of inner-city San Diego neighborhood City Heights, this paper finds its analysis on a critique of certain practices of for-profit development which seek to position the accumulation of monetized wealth as generative of community enhancement [1], therefore skewing the idea of human productivity as solely constituted by labored landscapes and fiscal measurements [2, 3]. It is then hypothesized that for-profit development creates an ideology and circumstance of commercialization and privatization, thereby disabling equal access to land. Historically excluded from the private ownership of United States’ land, communities of color continue to be prevented from full participation in rights to property, unable to procure initial capital through discriminatory lending policies, or discounted by the precondition of having to produce revenue [4, 5]. The empowerment of a community is inextricably linked to its access to self-sustaining resources, otherwise regarded as a paradigm of economic and environmental justice [6, 7]. However, along with modern constraints to human and community exploration of potential also arise consequences of environmental degradation, labor exploitation, and a greater inability to resist the former [6]. The process of mapping the manufacture of development norms in City Heights, however, reveals attempts of “counter-position” [8], in which community members organize through the intersections of enrichment strategies, therefore promoting networks of interdependence and holistic growth.

This paper ultimately challenges the normative definitions of development and the ways in which they are perceived by engaging a framework of critical environmental studies. Despite a focus on relationships with land, this study does not equate development to the unilateral use of land. Development and its connotations of progress and growth can perhaps be truthfully

realized if removed from capital-based economies, which reify the power structures of heteronormative patriarchies [9]. Largely externalized, the industrial age measurement of benefit devalues non-monetary, multi-faceted growth. Disconnected from that which cannot be numerically measured, development is officiated by one-dimensional strategies that reproduce structures of inequality. Ambiguity would perhaps rid the world of bias and lend to its critical expansion.

## The Problem with Capital Based Development

Neo-liberal promotion of free international trade and investment has limited price controls and increases the transnational movement of goods, services, and capital at the expense of worker’s rights and the environment [4]. Increased economic growth is often justified by the expectation of utilitarian results, but historical experiences of large wealth disparities and social unrest have continued to refute this [9]. The monetization and disproportionate absorption of profit are most visible when institutions engage in the justification of economic prosperity as the equivalent of social prosperity – at global and local levels [10]. Current frameworks of development are thus rooted in industrial economies because of their alleged contribution to the reduction of global poverty – a condition ironically reached through the very institution of industrialism as a mode of operation and impetus for previous frontiers of colonialism. Poverty, or the disproportionate distribution of resources, is said to have intensified from the industrial “advance in production,” which “increased the range of powers which sections of society had over other sections” [11, 12]. More simply, the expansion of the capitalist economy identified greater power in some, leading to a production-based struggle for growth. In the case of colonial capitalism, power manifested itself in the imperial stronghold, allowing for massive resource and labor extraction, commodification, and in the case of the latter, racialization; this led to the “underdevelopment” of the colonized [11].

As profit-based development qualifies the uninterrupted acquisition of resources and their manipulation by exploited laborers, the alliance of social and environmental political action would seem likely [13]. However, mainstream environmental discourse posits global transformation as a subset of mitigation, wherein the welfare of the planet is achieved through technologized innovation. Ecological modernization and conventional sustainable development schemes “attempt to resolve traditional tension in environmental politics between striving for economic



growth and protecting the environment,” disregarding the acquisitive nature of global economies [14]. Comprehensive sustainable change requires the mutual recognition of the commodification of nature and labor [13, 15]. Valuable environmentalist strategy understands the trope of sustainable development bounded by the interests of capitalism, intimately connecting stewardship of the environment with the liberation of people. Liberation is understood in the imperative context of individual self-determination beyond the indoctrinating control of totalitarian and democratic nation-states as well as the human rights discourse, in which an anthropocentric order is established and therefore dismissive of the intrinsic rights of the rest of the world. Here, liberation of the people is therefore a counterpart of environmental stewardship and vice versa.

In rematerializing the lost link between humans and the environment, there have been recent efforts to devolve decision-making at the community level. However, implementable solutions are still predominantly conceived by the industrialized world and imposed on the remaining social majority (Agrawal and Gibson 2001). The climate change debate, for example, urges the employment of nation-state agreements capable of misrepresenting populations and holding historically colonized peoples accountable to lower levels of emissions without first recognizing the disparate conditions created by Western imperialism itself [9]. In attempting to limit disastrous climate change, the industrialized world perceives the switch to an electric vehicle, for example, a palpable pathway to real change – just as the exchange of a coal stove to a solar cooker is heralded as a sufficient move toward sustainability. “Green” consumerism continues to lie within a framework of commodity capitalism, continuing the use of resources for the world’s social minority and yet often policing the minimal and often traditional use of resource by forest, riverine and rural agrarian communities [18]. Consuming its way out of consumption, the industrialized world’s contemporary environmental “greening” movement “only furthers the disempowerment of people elsewhere” [14].

### Against Universal Binary

Conscious of both its social and environmental implications, anti-normative development can divert the negative influences of modernity while redefining the contexts in which we perceive growth. However, in exposing the separate impacts of industrialism on people and planet, we create an unintended distance between the two. Despite the concurrent effects on both, the language behind socialism and environmentalism divulges a true relation. This dualism inhibits the full realization of development that is ethical and ecologically sound for the very reason that it separates justice on those two fronts. “Post-materialists see environmental welfare (through the rhetoric of sustainable development and ecological modernization) as something largely separate from humans,” abstracting the problems of industrialization as largely conservation-based [14]. Efforts to protect the environment by, in fact, protecting a limited and linear definition of the environment – nature, the wilderness, the outside – serve to alienate humans and sustain environmental discourse simply through the preservation of biodiversity. Dominant industrial narratives further relegate humans to the urban corners of the world, creating a distinctive human landscape, which restricts the inclusion of the human species in natural terrain as simply transitory. The environmental

demarcation of wilderness seeks to protect natural landscapes through the elimination of human interference, although in that process it further justifies the overt urbanization of the human habitat (Cronon 1996). This produces a rather cyclic expansion of the human rights discourse as incumbent on urban-industrialization, deferring the character of human being as existent only within its exclusivity. The long history of human cultivation of nature is ignored in this dualism, producing a paradigm of social invisibility in which all humans are typecast by modernity, therefore excluding those who rely on direct use of their environment [18]. The future of nature is reliant not only on the diffusion of conventional human development, but also on the acknowledgement of the human as a notwithstanding part of nature (Cronon 1996). The definition of environment thus plays a crucial role in expanding and reevaluating the ways in which the discourse of development is established.

Similarly, many labor rights discourses engage the uplift of the worker with the assumed foundation of industrialism, creating the rift of duality, but also disallowing the possibility of industry itself as the primary perpetrator of systemic inequality. Of course, in this sense, industry is limited in definition by its ecologically taxing and material producing nature, and reliance on the globalized free market. Marx’s developmental model of economic change has been criticized for its resource exploitative basis, specifically as a further deterrent to the equality of human by the contradictions of (1) creating an impoverished global ecology and therefore ensuring greater class competition for resources, and (2) creating an elite class order in the very distinction of humans vs. remaining environment as commodity (Sayers 2007).

### Generating Counter Discourse

Dissolving the human/nature binary requires us to further bridge social and environmental concerns by refusing to see them as separate issues. Following similar paths, eco-epistemologists attack Western hegemony on various levels – denying the division of thought into duality, reimagining human relations with their landscapes, and expanding the valuations of work, progress and growth beyond contemporary habituations [13, 7]. The politicization of space is seen on many levels, working to reintroduce affinities with land, practice and dignity, and asserting the undeniable rights to these affinities [19]. Cherrie Moraga portrays a strong understanding of community as distinguished by both spatial and nonliteral configurations of land through her poem “War Cry,” in which “Lo que quiero es tierra” can be translated as both “what I want is territory” and “what I love is land.” This line’s double meaning thus demands social justice at the same time that it expresses environmental kinship [13].

Eco-epistemologists challenge the colonization and usurpation of land, destruction of native philosophies and relations with land, and establishment of slave-worked practices of destructive agriculture by refusing the rhetoric and practices of development that feminize, monocrop, and industrialize lands [13, 7]. Moraga suggests that non-acquisitive relations to land enable the emergence of types of love and sexuality that are generally repressed; seeing land as a homeland rather than a piece of property, or as a child or lover rather than a rapeable and controllable unit can radically change the way we use and respect land (Ybarra 2004). Reinventing traditional methods of cultivation that are not harmful to people and soil, small farmers

are reaffirming the practice of *la milpa* or the intercropping of plants in the production of foods and herbs, feeding and healing simultaneously [20]. Development therefore steps into a threshold of ambiguity, but remains to face a large trajectory of challenges that seek to order, capitalize, and subvert its possibilities.

In advocating a reconsideration of development, I recognize the subjectivities of knowledge production through the very real power of geography and group – of people and their position in dictating the construction of truths [19]. The paradigm of problem-solving frequently uses the methodology of pattern recognition to create models of change that are easily reproducible, at times resulting in the generalization of a problem [10]. This paper hopes to disestablish the concept of “best practices,” focusing instead on documentation and interpretation – not exclusive to either the social or biological realities of the world. “Foundational truths,” seen in the mainstream as response and resistance, are available to then serve not as exact recommendations, but as interlocutors through which strategy can be learned, modified, and applied autonomously [21, 22]. There is perhaps no ultimate global plan which can single-handedly create a more sustainable and equitable world without reducing the cultural, political, and social autonomy of peoples and/or the existence of the natural world.

This paper then attempts to decolonize the prevalent “rhetoric of sustainable development and ecological modernization” as it portends conventional economic growth, through a study of exclusion reinforced by the institutional and cultural commoditization of land [14]. To call it unequal participation would only serve to reify characterizations of lethargy, vacancy, and inaction; exclusion is but superficial. In other words, I look at the interaction of empire and counter-position (the interstice of resistance and practical existence [21]) in the community of City Heights in the County of San Diego, California, as parts of the neighborhood challenge the conservative bounds of development – simultaneously affecting ecological destruction, while defending the rights to feed, heal, retain tradition, remain socially visible, and deconstruct class inequity.

## Methods

For the purposes of creating a framework of field and primary source research, I ask the following questions: what are the historical and institutional influences of land use and on land use in City Heights; how do those influences create and maintain ideologies of how land should be used or developed; and together, are these institutions and ideologies limiting access to land and therefore disempowering a community and engendering exclusionary politics? The investigation of these questions is structured by the analysis of two planning legislations: the Mid-City Communities Plan and the Redevelopment Project Area plan of City Heights; twelve formal interviews with members of various organizations including International Rescue Committee and its two farm projects (New Roots Community Farm and Aqua Farm), City Heights Remedy Garden, Mid City Coalition Action Network, Price Charities, and Speak City Heights; and regular organizational meeting observations.

## History of Land Use in City Heights

It should first be recognized that the unincorporated land purchased by Abraham Klauber and Samuel Steiner in the late

19th century and later annexed into San Diego was available for acquisition due to the colonization and removal of native Kumeyaay peoples. Before European settlement of the southwest, tribes of the Kumeyaay lived in the current County of San Diego for over twelve thousand years, tracing approximately six hundred generations of native lineage [23]. Kumeyaay uses of land included animal husbandry, wild animal stocking, sophisticated plant agriculture, and the creation of watersheds [23]. Originally a piece of native land and later obtained by American developers, the locality of City Heights was known as the City of East San Diego before its incorporation into the City of San Diego in December 1923 [24]. As shown in the map below, the neighborhood of approximately 1,984 acres is bounded by El Cajon Boulevard in the north, Interstate 805 in the west, 54th Street in the east, and Euclid Avenue in the south, and is divided into sixteen sub-neighborhoods.

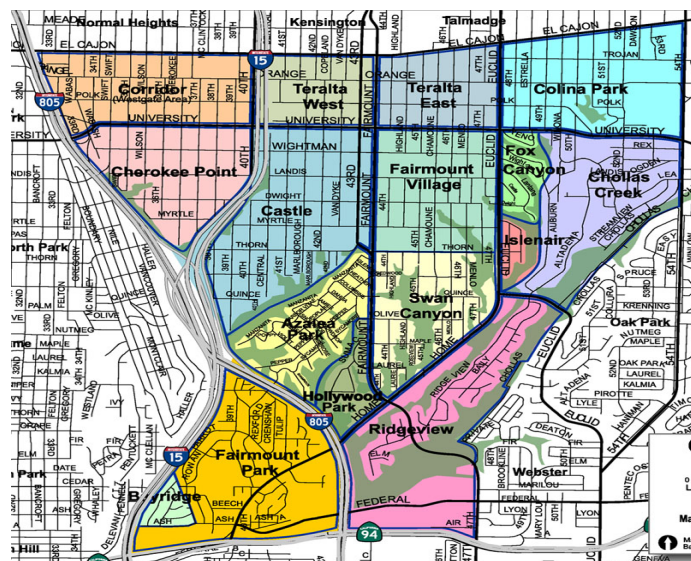


Fig. 1. Map of City Heights Sub-Neighborhoods

Densely populated, City Heights was measured in 2010 to hold an estimated population of 78,893, 57% of which is Latino/a, 18% Asian and Pacific Islander, 12% Black, 7.8% White, and less than 3% Native American [22]. In 2011, San Diego was distinguished as the nation’s primary refugee resettlement location, with City Heights as one of the favored areas of relocation [24]. San Diego County has witnessed large influxes of Vietnamese and Cambodian refugees in the 1980s after the respective incidences of the Vietnam War and Khmer Rouge reign, as well as the arrival of East Africans in the 1990s, in large constituted by Somalis and Eritreans as a result of an upsurge in civil warfare. The last decade has also seen a sizeable exodus of Iraqis to Southern California after the initiation of the United States-Iraq War. The presence of large groups of refugees and minorities in City Heights has led residents and outsiders alike to note dynamics unique to the area, negotiated by the many interactions of ethnic diversity (Burks M, personal interview, 2011). Comprised of even smaller neighborhoods like Little Mogadishu or Little Baghdad, City Heights is radically different than it was seventy years ago and has since experienced a tumultuous history, argued within this work to play a significant role in the present conditions of the community.



## Mid-City Plan

Constituted by several businesses on the University Avenue and El Cajon corridor, City Heights was a successful commercial center from the 1930s to the 1950s, losing its merchant and customer base in the late 1950s as a result of the popularization of nearby single-location suburban shopping centers and the construction of Interstate 8 [24]. In 1965, San Diego City Council approved a plan seeking to promote commerce by increasing housing density in City Heights and surrounding mid-city areas – Normal Heights, Kensington-Talmadge, and Eastern Area [26]. The Mid-City Development Plan of 1965 was later updated in 1984 as the Mid-City Communities Plan and once again in 1998. The updates to the original plan are important on two fronts, as they (1) establish the four mid-city areas of focus as communities, which then contain twenty-seven smaller neighborhoods; and (2) each increase or restore commercial zones to encourage the local economy (although the second update decreases both residential and commercial density maximums to address a lack of community facilities) [26].

In characterizing the larger mid-city areas as communities rather than neighborhoods, the updated plan engages in mixed-use strategy – affirmed by smart growth theorists as a crucial antithesis to consumptive suburban landscapes (Fulton and Shigley 2005). Promoting the intermixing of housing and business, the Mid-City Plan distinguishes the role of communities as fundamentally different from suburban neighborhoods reserved solely for residences. Maintaining the original plan's goal of increasing local economic growth, the 1998 plan shifts some focus away from the expansion of real estate and recommends “an emphasis on capturing the local community's spending dollars by focusing on community goods and services” [26, 20]. Externally, this emphasis seems to operate under workers' control of production, and retains capital locally. However, the recommendation reproduces the idea that goods and services are so deemed only if they can quantifiably generate revenue. Community exploration of potential continues, then, to exist within the precondition of creating capital. Inquired by many scholars, the revealing question asks whether generated revenue truly represents the “wealth” of the community, and if it is distributed proportionately across the community [5].

The ideological implications of American work culture, or what is seen as viable and productive work, can be said to encourage the development of industry. The Mid-City Plan's prioritization of economic development is further evidenced by the highlight of certain plan details in its summary, including the recommendations of: “the addition of light manufacturing designated land in City Heights,” and “capitalizing on the community's diversity...by fostering an International Marketplace” [26]. Lending legislative favor to business- or property-related projects; institutions, such as the City Planning Association, have the direct ability to exclude participants from initiating projects “of risk” and the indirect consequence of negatively influencing other institutional or social perceptions of development outside convention.

Market-driven trends, in addition to city planning, may also influence the ability of local projects to receive capital. Attributed to the revitalization of communities, localized economies theoretically allow for increased investment in greater-risk ventures (projects conventionally deemed difficult

outside of property and infrastructure) through various single or combinatory strategies, including the greater use of state regulation, the involvement of trade unions and community organizations in decision-making, and the intensification of control of production by workers and residents [27]. In response to exploitative free market economics, democratic decentralization (or the socialization of production) is believed by many to be founded in the greatest capture of profit or benefit at the level of the worker. The theory of economic socialization works mainly through the worker-product relationship and is perhaps limited in further analysis of what constitutes a benefit beyond its monetized valuation [28]. Eisenschitz and Gough explain the contradictions of socialized local economies in their requirements of capital: “local collaboration – in order to compete for internationally mobile capital; local collective services – in order to foster enterprise” [27]. Localized exchange and labor are dependent on results that cyclically enable them, producing either a reliance on state intervention or a local competition based on criteria akin to market-driven neo-liberalism. In both cases, local development is directed by an outside entity or an external demand, reducing the self-determination of the community to a pretense of relationship.

With only ten representatives from all four mid-city areas, the planning process lacks substantial community participation [26]. “Community” rhetoric is used within the plan insofar as it relates to the meeting of planning groups, although a significant portion details the expansion of public facilities for community connection. According to the association, public facilities for the mid-city are defined as such: schools, parks, libraries, and community service centers [26]. The second update of the Mid-City Plan calls for the imperative establishment of additional elementary schools and public parks – setting up a land use emphasis on the acquisition of open space. The transformation of open spaces into public parks has long been of thematic importance for American land use planning, underlying a culture of recreation that is hard to contest. These manicured rearrangements are being challenged and reimagined in important ways that establish different sets of ideals and redefine the meaning of public space.

## Redevelopment

With the 1970s influx of the methamphetamine industry, City Heights experienced an accelerated increase in crime rates up until 1995 - indicated by City of San Diego officials to contribute to the degradation of the physical and social environment of the community [22, 29]. Responding to the escalation of crime and the onset of urban blight, the Redevelopment Agency of the City of San Diego proposed a City Heights project area redevelopment plan, which was approved by City Council in 1992 and incorporated into the San Diego City and Mid-City plans [12].

Correlating the physical appearance of an area to its economic and social problems, California redevelopment agencies have always sought to invigorate communities on a material basis. Focused simply on the physicality of an area, redevelopment and its federal urban renewal precursor have been debunked as inherent indicators of change, exposing the misguided emphasis on the beautification and construction of physical structures (Fulton and Shigley 2005). Policy analysts further point to the serious implications of redevelopment as a pathway to power, criticizing

its actions as justified by a partisan understanding of public interest. Granted the authority to plan private development on property procured by eminent domain, cities and counties often forego traditional public use schemes for acquired land (Fulton and Shigley 2005). “Originally designed to revitalize struggling inner-city neighborhoods,” redevelopment is a controversial planning tool, as “it permits [local governments] to manipulate private real estate markets to the cities’ own financial advantage” (Fulton and Shigley 2005). Supported by state and federal loans, the retail of bonds, tax increment financing or a combination of the three, the reuse and redevelopment of classified blighted areas fall under a heavy liability of debt. To counter this, local governments encourage and subsidize private redevelopment through low eminent domain sale prices, reaping the growth in property tax revenue as it is siphoned into redevelopment agency accounts – often closely linked to the city treasury and unavailable to public redistribution (Fulton and Shigley 2005). The structure and past interpretation of California’s Community Redevelopment Law (CRL) have both significantly altered the scope of land use, qualifying the privatization of land and emphasizing development as relative to economically viable, concrete structures.

The City Heights Redevelopment Project tasks itself with the very similar objectives critiqued above, referencing redevelopment as generally “reflect[ing] the goals of removing physical and economic blight and improving infrastructure, affordable housing, retail and office space, as well as community beautification” [12]. Completed projects commissioned by the agency include the restoration of the historical Euclid Tower, La Maestra clinic and medical building, affordable single and multi-family housing including senior facilities, and mixed-use residential, retail, education, urgent care and recreation centers. Heavily invested in physical renewal, the redevelopment of City Heights has undertaken significant construction of new buildings (Macgurn R, personal interview, 2011). Programs established by the redevelopment plan reflect a need to refurbish the exterior infrastructure of City Heights with arrangements that have loaned up to \$4.1 million to homeowners and forgivable loans of partial project cost to businesses for storefront improvement as per surrounding design standards [12]. Most projects have been tailored to maintain density-based growth and limit sprawl by building up rather than across, placing a Walgreens within apartment complexes, a library next to a police station, and a gymnasium atop a daycare. Since land acquisition in City Heights is allowed financing by tax increment only in the case of public facility development, the investments of private companies have largely funded the real estate and commercial expansion of the project area. Debates surrounding planning mechanisms might extend approval to the redevelopment of City Heights, accounting for the reduction in crime and the attested “renaissance” of activity that the community is experiencing [22, 29]. The City Heights Urban Village, comprised of an amalgam of retail and public education and safety buildings, is in fact nationally recognized for its “comprehensive urban revitalization and development” [12]. However, the narrative of comprehensive or wide-ranging here appeals to the existing parameters of redevelopment, as national recognition has and continues to operate on prevailing American values of privatization [19]. Looking beyond the purported improvements and diversity of use in redevelopment, we apprehend the politics of space.

Private development elicits supporters and critics who investigate the effects of urban landscape changes on community residents, often reassessing purported economic and physical revitalization as gentrification. Gentrification has historically been disparaged by disenfranchised communities of color forced to relocate as a result of increased property values in newly developed areas [30, 31]. Distrust of gentrification stems particularly from a noted lack of low- and moderate-income housing in areas that seem to be revitalized for the middle and upper classes [32]. Reforms to the CRL under AB 1290 in 1993 mandate the setting aside of 20 percent of redevelopment revenue for affordable housing, threatening to shut down agencies if failing to adequately use the housing funds (Fulton and Shigley 2005). The City Heights Project Area is proportionately planned to include the housing requirements, touting approximately three different projects that either include or fully develop units of affordable housing. In order to create these housing complexes, however, the agency marked several streets of existing housing as zones of modification – a euphemism for the imperial takeover of homes under eminent domain. Displacement is a plain reality for the poor, as the required establishment of a relatively small percentage (twenty percent) of affordable housing cannot fully counteract the significant increase in rent or mortgage values – almost double in a matter of six years [33]. Ignoring the palpable fear of displacement for a fleeting moment, residents of gentrified inner cities are verifiably distributed on a spectrum of support – partial to the arrival of much needed services, but also wary of the positive relationship between the resettlement of whites with the institution of amenities [5, 30]. Scholars have indicated no real link between gentrification and its assumed theory of poverty alleviation, rather identifying it as “a calculated process designed to benefit developers, real estate companies, speculators, and investors” [32, 17]. Fundamentally based upon the ideas of commodity capitalism, the privatization of neighborhoods is liable rather to instill a culture of private ownership and the community distancing mechanisms that follow. The creation of ideology is extremely consequential to the priorities that succeed it; the confluence of City Heights Redevelopment and the Mid-City Plan initiatives demonstrate the commodification of land, implicating a very narrow delineation of development.

### Access

A lot of power and resources are with people who don’t have to deal with daily realities. You have to be very aware in walking the line responsibly – most don’t do that here or even live in the neighborhood (Camacho V, personal interview, 2012).

Community self-determination is threatened by power – power unavailable to overt recognition and permissive of uneven privilege. The distribution of power in City Heights reflects the interests and ideologies of some and not of others. It is important to remember to ask why power is concentrated as it is, and how that concentration influences the passage of bodies and their realities. A refocus on journey is necessary because access to land cannot represent a singular resource privilege; it is interconnected to mobility, or the capacity of realizing numerous other privileges. So far, the political character of settler colonial-influenced land-use planning has illustrated passage that shapes investment in investors masked as community benefit. Because

private investors can restructure community function and values through the power of capital transfer [32], development is liable to direction without the consent of community.

A prominent influence on the redevelopment of City Heights, private family initiated development firm Price Charities is largely responsible for the non-profit investment and for-profit real estate development of the community [25]. Within its non-profit scope, the Price family has established the operation of two entities: the Price Family Charitable Fund and the more popularly known public 501(c)(3) non-profit Price Charities. In order to be nationally registered as a non-profit, the latter is mandated to receive one-third of its funding from unrelated sources, with the remaining two-thirds accounted for by the Price family wealth. In City Heights, Price Charities uses these funds to generate or strengthen programs of education, health, and human services. From providing high schools students with college scholarships through qualifying fellowship programs to creating an “absentee rate-lowering revolutionary full school health clinic” at Central Elementary, Price Charities aims to provide the connections and resources needed for a community to “adapt to American culture” [29]. Indeed, the organization impacts the capacities of individuals and institutions, focusing on the youth and the empowering ability of communication and higher education. However, working through assimilationist parameters, it encourages adaptation without thoroughly evaluating what is entailed by American culture. Perhaps to be American, one must experience a full, comfortable life; “the mission of Price Charities is to improve the quality of life in low-income communities, especially in City Heights and San Diego County” [25]. Are all Americans unequivocally entitled to this quality of life that is without dispute defined by quantitative living, unwilling to question the psychological needs of humans in modernity? Asserting melting pot multiculturalism [8], Americanism rears its head as the non-solution to a non-problem. The rhetoric of opportunity often trumps real inequality – real frameworks of power that deny existence, naming it difference. The narrative of civic rights goes only so far as to quantify living, focusing simply on the limited material factors of well-being [5]. Price Charities resides at a point of privilege, which allows it to signify certain issues with more importance than others. Even the benefit generated by its focus is decided by the way it shapes discourse on “issue”. The subjectivity of an urban education dialogue facilitated by district superintendents’ best practices is itself preceded by a partiality on the issue of education, simultaneously differentiated by and to be of urban nature. The problem here lies not in the complicity of private developers, but in the design of reformist culture that marks the strict outlines of development. At times, power can itself confuse justice (charity) with convention. Put simply, I argue that institutions such as the Price family locate their clout in being able to charitably fund projects unable to disrupt fundamental American truths of progress and property – truths conferred through the existing power structure of U.S. imperialism.

The Price Family Charitable Fund organizes its fund- and land-based grants “with special focus on the community of City Heights” [25]. Attesting to the “very expensive value of land”, the foundation bases its internal assessment of applicants on the projects’ “development and design plan, community improvement and support” and impact on “Price Charities’ public image” [29]. According to a lead coordinator, the grant committee evaluates

the longevity of a project through the relation of its mission with the development it offers procured land. Moreover, an advanced plan of design – while faring well in the foundation’s assessment – can also garner the organization further contacts and resources or “non-monetary help” from the Price network [29]. The assessment follows with the project’s intent of community improvement as it is closely “related to improving health and social services” [29]. Here, the community can perhaps influence the institution’s decision, relying on its mechanism of support – a legally unbound, informal tool navigating its “x-marks” in formalities that let communities function in the benign ways that they should [34]. Community advocacy network, Mid-City CAN is a large system of representation, based partially in City Heights and managed through the organization and communication of several momentum teams, including but not limited to: Access to Healthcare, Improving Transportation in City Heights, Peace Promotion, School Attendance, Food Justice, and Building Healthy Communities Momentum Team [35]. Interested in “creat[ing] a safe, productive, and healthy community through collaboration, advocacy, and organizing,” Mid-City CAN is an active collection of local voices [35]. Unable to fully achieve a representative role in the land use decisions of City Heights, however, CAN momentum team projects have been refused Price Foundation land grants several times in the past (Kosower E, personal interview, 2012).

## Retention

City Heights’ Building Healthy Communities Built Environment Momentum Team (BEMT) gives impression of similarity to Price priority, working to create an advocacy plan over 12 months to promote a policy agenda focused around the “health and economic development for community residents” [35]. Included among objectives are aims to “develop land use policies that will improve community health” and “reduce environmental impacts that damage health”. One of the primary platform issues listed reads: “improve access to healthy food” [35]. The succeeding incumbent, Food Justice Momentum Team (FJMT) goes even further to connect the incidence of land use to access to healthy food and the specific needs of City Heights residents, directing attention to immigrant transition. FJMT has been instrumental in pointing out the negative impact of eventual refugee adaptation to a sedentary and innutritious American lifestyle, encouraging space, instead, for the cultivation of traditional diet foods. According to the CAN, the ability of immigrants to grow their own food is not only tantamount to their good health but also their improved ability to sustain themselves economically [35]. An active voice in the CAN and a large force in connecting City Heights’ refugees to the option of small farming, the International Rescue Committee (IRC) operates two sizeable community farms – New Roots Community Farm and hydroponic New Roots Aqua Farm, each of which rents out approximately eighty plots of land or hydro-beds to families and individuals (DeCampos F, personal interview, 2012). The value of community farm has been attested to provide food security through the use of diversified cropping methods, which ward the erosion of land and the excessive use of irrigation [13]. The farms have been given much regional and national attention for the qualification of groundbreaking projects as primary approaches to the rehabilitation of immigrants. Providing a source of food and income for residents,

the farms have contributed to a shifting standard of contractual agreements, having fostered partnerships between small farmers and larger-scale product processing businesses (DeCampos F, personal interview, 2012). Despite validating recognition and the increased societal endorsement of food justice, the IRC has had a range of problems with land and funds procurement for the expansion of their food based projects. To counter this, the committee has launched a land bank program, inviting existing landowners in the area to offer “entrepreneurial refugee farmers” unused space. Facilitating land matches, the project suggests that “inviting a refugee farmer to your land will beautify your space and help the farmer feed their family and their community” [36]. In bold defiance of American anti-trespass culture that has instigated an ethos of mistrust, guided in part by a history of racism, the land bank implicitly redefines proprietorship. Enabling shared ownership, the program attempts to remove the culture of private land, although limiting the scope of ownership to its organizational focus: refugees. Perhaps the absence of a clear definition of “refugee” would allow the program to qualify all landless as refugees of private interests. However, the land bank is specifically organized around the needs of immigrant refugees, as per IRC efforts. While heralded for its concentrated work toward the recovery of incoming and established refugee populations, the IRC can also be criticized for directing attention away from original City Heights residents of color, also faced with the challenges of health and food access (Burks M, personal interview, 2011).

Additionally, with an increasing emphasis on refugee entrepreneurship, the New Roots projects risk agreement with the rhetoric of commercial development, endangering projects founded on the non-profit cultivation of land. Navigating these politics of space, for example, City Heights’ Remedy Garden organizes itself as an antithesis of privatization, counter-posing as a collectively run garden initiated for the empowerment of resident and community health. The Remedy Garden holds the view that the cultivation of remedy in addition to food is crucial for the holistic practice of preventive health. Besides diagnosing and dispensing low-cost and often free herbal medicines in the forms of tinctures, powders, and whole plant parts, the garden hosts free workshops adapted to recurring ailments within the community. “Equipping people to understand the system they have to interact with,” the workshops aim to give “immigrants and refugees who have dealt with extensive trauma some ground to stand on” (Camacho V, personal interview, 2012). Enabling a “genuine sharing of resources,” the organizers at the garden find a “lack of autonomy and dignity in the dominant health system,” explained in part by healthcare models that function via dependence; “agencies helping people only exist as far as there is a need” (Camacho V, personal interview, 2012). The workshops work instead to validate people’s physical and material and emotional life experiences by basing an educational approach on self-healing and community support. Indeed at a workshop titled “Stress Management,” a Latina woman confided in the “horrible treatment of her sisters” and her subsequent wariness of doctors and their treatment as “simply experimental” (Maria interview). Her sister was undiagnosed and died of cancer, while her other sister, although diagnosed with terminal cancer, remained to live a healthy life. Another Somali family present, while translating their mother’s words of gratitude, added their appreciation of information beyond herb qualities and uses. The

workshop detailed the influence of patriarchy in the history of western medicine, in addition to highlighting the neurological, physiological and emotional responses to chronic stress. Inviting attendees to share traditional remedies, the organizers shift dominance of knowledge from presenters to the round table – reaffirming the wisdom of several different cultures and the abilities of individuals.

The coordinators of the homegrown garden collective are perhaps the better judges of surrounding illnesses as they themselves identify as residents and with challenges associated. Their work and methodologies prioritize equality of health, sharing knowledge rather than passing it on condescendingly. Renouncing chains of command, the space is truly communal and yet considered “a vacant lot” [29]. Renting land from the supposed beacon of philanthropy, Price Charities, the garden faces interminable volatility unless it is terminated. The development firm exhibits its power through a shield of U.S. private ownership laws, which guarantee land titles under a fair value exchange; in the case of the very first settlements, even lives were accountable for exchange. Once granted, the power of territory enables other powers of influence, in this case a power of definition. As stated before, Price justifies the grant of land under the condition of future development. A largely transnational trend, however, the requirement of progress and development is largely parochial and as Arundhati Roy has aptly stated, “the battle for land lies at the heart of the ‘development’ debate” (2009, xiv). Understanding the misappropriation of language, the Remedy Garden clarifies intent in a triad, ‘tierra, salud y libertad’ – land, health and freedom, each mutually reliant. The garden can provide significant anchoring against the privatization of land by first reimagining landscape.

The Price foundation is liable to require the evacuation of the garden in the case that a more viable project committed to the development of land rises in need for property [29]. Viability and development are two terms that can be heavily contested here. The garden sits at the heart of viability, providing public health care with a strong commitment to understanding the public, but it is not, nor will it ever be, in the process of creating a concrete building around and over its plants. It will not impede life for the very purposes of ‘developing’ an already developed plot of land. The equation of a life-giving – and itself living – space to a vacant, unused lot of land is the central paradigm that allows for



Fig. 2. Image used with permission from The Remedy Garden Facebook archive

the imbalances in power, which we have thus far outlined.

Indeed this position of property instability has spread far in dense City Heights, and even within allied organizations financial stresses have driven subtle conflicts. A portion of the Remedy Garden is set aside for free use family plots, many of which are utilized for the production of food by IRC situated refugees. The confluence of food and remedy here recreates the indigenous Mayan practice of *la milpa*. However, the increasing strain on land resource has impelled non-profit IRC to seek a larger presence within the Remedy Garden (Macgurn R, personal interview, 2011). Although tacit and thus far internal, this shift has propelled organizational outreach highlighting the entrepreneurial successes of refugees and a middle-class ambition as opposed to an earlier focus on food and community justice (Burks M, personal interview, 2011). The shift is perhaps shaped by private developers' conditions of 'sustainable growth' – a misnomer readapted to the industrial modes of capital growth. Although successful partnerships and the limited access to land have created flourishing sources of local produce and prepared food, an increased awareness of food systems and health, and community mobilizations for affordable prices (including a successful push for the acceptance of EBT at the City Heights' farmers market), the over-emphasis on 'food' strips the discourse on health of input, likely that of preventive and healing plant based medicine. Access to traditional remedies is equally important as access to traditional diets in a community that seeks to limit implicit assimilation, but more importantly limiting the prospect of good health to the intake of unprocessed, pesticide-free, GMO-free vegetables, fruits and grains, while a largely essential factor, can actually pathologize disease on a strict individual basis even if it is a symptom of a larger local issue of lack of mobility, for example. Additionally, an agency-based focus on an agenda item is liable to shift even more focus away from an already disenfranchised demographic – this has been contested to have occurred in City Heights where a vibrant food community was recently unaware of the health conditions and food access of minorities outside refugee status (Burks M, personal interview,

2011). Centers of alternative health like the Remedy Garden can promote a comprehensive understanding of community sources of ill-health, seeking a physical and intentional meeting space, which can mobilize against environmental injustice like the placement of polluting industry (Macgurn R, personal interview, 2011).

## Conclusion

While we have questioned the connotations of development and entrepreneurship, we have been unable to go past the complicity of industry and involve it in the redefinition of productivity and work. Why can't industry itself entail economic activity that is ecologically permissible and viable beyond the limiting material producing paradigm? Furthermore, the topics of access and retention are perhaps incapable of fully dissolving any problems related to land, as they automatically mire it in a sort of property paradigm. Of course, while paving a way for the illustration of immediate material consequence, the inclusion and preservation discourses have sought here to change the very pathways that produce these conversations; the injustices, the biases, and the supposed "opinions" informed by the pathways have been challenged under recognizable terms but through a careful process of understanding buildups, blockages and other dynamic details for which there are not many technical names save perhaps "the idiosyncrasies of community." Consequently, what we have is not a point to completely move forward with but one with which to keep returning and asking the same questions as they relate to the specific temporality, just as it was asked of the post-L.A. riots South Central garden, poisonous Bt cotton, Delano grapes, the machinated mid-west, swing riots of east Kent, and Tacky's War.

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Tarangini graduated from the University of California, San Diego in 2012 with a major in Environmental Systems. She believes in politically organizing at the intersections of environmental and social justice, and likes to spend time with those who do as well. She has worked with agrarian and landless workers’ movements in India and Brazil and hopes to continue to understand the various ways in which the world responds to the influence of power. On days off, you’ll find her reading beautiful books, dancing, and talking about herself in the third person.

# Encountering Gender Theory: A Service-Learning Approach

William Simmons

Harvard University

## Abstract

Service-learning, a teaching method wherein students learn by combining academic concepts with community service, has received much attention as a means to empower youth and equip them with important skills that are conducive to both community engagement and self-esteem. However, it also functions as a mediator between gender issues and educational practice, an important divide that has enormous implications for academics and educators alike. Youth development is not an inherently unified field; young people present a multiplicity of identities that cannot easily be addressed by a totalizing methodology. Theories of gender and sexuality remind us that reforms for girls in public schools must not take an essentialist stance that purports to speak for all girls and women, given that there is no easy reform for a category so unable as “woman.” The key question becomes how to keep this principle in mind in practice. Curricula that are designed to serve the “needs” of “women” make the mistake of purporting that there is a delineated population called “women” that has specific issues to be dealt with. Though there is no doubt that girls in public schools need attention, especially when one contends with the masculinist tendencies of the American schooling system, there is such a wide array of voices within the category of “woman” that some are silenced for the sake of others. Service learning combats this by allowing young people to examine the structures of power that occupy their lives while encouraging personal achievement and growth alongside fellow classmates.

Education’s impact is not only felt in measurable indicators of success, but also in the more subjective arenas of self-esteem and social conditioning. Education, curriculum development specifically, can be seen as a primary force in the creation and dissemination of cultural norms, such as those pertaining to gender roles (Lather 1994, 245). Among the various institutions that shape American youth, “only the school has the socialization of youth as a principal function” (Saario, Jacklin, Tittle 1985, 99). Teachers prepare students for entry into the public sphere, and in doing so instill the values of the dominant society, often to the detriment to marginalized voices (Lather 1994, 245). Indeed, the “work of the teacher is part of the discursive practices that enable these [normative] processes” that perpetuate institutionalized systems of power that directly hamper girls and women within a patriarchal society (Coffey and Delamont 2000, 13). Specific identities therefore become very important when

inscribed in this framework of the preparation and instillation of norms, and one need not look far to see that public education has failed women and girls in a variety of ways, from achievement to self-esteem to safety. An intervention on behalf of women and girls in the American education system becomes increasingly necessary as gender gaps within and beyond the academic sphere persist and even widen.

One might naturally look to feminist models of girls’ empowerment to address the problem of gender inequities in schools by targeting female-bodied individuals with specific, gender-based interventions. By themselves, however, gendered interventions have the capacity to marginalize female students by re-inscribing them within the very system of difference that feminism seeks to undo. Targeting girls specifically as an “at-risk” group does not allow for an appreciation of the wide range of sexed bodies and gendered identifications that exist within all youth of various backgrounds. As gender theory has indicated, the group called “women” is constantly in flux, filled to the brim with every race, socioeconomic background, and sexual/gender identity. As a result, there is renewed interest in the influence of different and intersecting identities in the search for educational equality; in order to fully consider policies aimed at underrepresented groups, educators and academics must collaborate to find a solution that is both inclusive and effective. A crucial component that has often been left out of curricula, especially as budgets shrink and testing increases in importance, is the opportunity for enrichment activities, especially service-learning. These experiences have the potential to supplement curricula and integrate meaningful youth development exercises into the schooling process. More importantly, service-learning has the capability to mediate the essential disparity between gender theory and gender disparities in practice by giving agency to girls without perpetuating their outsider status through single-sex methodologies. Service-learning occupies a middle ground in the conflict between identity and education that allows for the appreciation of subjectivity alongside meaningful prescriptive reforms. The integration of enrichment programs into school curricula has a proven history of success in several crucial areas of youth development, especially independence, collaboration, positive self-image, and community awareness.

## Gender Theory and the Problem of Identity

Given the role of schools in the propagation of norms, it is important to look at the theories behind prescriptions for women in American schools, the silent arena wherein youth are groomed for integration into a deeply ideological and stratified society. It

is true that “the trying on of dominant forms is played out within student cultures and exists at the expense of marginal or less conventional sex-gender identities,” and as a result, identity work must be done in order to address the gender achievement gap (Kehily 2004, 214). This, unfortunately, is not a simple task. When looking to produce change, one must acknowledge that systems of power are “broken apart, scattered, and multiplied in an explosion of distinct discursivities” that operate together to diffuse and perpetuate power throughout an ever-changing society (Foucault 1990, 33). Given the number of stakeholders in the American education system, a phenomenon that is the result of many years of competing, collaborating, new, and old powers, Foucault’s argument becomes especially relevant, even when examined irrespective of gender. A school is not an autonomous entity; it has a history and a culture. Surely, a complex conglomeration of competing interests governs relationships between students and administrators, as well as between groups of students. There is a multitude of interested parties – parents, students, teachers, academics, administrators, government agencies, nonprofits, community organizations, activists, curriculum developers, etc. Equally important are the power relations inherent in student interactions; for instance, the sociologist C.J. Pascoe tacitly employs Foucault to unearth the competing identities, alliances, and sensibilities of young people, especially with regard to issues of gender and sexuality (Pascoe 2007, 25-50). These processes, according to Foucault, are deployed over time, and our present state is a result of the shifting of powers that have oscillated between various alliances for decades.

Clearly, gender is not free from inscription into a complicated scheme of power relations, thereby complicating any discussion of gender within normative educational models. Gender, in fact, is essential to, and perhaps constitutive of, Western hegemonic concepts of knowledge production and dissemination. The tradition of Sigmund Freud and Jacques Lacan present the vision of the unified male ‘Self’ whose creation is dependent on the existence of an ‘Other’, a vehicle of meaning by which the phallic subject can find expression (Lacan 2006, 77-81). Luce Irigaray, a philosopher whose work has informed much of feminist/queer poststructuralist thought, critiques this phallogocentric tradition by contending that it represents the feminine as the perpetual Other, even at the level of language (Irigaray 1985, 34-86). The foundational processes of human interaction, therefore, are informed at their core by a structure of gendered difference. The philosopher Judith Butler, whose work has been essential to questioning the very existence of gender as an interpretational mode, complicates this discussion by theorizing that the production of gender can be analyzed as such – an illusory product of power relations. In sum, Butler argues that “if gender attributes and acts, the various ways in which a body shows or produces its cultural signification, are performative, then there is no preexisting identity by which an act or attribute might be measured; there would be no true or false, real or distorted acts of gender...” (Butler 2006, 192). The implications of this are immense, for if gender is a performance that is set in motion by the power that culture holds over its bodies, there are no stable categories of gender. Butler makes this explicit; if all this is the truth, “the postulation of a true gender identity would be revealed as a regulatory function” stemming from “masculinist domination and compulsory heterosexuality”

(Butler 2006, 192-193). It follows that the relationship between female bodies and conceptions of “women” are wholly based upon hegemonic discourses of power. Butler untethers sex, gender, and self-expression and calls for an embrace of their separation. The instability and mutability of the categories of gender, therefore, require a more nuanced approach in practice, though Butler’s analysis does not preclude activism. It certainly does problematize the ease of proposing prescriptive reforms for girls, because of the difficulty of discussing the essentialist notion of “woman.” Activism must be combined with an understanding of the unsteadiness of gender categories, as well as the specificity and uniqueness of underserved groups.

One possible method in the wake of this has been advocacy for post-gender education in which children are treated as if gender did not exist. On the other hand, a Foucaultian model could necessitate and legitimate a gender-cognizant approach: “Because gender is a set of relations that are constantly changing and are constantly affected by other structuring processes in social relations, the gender-free strategy has to appear somewhat simplistic” (Houston 1994, 130). Carol Gilligan’s work, epitomized by her iconic *In a Different Voice*, presents a similar conclusion, especially given the historical context of her theoretical intervention wherein the unique experiences of women were often overlooked in many disciplines, especially in the field of human development (Schneir 1993, 428). The contribution of feminism and its effort to carve out a space for women is certainly a historically-consecrated phenomenon with regard to education: “Schools have benefitted directly from education feminism’s unique historical trajectory. This is largely because its political reforms were explicitly directed toward education” (Dillabough 2006, 51). Still, paying attention to gender can have adverse effects; grouping girls together and working to support their supposedly inherent needs can be essentialist and perhaps detrimental in the long run. Moreover, there is no single narrative of “womanhood,” and no female-bodied person can be wholly reduced to biological gender. With this tricky road to traverse, education needs a new methodology that is able to incorporate the historical inequalities that exist between genders without relegating either gender to a separate sphere.

### **Community Service: Expanding the Classroom**

The search for a mediator between the gender issues I have outlined and tangible gender inequities in education must begin with service, for it is clear that the extension of learning beyond the classroom has immense implications for identity formation. Service-learning refers to an educational model wherein academic disciplines are combined with real-life application through community service. By allowing students to utilize academic skills in order to benefit the community, youth have the opportunity to put their learning into practice in meaningful ways that enable self-reflection and self-determination. This is an essential first step toward understanding how women and girls can harness and assert their own subjectivities. For example, extensive work in new forms of youth development have shown that “theory and research both suggest that community service can support adolescents’ development as they go through [the] process of identity development” (McIntosh, Metz, Youniss 2005, 331). A three-year longitudinal study conducted in a high school near Boston, one of many such investigations, “illustrate the



growing importance of community service and leisure activities as predictors of identity development over the high school years in [the] sample,” which is “consistent with other research showing positive developmental benefits associated with participation in community service” (McIntosh, Metz, Youniss 2005, 340). At its core, “service-learning is inherently a unifying agent” that allows youth to mentor other students, thereby developing self-esteem and a sense of personal accomplishment (Furco 1996, 66-67). Giving students the opportunity to hold positions of leadership within the development of enrichment activities proves to them that they are each “seen as a resource who has something to offer,” thereby giving them practice in essential skills that will benefit them later in life (Furco 1996, 67). Gaining experience in leadership and other essential life skills has a wide array of important implications for young people. Certainly, “taking initiative, becoming motivated to act, and following through on a service project all require leadership within oneself” that affords young people the chance to find personal and developmental meaning in their academic studies (Hollinger 1996, 165). Furthermore, service-learning encourages students to engage in a process of reflection and evaluation, and a cornerstone of service-learning is the final step of the project, wherein participants look back at their work and evaluate its strengths and weaknesses. This produces a very valuable effect: “Reflection and evaluation reinforce the maintenance of a positive environment that supports volunteers expressing their inherent power, developing their individual strengths, and appreciating their diversity. We facilitate a process of doing with youth, not for them” (Ebbighausen and Batson 1996, 173). Youth thus become agents in control of a personally relevant and enriching project that allows them to understand their own selves as unique subjects unhampered by masculinist norms. It is with this combination of personal fulfillment and addressing a community need that girls can be best served in public schools.

### Service Learning and Positive Identity Formation

Service-learning is thus an integral component of curricula that seek to achieve gender equity without hampering any genders along the way. The key to an equitable solution is enabling girls (and, by extension, perhaps, boys) to understand the constructed nature of gender while encouraging collectivity and cooperation in schools (Currie, Kelly, Pomerantz 2009, 202-203). In so doing, educators can both acknowledge gender and reject its constraints. Put concisely, “as a social, not individual, accomplishment, the gendered, racialized, and classed nature of Subjecthood remains in view” while “[inviting] interrogations of the conditions under which we ‘do gender’” (Currie, Kelly, Pomerantz 2009, 203). Service-learning acknowledges that youth are capable of understanding and analyzing the sources of power that structure their lives, a skill that is foundational to marginalized youth who would otherwise be denied this deconstructive tool. The Association for Experiential Education makes the link clear: “The social justice work that has been fundamental to women’s studies curriculums is considered an excellent addition to a curriculum utilizing experiential education” (Warren and Rheingold 1996, 119). It is the common interest in a shared, community-based goal that allows girls to find those skills that might otherwise be denied to them, for fear of traditionally masculine characteristics encroaching on their femininity. Girls

can be assertive leaders in a supportive, open environment founded upon shared passions or interests among many different students and community members. Ultimately, there is a focus on “three developmental concepts relevant to identity development: agency, social relatedness, and moral-political awareness” (Yates and Youniss 1996, 87). Service-learning benefits both genders while allowing girls to engage in activities that support positive identity development. The process of forming an idea, following through with it, and completing a reflection and follow-up activity is a clear example of agency that allows young people to imagine themselves as actors in an interconnected world.

By inviting young people to think critically about the conditions of their respective communities, girls can understand their own subjectivity as gendered, sexed, raced, and classed individuals in a collective, productive context that encourages the deconstruction of identity as a stratifying phenomenon. One can see that “youth who are marginalized by virtue of their identity find themselves disconnected from key institutions and social systems,” thereby precluding girls from taking a role in the dismantling of their own oppression (Delgado and Staples 2008, 20). This disconnect, however, can be repaired. Put succinctly, “addressing these forces through consciousness raising and social action is critical to engaging and sustaining marginalized youth,” though this end need not be accomplished through the explicit taking on of gender inequality, since that approach has the capacity to deepen divides (Delgado and Staples 2008, 20). In order to satisfy both gender theory and educational practice, one cannot divide boys and girls and have them look at boys’ issues and girls’ issues as separate entities. Instead, children can learn to adopt a critical eye for their environment, with all its successes and inequities, and move forward together to make a difference. In this way, service-learning can certainly be utilized as a means to address the gender gap that has characterized the American public education system in such a way that theorists and practitioners have their needs met. By offering girls and boys an opportunity to work together in the common aspiration for self-esteem, competency, and high-quality relationships, schools can create an environment that fosters learning for both genders without denying the subjectivity of either. Nontraditional education models also satisfy the critiques of the institution of gender brought forth by academics. The assertion that gender is both a performance and a manifestation of power relations can, in fact, be reconciled with applied education principles through enrichment activities. These experiences are, in a sense, blind to gender insofar as they allow for the productive coexistence of both genders in educational contexts, but they also allow for an individualistic, personal approach to youth development that cultivates a multiplicity of identities.

### A Way Forward

Of course, the feasibility of this project is unsteady, as schools become increasingly beholden to standards and test scores in pursuit of funding. Policy makers, educators, and academics need to work together to ensure the inclusion of these transformative experiences in public schools if substantive change is to take place. Still, the recognition of the essential place of identity in the reformulation of education in the United States paves the way for new ways of thinking about the role of knowledge in an intersectional world. Wide-ranging reform involving all those

who structure knowledge production and youth development can provide an impetus for the elimination of gender disparities. My intervention is by no means an exhaustive one. The consideration of transnational and queer critiques must take place in order to complete what is certainly a complicated and rewarding topic.

### Acknowledgements

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William J. Simmons is a junior at Harvard University concentrating in History of Art and Architecture and Studies of Women, Gender, and Sexuality, with a focus in LGBTQ Studies. He is also a Mellon Mays Fellow and a Carol K. Pforzheimer Fellow at the Schlesinger Library/ Radcliffe Institute for Advanced Study. His current research includes the Downtown New York City punk and art scene, as well as early 20th century farm women in the 4-H Youth Development Program. As a Summer Study Scholarship recipient at the University of Cambridge, William studied the archive of the British painter Elisabeth Vellacott.

# The Effects of Three Species of Macroalgae on *Acropora Aspera* Physiology

Alex Ritchie

Stanford University

## Abstract

The recent decline of coral reef cover has been associated in many cases with an increase in algal biomass. Macroalgal blooms are common in nutrient enriched waters, and can often outcompete coral. This experiment considered the effects of three species of macroalgae on the physiology of the branching coral *Acropora aspera* on a reef flat in the southern Great Barrier Reef. Samples of *A. aspera* that were in direct contact with the macroalgae *Hypnea* sp., *Padina* sp., or *Colpomenia* sp. were collected and studied. The effects of the macroalgae on *A. aspera* physiology were analyzed using measurements of protein concentration, dinoflagellate density, and chlorophyll a concentration. The experiment revealed that direct contact with any of the three species of macroalgae resulted in reduced protein concentration in *A. aspera*. Contact with macroalgae also impacted the density of dinoflagellates and chlorophyll a concentration in *A. aspera*, but the effects varied between each of the three species of macroalgae. These changes in coral physiology may suggest that *A. aspera* has the ability to adapt to competition and abrasion by macroalgae. Furthermore, these results suggest that the effects of macroalgae on coral physiology is variable and dependent on the species involved. Physiological changes could potentially lead to a decline in the coral reef's structure and functioning, which represents a significant loss of biodiversity and economic value.

Coral reefs increasingly face a number of threats including climate change, ocean acidification, overfishing, and eutrophication (Hoegh-Guldberg et al. 2007). Due to a number of these threats, coral reefs have experienced a distressing decline in the past several decades, associated in many places with an increase in algal biomass (McCook 1999). Accordingly, the loss of live coral cover is often associated with a phase-shift from a coral-dominated community structure to a fleshy algae-dominated ecosystem (McCook 1999; Done 1992).

There are many ways that this community shift can happen, and controversy exists over the relative importance of different factors in contributing to change (Jompa & McCook 2002). According to the bottom-up model, nutrient enrichment of coral reef areas results in an increase of benthic algae, which can grow quicker than coral in large blooms and outcompete coral for resources, leading to reef degradation (Lapointe 1997). In the top-down model, herbivory keeps macroalgae biomass in check and allows the coral-dominated community to persist (McCook 1999). Furthermore, disturbance events like bleaching can lead to a community shift because coral cover grows at a slower rate

after a disturbance event and competitive interactions with macroalgae become more frequent (Hoegh-Guldberg et al. 2007). The health of corals has come under more scrutiny particularly because of incidences of bleaching, which has been linked to heat stress (Brown 1997). Thus, knowledge of coral physiology and coral-algae interaction is becoming increasingly relevant to understanding how corals can recover from stress events.

Previous studies have shown that a number of algae species have negative effects on coral health and physiology (McCook et al. 2001; Jompa & McCook 2003; Nugues et al. 2004). For example, coral tissue mortality may be strongly affected by the presence of competing macroalgae (Jompa & McCook 2002). However in some cases, coral has been shown to actually overgrow and displace algae (McCook 2001), while in other cases the algae has no significant impact on the coral (Jompa & McCook 2003). It seems the impact of macroalgae on coral is dependent on both the coral and algae species, and that the competition between the two is highly variable, sometimes showing very little to no effect.

Despite the importance of understanding coral-algal competition and the phase-shifts in community structure, there has been very little previous experimental research on quantifying this interaction. Past studies have focused on the impact of herbivory or nutrient enrichment on algal growth and resulting competition with corals, but few quantify the effects of algae on coral physiology to measure the possible competition between the two (McCook et al. 2001). This paper seeks to use a natural experimental design to investigate the effects of three species of macroalgae on the physiology of *Acropora aspera* on a reef flat in the southern Great Barrier Reef. *Hypnea* sp., *Padina* sp., and *Colpomenia* sp. were chosen to study because they represent some of the most common and well-established macroalgae species on an intertidal reef flat. Thus, it is beneficial to see what effect, if any, they are having on a coral-dominated ecosystem. Specifically, this paper examines how direct contact with *Hypnea* sp., *Padina* sp., and *Colpomenia* sp. affect chlorophyll a concentration, tissue thickness, and dinoflagellate density of *A. aspera* at Heron Island.

## Materials and Methods

### Collection of samples

Heron Island is part of the Capricorn Bunker group of the southern Great Barrier Reef, Australia. The island is approximately 70 km from the mainland. The study site on the reef flat remains submerged at low tide, with the exception of the tops of some coral colonies that are exposed for a few hours of the tide. Forty *Acropora aspera* branches were collected from separate colonies on the reef flat. Ten of these samples were control treatments

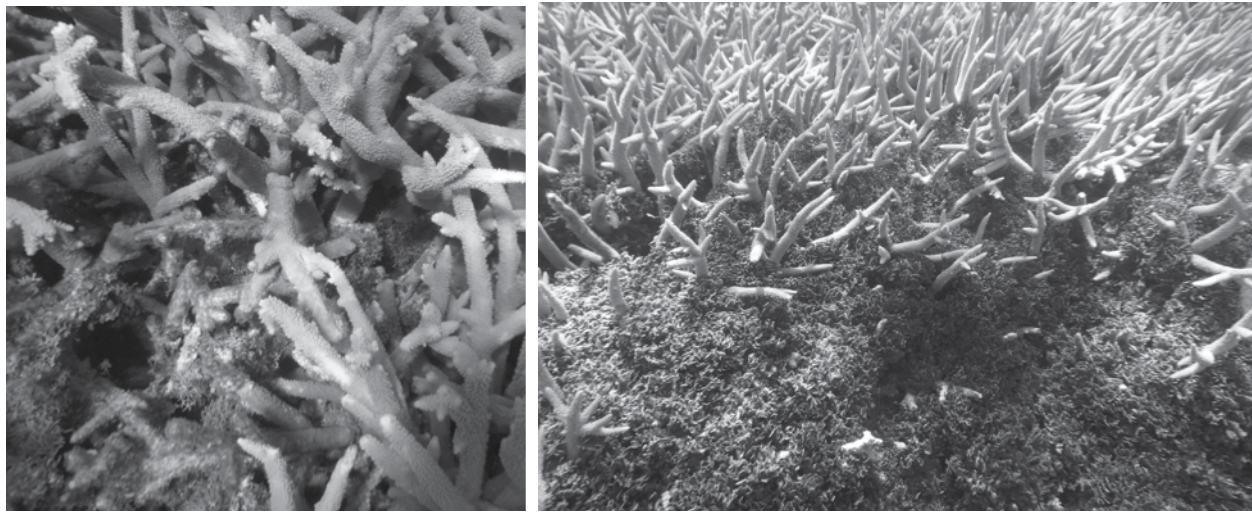


Fig. 1. Examples of well-established macroalgae in contact with *Acropora* sp. On the left, the algae is *Hypnea* sp., and on the right the algae is *Halimeda* sp.

from colonies that were not in close proximity to any macroalgae. Ten samples were in direct contact with *Hypnea* sp., ten samples were in contact with *Padina* sp., and ten samples were in contact with *Colpomenia* sp. *Hypnea* spp. is a red algae with thin stipes and feathery branches. *Padina* spp. is a brown algae that is lightly calcified and has a fan-shaped thallus. *Colpomenia* spp. is a non-calcareous brown algae that is mostly hollow. "Contact" was defined as algae that was growing very close nearby and was among the branches of *A. aspera*, physically touching the selected samples of branches (Fig. 1). Samples were chosen only from colonies where the algae was well established or had a holdfast so as to avoid the case where a dense ball of macroalgae may have been pushed near the coral by the tide and would not have been in direct contact long enough to have any physiological impact on the coral.

Coral tissue was blasted from each skeleton with fine jets of 50 mL of filtered seawater using a Water Pik, which is a dental device originally designed for cleaning particles from between teeth. Water piking has become a standard way of removing coral

tissue from the skeleton in order to measure biomass (Rohannes & Wiebe 1970). The collected water and tissue suspension was abaaaasdthen centrifuged (4500 X g for 5 minutes).

**Protein concentration**

Supernatant from the coral tissue and seawater mixture was prepared in a 1:25 dilution with filtered seawater. Protein measurements were determined following the method of Whitaker and Granum (1980). A spectrophotometer measured the absorbance of each sample at both 235 and 280 nm. The difference in absorbance between the two wavelengths was used to determine protein concentration, which was standardized to coral surface area (cm<sup>2</sup>).

**Dinoflagellate density**

The remaining supernatant from the coral tissue and seawater mixture was removed. The pellet was resuspended in up to 10 mL filtered seawater and vortexed. 1 mL of the pellet was used for dinoflagellate density determination following the method Dove et al. (2006), which was standardized to coral surface area (cm<sup>2</sup>).

**Chlorophyll a concentration**

The remaining liquid was centrifuged (4500 X g for 5 min). The seawater supernatant was discarded and the pellet was resuspended in 3 mL 90% acetone. The sample was placed in a sonicator for 15 min, then centrifuged (4500 X g for 5 min). The acetone/chlorophyll supernatant was collected. The chlorophyll extraction of the pellet was repeated with 3mL acetone until the acetone was clear. A spectrophotometer measured the accumulated acetone/chlorophyll extraction for chlorophyll a concentrations at 630 and 663 nm. Chlorophyll a concentration was determined following the method of Jeffrey and Humphrey (1975), which was standardized to both coral surface area (cm<sup>2</sup>) and dinoflagellate count (per million zooxanthellae).

**Coral surface area**

Protein concentration, dinoflagellate density, and chlorophyll a concentration were standardized by surface area of the coral branch. The coral branch was dipped in wax twice instead of once

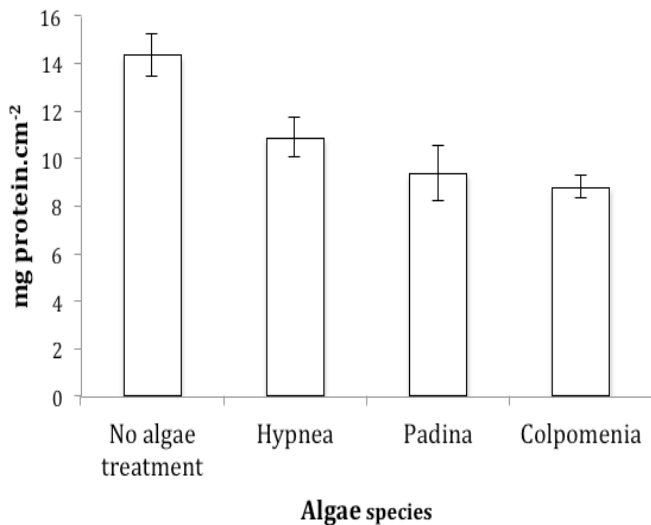


Fig. 2. Protein concentration of *Acropora aspera* tissue that was growing in close proximity to different algal treatments on the reef flat at Heron Island (n = 40). Error bars are standard errors.



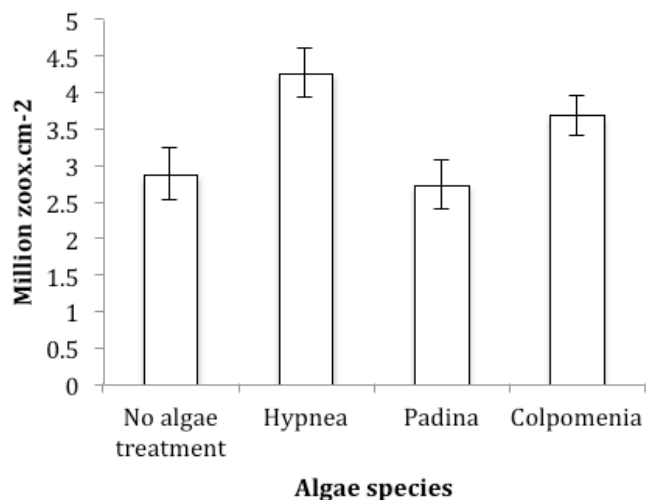


Fig. 3. Density of symbiotic dinoflagellates (zoox) in *Acropora aspera* that was growing in close proximity to different algal treatments on the reef flat at Heron Island (n = 40). Error bars are standard errors.

in order to give a better indication of the original surface area of the tissue (Crawley et al. 2010). The increase in mass due to the second layer of wax was calculated and surface area of the coral branch was determined using the modified melted paraffin technique of Stimson and Kinzie (1991).

#### Statistical analysis

A two-tailed t-test was used to compare individual algae treatments to the control. STATISTICA software was used for a one-way analysis of variance to compare protein concentration, dinoflagellate density, and chlorophyll a concentration between algal treatments.

## Results

### Protein Concentration

The protein concentrations of all three algae treatments were significantly lower than that of coral in no direct contact with macroalgae ( $p = 0.0004$ ) (Fig. 2).

### Density of symbiotic dinoflagellates

The density of symbiotic dinoflagellates of all three algae treatments was significantly different than that of coral in no direct contact with macroalgae ( $p = 0.006$ ) (Fig. 3). The density of symbiotic dinoflagellates in the *Hypnea* sp. treatment was significantly higher than that of the control treatment and the *Padina* sp. treatment. The density of symbiotic dinoflagellates in the *Colpomenia* sp. treatment was significantly higher than that of the *Padina* sp. treatment.

### Chlorophyll a concentration

Chlorophyll a concentration was standardized to both coral surface area and density of dinoflagellates. The *Padina* sp. treatment had significantly more chlorophyll a per dinoflagellate than all other treatments ( $p = 0.004$ ) (Fig. 4). However, there was no significant difference between the concentrations of chlorophyll a across surface area of different treatments ( $p = 0.520$ ) (Fig. 5).

## Discussion

Direct contact with any of the three algae treatments resulted in reduced protein concentration in *A. aspera*. Protein concentration is used as a proxy for tissue thickness so algae contact seems to reduce tissue thickness. These results are consistent with those from the experimental design of a concurrent study using the same macroalgal and coral species as this study and following the randomized controlled trial method from Smith et al. (2006) (Nicholas, unpublished data). They are also consistent

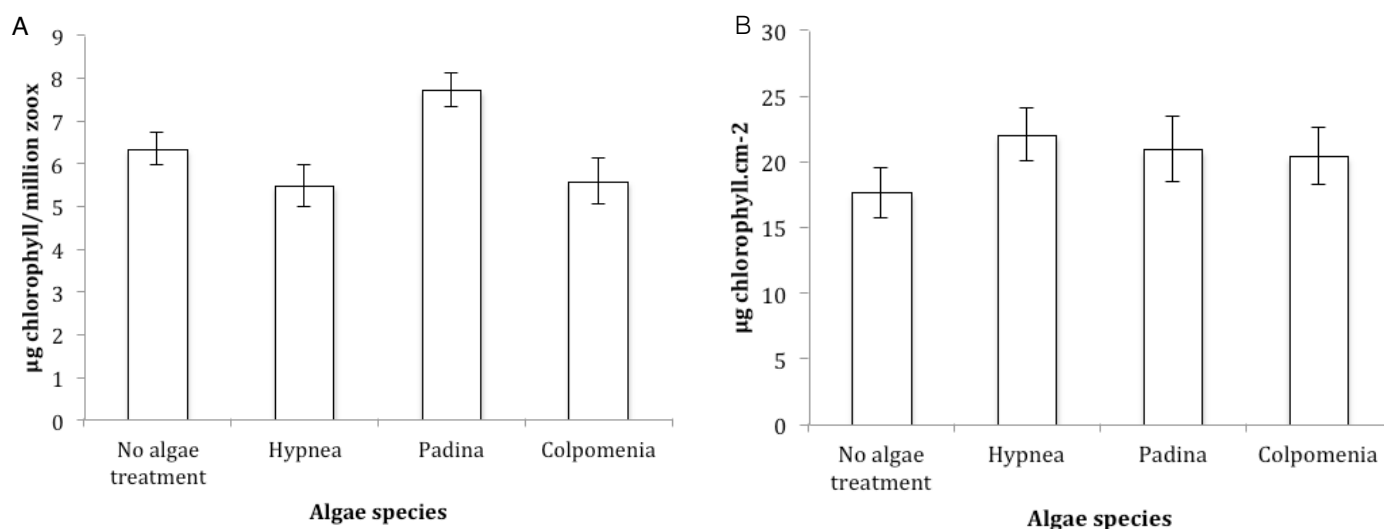


Fig. 4. (A) Concentration of chlorophyll a per million dinoflagellates in *Acropora aspera* that was growing in close proximity to different algal treatments on the reef flat at Heron Island. (B) Concentration of chlorophyll a over tissue surface area of *Acropora aspera*. (n = 40). Error bars are standard errors.

with the findings of Quan-Young & Espinoza-Avalos (2006) that *Montastraea faveolata* had reduced tissue thickness when it was competing with mixed turf algae. It is suggested that this was due to the stress imposed on the coral by the nearby competing algae. A loss of tissue may make it difficult for corals to meet their energy requirements to stay healthy, which forces the coral to spend more energy on maintenance. Reducing the energy available for reproduction and growth potentially makes the coral more susceptible to other threats in the future.

Algae also had an effect on the density of dinoflagellates and chlorophyll a concentration in *A. aspera*. The *Hypnea* sp. and *Colpomenia* sp. treatments had higher density of dinoflagellates across their surface area than that of the *Padina* sp. treatment. However, they had less chlorophyll per zooxanthellae in comparison to the *Padina* sp. treatment. These results suggest that the *Hypnea* sp. and *Colpomenia* sp. treatment corals were trying to adapt to the competition for sunlight by increasing their number of dinoflagellates. At the same time, their general health may have been decreasing because of the stress of competing algae and the reduced amount of energy, so each dinoflagellate had less chlorophyll a. In some cases, corals have been shown to reduce their dinoflagellate density in response to stress (Brown 1997; Quan-Young & Espinoza-Avalos 2006). However, this is usually in the case of extreme stress when the coral no longer provides a suitable environment for its symbiotic dinoflagellates. In this study, the macroalgae does not seem to be posing enough competition to reduce dinoflagellate density. In fact, it seems more adaptive for the coral to increase the number of dinoflagellates as a coping mechanism.

On the other hand, the corals in contact with *Padina* sp. seem to try and cope by increasing the amount of chlorophyll a in each zooxanthellae in hopes of absorbing more light to use for energy in order to compensate for shading by the algae. A concurrent experimental design using the same study species supports this finding (Nicholas, unpublished data). When compared to the response of the *Hypnea* sp. and *Colpomenia* sp. treatments, these results suggest that different species of macroalgae can have different impacts on the physiology of the same coral species. Bender et al. (2012) similarly proposes that the effects of macroalgae on coral regeneration is variable and dependent on both species involved.

The concentration of chlorophyll a by surface area did not significantly change in any of the algae treatments even though we did see changes to the dinoflagellate density and the chlorophyll a concentration per dinoflagellate. Even though the corals were trying to adapt, it appears that they were probably not healthy enough to significantly increase the total amount of chlorophyll a across their surface area.

Previous studies have suggested several potential mechanisms for competition between corals and algae such as shading, abrasion, and allelochemical secretions (McCook et al. 2001; Jompa & McCook 2003). The fan-shaped thallus of *Padina* sp. gives it more surface area available to absorb sunlight, possibly helping it compete with the *A. aspera* by shading the coral. *Hypnea* sp. is thin and is often found tightly wrapped around the branches of *A. aspera*, possibly causing abrasion of the coral tissue as well as shading from sunlight. The large bubble-shaped thallus of the *Colpomenia* sp. may also contribute to shading of the coral.

Once a coral starts to lose both dinoflagellates and chlorophyll, it is likely the coral will die due to a lack of sufficient energy. The

results of this study show that the *A. aspera* are not yet dying, though they are showing signs of stress. It is reassuring to know that this species can adapt to stress from algal competition and hopefully survive.

This study was limited by its natural experiment design because there were confounds from the environment, such as herbivory and water flow, which could not be completely controlled as they can be in an randomized controlled study. Furthermore, the study was limited by time because there were only three days available for the coral physiology measurements. Given more time, more samples could have been collected and measured to better capture the true interaction between *A. aspera* and the three species of macroalgae. A natural experiment is also limited by the presence or absence of certain species in the environment. The three study species of macroalgae were chosen because they were the three most common species found living in close association with *A. aspera*. For this reason, they were useful and important species to study. However, there were other species of macroalgae present on the reef, such as *Chlorodesmis* sp. and *Halimeda* sp., which would have also been useful to study had they been found in contact with *A. aspera* more frequently. While it would have been interesting to study their impacts on *A. aspera* in the field, perhaps their absence around *A. aspera* is significant and would be useful to study in future research.

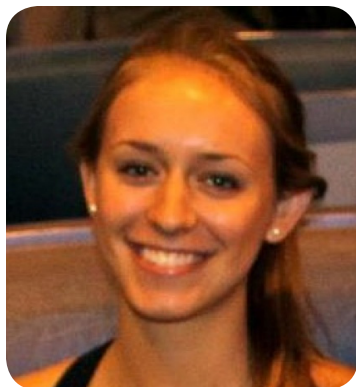
The benefit of a natural design and the reason for choosing it for this study is the long treatment time it allows. The algae in this study had been growing naturally around the coral on the reef flat, possibly for years, giving plenty of time for the algae to potentially influence physiological factors in the coral. In experimental designs such as those used in Smith et al. (2006) and Nicholas (unpublished data), the interaction between coral and algae is manipulated by physically tying different combinations of the two together. However, coral health was measured after just 4 days, which may miss the potential evidence of the coral adapting physiologically over time. Despite these differences in study design, the same interaction between coral and algae was observed in this study and Nicholas (unpublished data), strengthening the results of both studies.

Overall, the competition between algae on coral is important to study as anthropogenic factors increasingly threaten coral reefs. Expanding coastal development leads to sediment runoff and nutrient enhancement in freshwater systems, a portion of which eventually make their way to the ocean and are believed to cause an increase in bent algae and consequent reef degradation (Lapointe 1997). Reductions in seawater pH, rising temperatures, and overfishing may change not only coral physiology but also algae physiology (Bender et al. 2012). We need to understand how these human impacts will affect algae growth in coral reef communities and how this may influence the coral reef's structure and functioning. If a community shift does occur, algal-dominated communities not only represent a loss in biodiversity but also represent a loss in economic value because they usually have lower fish stocks and less tourism appeal (McCook 1999). Furthermore, coral reefs provide vital ecosystem services to humans through fisheries and coastal protection by wave attenuation (Hoegh-Guldberg et al. 2007). The results of this study emphasize how critical it is to understand the interaction between specific coral and algae in order to recognize how degraded reefs could potentially recover and become coral-dominant once again.



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Alex Ritchie is a junior at Stanford University studying Human Biology. She is particularly interested in genetics, disease, and biotechnology. She also enjoys running, music and doing anything in the outdoors. Alex recently returned from studying abroad in Australia, and is now exploring her research interests back at Stanford. She is considering various graduate school opportunities for the future and ultimately hopes to work in biotech or healthcare.

# Effects of Pax-4 on Beta-Cell Differentiation in C57/BL6 Mus Musculus

Noam Rosenthal

Stanford University

## Abstract

Diabetes Mellitus is a pandemic disease that affects 250 million people worldwide, and is characterized by defects in insulin secretion and insulin action, resulting in chronic hyperglycemia. Islet Transplantation has been viewed as a potential curative treatment to replace traditional insulin injections in addressing Type 1 diabetes. However, a shortage in the supply of islets from donors remains a setback in the widespread implementation of this treatment. Pluripotent human embryonic stem cells have been viewed as a potential solution to this cell scarcity given their ability to differentiate into insulin producing beta-cells. Protein Transduction, a novel technology that allows for the insertion of a biomolecule into the cellular cytoplasm through an 11amino acid Protein Transduction Domain (PTD), is seen as a viable mechanism for initiating cell differentiation. In this study, a novel protocol for recombinant protein purification was developed to transduce a known transcription factor, Paired Box Gene 4 (Pax-4), into pancreatic buds of embryonic Mus musculus in vivo. When compared to controls, our results show that treatment with PTD-Pax-4 induced an increased expression of key genes that regulate pancreatic endoderm maturation. These outcomes suggest that this treatment may be used to increase production of insulin producing cells in vivo.

Diabetes Mellitus is a pandemic disease that affects 250 million people worldwide, a number expected to reach 380 million by the year 2025 (1). Diabetes manifests itself in two major forms, known as Type 1 and Type 2 diabetes. The latter is the most common form of the disease defined by insulin resistance and insulin hyposecretion that inhibits glucose regulation in the body (2). Type 2 diabetes is known to be caused by poor health standards; fortunately healthy diet and exercise have been proven to help reverse the mentioned symptoms in many instances (3). Type 1 diabetes, involves an idiopathic autoimmune response of the body that targets insulin producing beta-cells in the Islets of Langerhans, resulting in chronic hyperglycemia in humans (4).

Management of Type I diabetes through insulin injections is the current standard of care. However, the necessity for daily injections and daily glucose monitoring prohibits a normal lifestyle for diabetics (5). Recently, an alternative treatment, islet transplantation, has emerged as a potential curative treatment for diabetes, shown to reverse the symptoms of the disease, and potentially ensure insulin independence for more than 5 years (6). In the past three decades scientists have witnessed tremendous progress in islet transplantation technology, due to inventions

such as the Ricordi chamber, which enables the automated isolation of transplantable islets (14). Furthermore, the discovery of new immunosuppressive drug therapies has reduced post-transplantation complications and increased treatment efficacy. Despite these achievements, the literature suggests that still only 10% of islet recipients are able to maintain insulin independence for a period greater than 5 years, warranting the need for additional transfusions and a greater supply of transplantable islets (13).

Given their ability to differentiate into any cell type and propagate infinitely in cell cultures, human embryonic stem cells are an excellent candidate to provide an unrestricted supply of islets. Additionally, recent research has uncovered the major transcription factors involved in the differentiation of a stem cell into an insulin producing beta-cell (7). However, due to the extreme physiological and biological complexity of stem cells, current technology is unable to reproduce, in vitro, the environmental factors necessary to initiate differentiation (16).

This research focuses on a novel approach to induce differentiation through protein transduction, a powerful technology based on the fusion of a protein of interest to a small cationic 11 amino acid PTD. Proteins attached to a PTD can penetrate cell walls and be “dropped off” within the cell cytoplasm, serving as transcription factor promoters within the cell (11). It is believed that one can induce differentiation of a certain cell fate, by introducing the correct set of transcription factors in stem cells. Studies in a diabetic model have demonstrated the ability of PTDs to transduce anti-apoptotic proteins into physiologically stressed islets thus preventing apoptosis (11). Furthermore, many known transcription factors associated with endocrine tissue formation have been transduced into embryonic stem cells resulting in increased endocrine differentiation (8).

The transcription factor Pax-4 is a key gene in endocrine development. This study observes the effects of PTD-mediated Pax-4, a known beta-cell transcription factor, on cell differentiation in vivo. Pax-4 has been shown to be an influential transcription factor in the final stages of beta-cell differentiation (10). This study utilized the Trans Activator of Transcription PTD (TAT), which is derived from the HIV virus and has been shown in previous studies to successfully transduce mammalian cells (9). In this study Pax-4 was purified and injected into embryonic C57/BL6 Mus musculus. This report describes advancements made in the purification of transducible Pax-4 in addition to elucidating its function as an endocrine transcription factor in vivo.

## Materials and Methods

### Protein Purification

Positive TAT-Pax-4 transformants were cultured in LB broth

for 24 hours and then induced with  $\beta$ -D-1-thiogalactopyranoside (IPTG). After incubation, the culture was harvested, pelleted, and washed with 10mL of PBS.

Starting and elution buffers at 30mM and 400mM respective imidazole concentrations were prepared in PBS containing 2mM  $\beta$ -Mercaptoethanol. The bacterial sample was incubated with a Protease Inhibitor Cocktail in addition to Lysozyme and Benzamide (Sigma-Aldrich). The treated sample was incubated on ice for 40 minutes. After incubation the sample was sonicated at 49% amplitude for 2 minutes and 55 seconds. Following sonication, the sample was pelleted, and the remaining supernatant containing the protein was inserted into an ÄKTA™FPLC™ chromatogram using a 6-His Tag affinity column (Amersham/GE Healthcare). The pumps and column were washed with water and ethanol, and then equilibrated with the 5mM imidazole starting buffer. The protein was injected into the affinity column at 0.7ml/min. Four washes were performed before eluting the protein with the 400mM imidazole elution buffer at a speed gradient of 0.5-3.5ml/min. The protein fractions were then passed through a PD-10 desalting column to remove all remaining reagents. Sample concentrations were then determined using electronic electrophoresis.

### Protein Labeling

Purified TAT-Pax-4 was labeled using the Alexa Fluor 568 Protein Labeling Kit (Invitrogen) as per manufacturer instructions. The labeled protein was then added at a concentration of 10ug/mL to a cell culture of human cord blood cells for 3 hours at 37°C.

### Electric Mobility Shift Assay (EMSA)

An EMSA was performed using the Pierce LightShift Chemiluminescent EMSA Kit according to manufacturer's instruction. The Pax-4 Probe Set used in the experiment was provided by Panomics and is commercially available. Control reactions were carried out according to manufacturer recommendations. Reactions containing Pax-4 substrate (1.5ug/ul) were prepared with the provided 10X Binding Buffer and 1ug/ul Poly (DI\* dC).

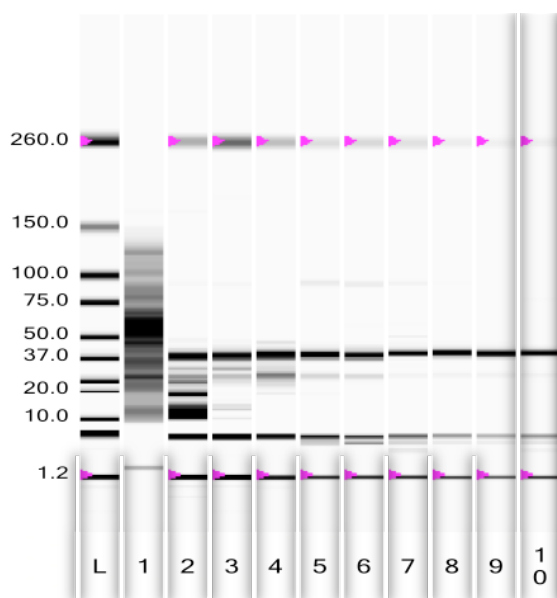


Fig. 1. Automated electrophoretic system reading. Lanes 1-7 represent column washes. Lanes 8-10 contain protein elution.

### Western Blot

Protein samples were run on a 10% Lonza SDS- PAGE Gold Tris-Glycine Precast gel (150V, 230mA, 45mins) at different volumes and transferred onto a nitrocellulose membrane. Rabbit Polyclonal IgG Pax-4 antibodies (Santa Cruz Biotechnology) were applied and used at a 1:250 dilution. The membrane was developed using the Fast Western Blot Kit (Pierce Thermo Scientific).

### Protein injection and analysis

TAT-Pax-4 was injected into two sets of C57/BL6 mice. Embryos were injected at e15.5 with 2.18mg of protein. Two sets of controls were prepared and injected with 10ul of PBS containing 200uM imidazole. The weight of the mice used ranged from 31-35g. The mice were sedated and using an ultrasound all embryos were located and injected with the protein. Immediately after birth, the pancreases of the neonatal mice were extracted and prepared for RT-PCR

RNA extraction was done using the mirVANA Kit (Ambion) following the manufacturer's instructions, and cDNA was prepared at a final RNA concentration of 5ng/ul using the High Capacity cDNA Reverse Transcription Kit (Applied Biosystems, ABI) following the manufacturer's instructions. Real Time RT-PCR was done on a 7500 Fast Real-Time PCR System using Fast Universal Master Mix and primers from ABI.

### Results

#### HPLC protein purification results in highly pure protein sample

Protein purification is a very complex procedure and protocols must be optimized individually for every protein. Proteins can be expressed by bacteria in two main ways: in the cytosol as a soluble polypeptide or in particle crystal-like structures known as inclusion bodies (12). Each physiological form requires a different approach in regards to the purification and refolding of the protein. It was discovered that recombinant Pax-4 is located in the cellular cytoplasm and can be extracted without the use of harmful denaturants that are typically used for inclusion bodies. Following the injection of the sample into the column, multiple peaks corresponding to the amount of eluted protein were observed. A wash containing 10% elution buffer was performed eluting non-specifically bound biomaterial. Upon elution, 100% of elution buffer was pumped into the column resulting in a peak exceeding 2000 mAU (milli-absorbance unit) signaling the elution of TAT-Pax-4.

Samples were studied on an automated electrophoresis chip to observe sample purities. Results showed a gradual increase in purity with the most contamination present in wash samples (lanes 1-4). Following the elution of non-specifically bound material, 100% of the elution buffer was pumped into the column eluting a more pure and concentrated sample of TAT-Pax-4. This is evident in the chip reading, as lane 10 displays a single dense band along the 40kD marker that represents Pax-4.

#### Immunoblot analysis confirms the identity of the protein

A Western Blot was performed to confirm the protein's identity. For this purpose, a specific Pax-4 antibody (see Methods) was utilized. A band near the 40 kD marker would indicate a positive result.

Pax-4 sample was added to four wells at decreasing volumes of

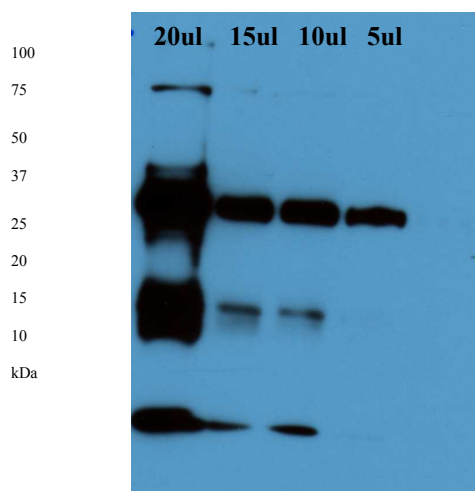


Fig. 2. Western Blot. Dark bands along the 40kD provide biological confirmation of Pax-4.

20uL, 15uL, 10uL and 5uL, respectively from left to right. The protein immunoblot results show the presence of a strong band at the 40kD marker, confirming that the purified protein is indeed Pax-4 (Figure 2).

#### EMSA assay confirms protein functionality

To characterize the protein-DNA binding interaction of purified TAT-Pax-4, an EMSA assay was performed. Based on protein interaction with probe DNA sequences, one can determine functionality based on a band shift that indicates a proper reaction on an electrophoresis gel.

In this experiment a band “shift” in lane 5 was observed confirming the successful binding of the Pax-4 Probe to the protein substrate (Figure 3). The sixth lane containing the Cold Pax-4 Probe successfully competed with the target Pax-4 Probe inhibiting the intended reaction. These results confirm functionality of purified Pax-4.

#### Protein labeling exhibits transduction capacity

To address the capacity of the purified TAT-Pax-4 to permeate cellular membranes, the protein was labeled with a fluorescent marker and culture images were acquired after incubating for two hours. The treated cells displayed a strong fluorescence at a wavelength of 568 nm. Almost 100% of the cells demonstrated an uptake of the TAT-Pax-4. This confirms the functionality of the TAT-Pax-4 in permeating cord blood cell membranes (Figure 4).

#### Pax-4 treatment increases the expression of pancreatic endoderm maturation genes

Despite several recently published reports on pancreas development and maturation, the roles of certain transcription factors remain to be fully identified. Pax-4 has been identified as one of the key transcription factors in pancreatic development. However, a detailed study evaluating how the protein will affect the genetic profile of pancreatic development and function genes (e.g. insulin release) has yet to be determined.

To address these questions, an in vivo set of experiments was performed by injecting lab mice with a pure, concentrated sample of recombinant TAT-Pax-4. Control animals were treated with

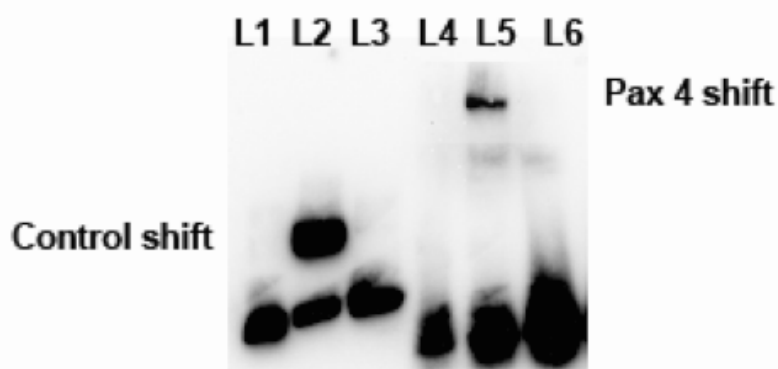


Fig. 3. Pax-4 EMSA. Samples were processed and assay was carried out as per manufacturer instructions.

equivalent volumes of an imidazole buffer devoid of protein. A total of 40 genes were studied using RT-PCR. TAT-Pax-4 treated embryonic Mus musculus RNA was compared to buffer injected controls. 18S rRNA was used as an endogenous control for the experiment. The 40 gene array was analyzed and up-regulation and down-regulation of multiple genes was observed. Insulin-1 and Insulin-2 (Ins1&2), two marker genes related to beta-cell differentiation were up-regulated approximately 1.5 fold (Figure 5), although this increase was not statistically significant. Glucose blood-level raising hormones, particularly Glucagon (GCG), displayed an even greater expressional increase, approximately 1.75 fold. Glucose monitoring enzymes such as Glucokinase (GcK) also exhibited a moderate increase in expression. Gata-4 a protein related to endoderm differentiation was also up-regulated, indicating greater genetic expression for pancreatic development (data not shown). Additional genes such as Slc2a2, which has been shown to be directly related to proper insulin secretion and beta-cell plasma membrane development, increased in expression as a result of Pax-4 injection substantially, approximately 8 fold. Pcsk1,

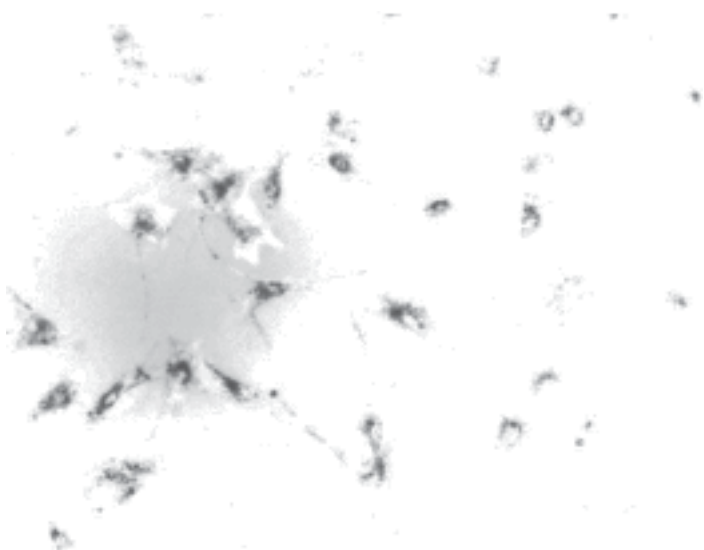


Fig. 4. Protein Labeling. Dark areas within the cell represent successfully transduced and labeled TAT-Pax-4

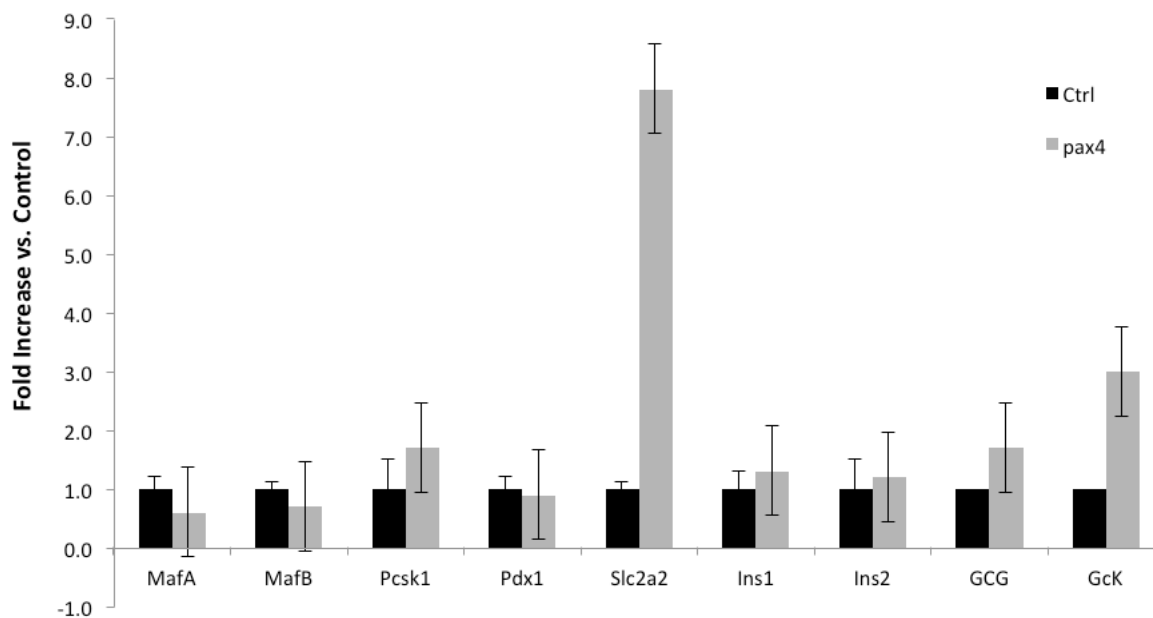


Fig. 5. RT-PCR results. Pax-4 vs. Control

a protein involved in insulin biosynthesis, was also observed to have increased expression.

In spite of these results, three genes considered to be integral transcription factors in beta-cell development, Pdx-1, MafA, and MafB, were down-regulated. Another gene, Arx, known to inhibit Pax-4 function, was up-regulated in injected mice.

## Discussion

Protein purification requires repeated trial and error (results discussed and analyzed in this paper constitute only a small portion of a total number of trials) to find the adequate buffer concentrations, pH, and elution rate. The results obtained in this study mark significant progress in the purification of TAT-Pax-4 and culminate with a successful isolation of a relatively pure protein at a workable concentration. FPLC protocols were optimized and all toxic reagents were removed successfully using PD-10 desalting columns. Furthermore all biological and functional assays were performed successfully indicating proper function of both the protein and the TAT-PTD.

Additionally 15 embryos were successfully treated with TAT-Pax-4 and were processed for genetic profiling. The analyzed genes are associated with final maturation and fully differentiated pancreatic tissue. A total of 40 genes were successfully analyzed to determine the effects of Pax-4 on genetic expression in embryonic C57/BL6 Mus musculus. While multiple beta-cell related genes were up-regulated, others were down-regulated. Additionally

multiple genes associated with alpha-cell development were up-regulated. A larger n will be necessary to draw meaningful, statistically significant conclusions. Thus the experiments were not definitive and will be repeated for further genetic and functional analysis. Studies of glucose stimulated insulin secretion will be performed to assess the actual pancreatic activity of the embryos in vivo. However, notwithstanding certain irregularities, the data does indicate an increase in pancreatic endocrine tissue maturation as multiple genes associated with cell structure development and islet cell hormones were expressed in all cases.

This paper marks the first experiment in a set of experiments to be performed using Pax-4 as a beta-cell differentiation transcription factor. In the future, the effects of Pax-4 in conjunction with other assisting proteins will be analyzed. Additionally, the effect of protein amount and time of injection will be observed in order to gain a better understanding of the effects of Pax-4 on beta-cell differentiation in C57/BL6 Mus musculus. Finally, although preliminary, these results are very promising. They suggest that a transcription factor can be successfully delivered into embryos and that the treatment leads to up-regulation of several key genes to the maturation of the pancreas. This suggests a window of opportunity to intervene and increase both alpha and beta-cell maturation despite down-regulation of certain genes. The results obtained from this set of experiments shed light on many unanswered questions related to pancreatic development and beta-cell differentiation.



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Noam Rosenthal is a sophomore who intends to declare a major in Atmosphere/Energy. In his free time he sings with his a cappella group Mixed Company and gives tours of Stanford to campus visitors. He is also a proud resident of Columbae, where a fellow resident encouraged him to submit his work to SURJ. He is excited to share his findings with the Stanford community and hopes it helps to raise awareness about exciting new diabetes treatments currently in development.



# The Effects of Wave Exposure and Tidal Height on Rocky Intertidal Community Dynamics

Matt Higgins

Stanford University

## Abstract

Rocky intertidal ecosystems are impacted by many different abiotic and biotic factors. Specifically, both wave exposure and tidal height have been shown to have strong effects on the dynamics of intertidal communities. Wave exposure and tidal height have long been shown to limit the ranges and abundance of intertidal organisms, although the relative importance of the two factors and the relationship between them has not been thoroughly examined. In this study, we set up vertical transects at two sites, one wave-exposed and one wave-protected, at the Hopkins Marine Station in the Monterey Bay National Marine Sanctuary. We found that the two sites contained similar levels of species abundance and richness except among mobile invertebrate populations. There was significantly higher mobile invertebrate abundance and species richness in the protected site compared to the wave-exposed site. However, we found no significant difference in mobile invertebrate species richness or abundance corresponding to variations in tidal height. As a result, we conclude that wave exposure is relatively more important than tidal height in contributing to mobile invertebrate abundance and species richness. Better understanding of community dynamics is essential to efficiently allocate resources to conservation efforts as we strive to protect our natural world.

In rocky intertidal ecosystems, species diversity and abundance can be strongly influenced by both biotic and abiotic factors. Our study focuses on two major abiotic factors: wave exposure and tide height. These factors can vary dramatically over a very short distance; a change of a few meters or hours can expose organisms to new challenges that can strongly limit the ranges and abundances of organisms living in the intertidal (1,2).

Species diversity is an important measure for communities because more diverse communities are frequently more stable and more productive (3,4). The intermediate disturbance hypothesis has long suggested that species diversity within a community should be greatest at an intermediate level of disturbance (5,6). In addition, in rocky intertidal communities, wave exposure has been shown to be a determining factor of species diversity (7). Organisms at higher elevations along an intertidal gradient experience greater desiccation stress (8), which can limit the range of organisms present (9). What is not as well understood is the relationship between these two factors — wave exposure and tidal height — or the relative importance of each one. It is crucial to fully understand community dynamics to determine where conservation resources can most efficiently be utilized.

In this study, transects were set up at two sites — one wave-exposed and one wave-protected — at the Hopkins Marine Station

in the Monterey Bay National Marine Sanctuary to investigate these questions. We originally hypothesized that the wave exposure at the exposed site would be an intermediate amount of disturbance, leading to higher species richness, as predicted by the intermediate disturbance hypothesis (5,6).

## Methods

### Data collection

We first selected two different sites — one wave-exposed and one wave-protected — in the rocky intertidal zone of the Monterey Bay National Marine Sanctuary. Working in a marine sanctuary allowed us to eliminate the threat of trampling, collecting, fishing and other factors that could unevenly affect the two communities. In addition, the proximity of the two sites normalized large environmental variables including average temperature and annual rainfall that would be identical at both sites. At each site we set up four 20m transects that ran perpendicularly away from the water, beginning at the water's edge. Our study was conducted at low tide on October 13, 2012. Species abundance and richness were measured using 1/3 square-meter quadrats that were laid to the left side (looking seaward) of each transect at even 5m intervals. The 5m intervals were designated as low (0m), low-mid (5m), medium (10m), mid-high (15m) and high (20m). For mobile invertebrate species, abundance was estimated by individually counting each organism that was found inside the quadrat. Percent cover was used to estimate the prevalence of sessile organisms and algal morphological types. Each quadrat contained 36 smaller squares of equal size and spacing. Percent cover was estimated by approximating the total number of squares that were covered by each sessile organism or algal morphological type and then multiplying that number by 2.77 (each square represented 2.77% of the total quadrat) to reach a final percent cover value. Species richness was determined for all types of organisms by recording every species found in each quadrat.

### Data analysis

After collecting our data, we performed statistical analyses in R. We ran two-way analysis of variance (ANOVA) tests on the effects of wave exposure, tidal height, and the interaction between these two factors on mobile invertebrate abundance, mobile invertebrate richness, algal species richness, and percent cover of sessile invertebrates between our two sites. Our data were log-transformed to better approach normality. We also ran unpaired T-tests for differences in algal species richness, algal percent cover, mobile invertebrate species richness, mobile invertebrate abundance, percent cover of sessile invertebrates, and on the Shannon Diversity Index (a measure of diversity that accounts for both species richness and their evenness) between the two sites.

2-Way ANOVA for Mobile Invert Abundance

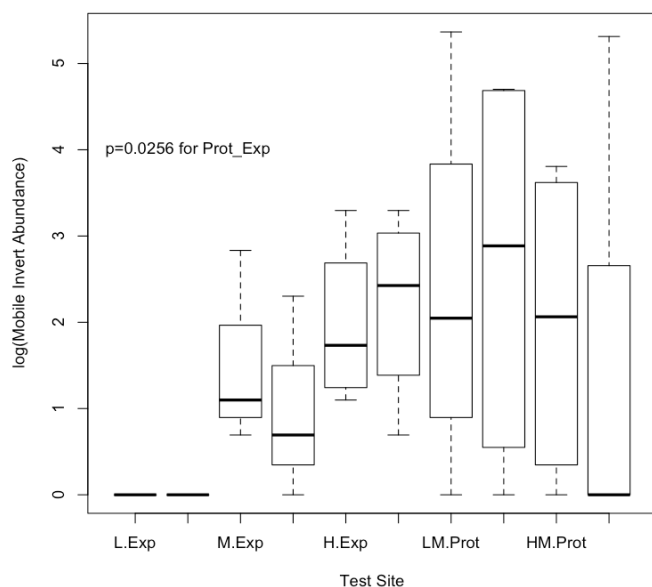


Fig 1. A two-way ANOVA test for the effects of wave exposure and tidal height on mobile invertebrate abundance. These data, combined with a post-hoc Tukey's test, demonstrated a statistically significant difference in mobile invertebrate abundance between exposed and protected sites ( $p=0.0256$ ). Tidal height had no significant effect on abundance, nor did any combined effects of both variables.

## Results

We found a statistically significant increase in mobile invertebrate abundance at the protected site compared to the exposed site due to wave exposure (Two-way ANOVA test,  $F = 5.533$ ,  $df = 14.70$ ,  $P = 0.0256$ , Fig. 1). A post-hoc Tukey's test confirmed that wave exposure was the determining factor in this significance ( $P = 0.0256$ ). Neither tidal height nor the interaction between wave exposure and tidal height were found to have significant effects on mobile invertebrate abundance. Wave exposure was also responsible for significantly more mobile invertebrate species richness in the protected site compared to the exposed site (Two-way ANOVA test,  $F = 5.44$ ,  $df = 1$ ,  $P = 0.046$ , Fig. 2). A post-hoc Tukey's test also confirmed that this variation was due solely to the difference in wave exposure ( $P = 0.046$ ) and was not due to tidal height or interactions between wave exposure and tidal height. There was no significant difference in algal species richness between the test sites (Two-way ANOVA test,  $F = 0.051$ ,  $df = 1$ ,  $P = 0.824$ ) or for percent cover of sessile invertebrate species (Two-way ANOVA test,  $F = 0.526$ ,  $df = 1$ ,  $P = 0.474$ ). Unpaired T-tests were also revealed that wave exposure had no significant effect on algal species richness ( $t = 3$ ,  $df = 3$ ,  $P = 0.057$ ), algal percent cover ( $t = 0.0651$ ,  $df = 5.586$ ,  $P = 0.9504$ ), mobile invertebrate species richness, ( $t = -1.5667$ ,  $df = 4.271$ ,  $P = 0.1878$ ) mobile invertebrate abundance ( $t = -2.4421$ ,  $df = 3.074$ ,  $P = 0.09028$ ), percent cover for sessile invertebrates ( $t = -0.6261$ ,  $df = 4.304$ ,  $P = 0.563$ ), or Shannon Diversity Index ( $t = -0.0453$ ,  $df = 3.487$ ,  $P = 0.9664$ ). The difference in algal species richness was marginally statistically significant, which warrants further investigation.

## Discussion

Our results show that the two sites did not have a significant difference in species richness, suggesting that wave disturbance is not a determining factor in an intertidal region's invertebrate species richness. We originally hypothesized that the protected and exposed sites would fall into categories of low and moderate disturbance, respectively, following the intermediate disturbance hypothesis model, and as a result there would be more species diversity at the exposed site (5). Additional studies are needed to quantify the amount of disturbance at each site. Furthermore, additional field sites in the same area would also be useful as points of comparison along the disturbance gradient.

There was, however, a significant difference in species richness between the two sites for one particular subset of organisms: mobile invertebrates. There was greater species richness among mobile invertebrates in the protected site. It may be that the wave stress at the wave-exposed site constituted high disturbance for this group of organisms. It has been shown that mobile invertebrates face increased risk of being dislodged from their environment by waves compared to sessile organisms (10). This makes it possible for the wave-exposed site to constitute high disturbance solely for mobile invertebrates — and therefore diminish this group's species richness — without the site having a lower species richness overall. Thus, wave-exposed sites may still have high overall species richness and may still have the high productivity and resilience that are associated with species-rich communities (3,4). Conservation efforts are most frequently targeted at areas with high species richness (11). Because overall species richness was still high in the wave-exposed site — irrespective of the low mobile invertebrate richness — these areas should remain targets for conservation programs.

We also found that mobile invertebrate abundance was greater at the protected site, a discovery that supported our hypothesis. This is an important finding for marine conservation efforts, as abundance and not simply species richness alone, is an important criterion in determining where to implement conservation programs (11). There are multiple possible explanations for this finding. One possibility is increased food availability at the protected site. Although there is some evidence that algae are more prevalent in areas with low disturbance regimes (12), our data show that the percent cover of algae was not significantly different between the two sites. More tests, such as a stable isotope analysis, are needed to determine the feeding behavior of mobile invertebrates at each site to see if there is a difference between the sites.

Another possible explanation is increased mortality at the exposed site caused by strong wave stress. As stated above, mobile invertebrates have a higher risk of being washed away by waves because they are not attached to a substrate (10), suggesting that increased mortality at the exposed site could be an important factor explaining the difference in mobile invertebrate abundance.

It is also possible that there is a difference between the two sites in the size of individual mobile invertebrates. Etter 1989 showed the intertidal snail *Nucella lapillus* had mortality rates that were positively correlated with increasing size in wave-exposed sites (13). With many of the larger organisms being washed out by waves, a community's average organism size at a wave-exposed site is likely smaller than the average organism

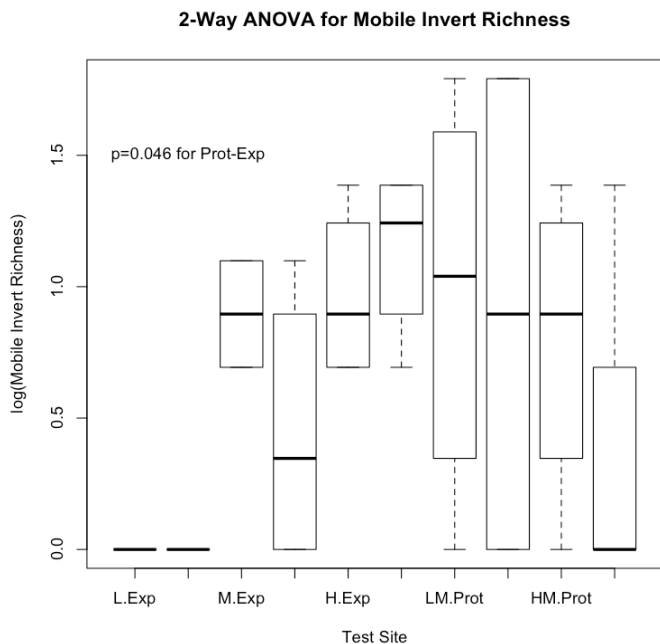


Fig 2. This graph shows the effects of wave exposure and tidal height on mobile invertebrate species richness. A two-way ANOVA, combined with a post-hoc Tukey's test, showed a statistically significant difference in richness between exposed and protected sites ( $p=0.046$ ). Tidal height had no significant effect on abundance, nor did the combined effects of both variables.

size for a similar community at a wave-protected site. Thus it is likely that the wave-exposed site has smaller individual mobile invertebrates in addition to a smaller total population.

Unlike wave exposure, tidal height (and the desiccation stress caused by increasing tide height) did not have any significant effect on mobile invertebrate population dynamics. Past studies have shown the importance of desiccation stress on intertidal organisms (9,14), however these studies focus almost entirely on sessile organisms, such as *Mytilus* or less-mobile genera such as *Acmaea*. Although limpets are mobile invertebrates, they are substantially less mobile than other mobile invertebrates such as crabs (15,16). Desiccation is much less of a risk to mobile organisms that can quickly change locations and seek out water if necessary. The majority of mobile invertebrates in our testing sites were highly mobile invertebrates like hermit crabs, specifically of the genus *Pagurus*, which may explain why desiccation stress seems to have been a less significant factor than wave exposure in our study. Past studies have shown that mobile invertebrates such as the hermit crab *Clibanarius digueti* display a Circadian rhythm, travelling vertically along the intertidal in correspondence with the tide (17), further supporting the idea that the mobile invertebrates in our site were able to migrate vertically in order to overcome possible desiccation stress. Different tidal heights on our transects were each five meters apart, well under the average distance traveled per day by hermit crabs (15), while our wave-protected areas and wave-exposed areas are a much farther distance apart.

Mobile invertebrates can move freely up and down the intertidal, but horizontal migration between different exposure regimes is heretofore undocumented. Given the greater distance, it appears less likely that they would be able to control the exposure regime in which they reside. In summary, this study suggests that wave exposure is a more significant factor in determining mobile invertebrate community dynamics.

These findings may be very insightful for future conservation efforts. Community dynamics, especially species richness and abundance, are important criteria in determining where conservation resources are used. By better understanding the primary abiotic drivers of community structure, we can be more efficient with conservation efforts and better target at-risk populations and communities. As rocky intertidal communities face an ever-increasing list of challenges, from pollution to rising sea levels to climate change, it is essential that we understand these communities' dynamics for our conservation efforts to be successful.

### Acknowledgements

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Matt Higgins is a junior from Seattle, Washington majoring in Biology with Honors at Stanford University. Matt loves getting involved on campus through his activities as a campus Tour Guide, camp counselor at Stanford Sierra Camp, and member of Theta Delta Chi fraternity. Currently, Matt works in Dr Joe Garner’s lab studying animal behavior and developing animal models for human diseases. He hopes to take at least a year off after college to live abroad before pursuing graduate studies.

# Implications of Observed Differences in Winter Soil Bacterial Profiles

Katie J. Steider<sup>1</sup> and Lisanne M. Spilgies<sup>1,2</sup>

<sup>1</sup>Washington & Jefferson College

<sup>2</sup>Radboud University Nijmegen

## Abstract

Bacteria are critical to many soil and ecological processes. Analyzing the bacterial profile of an ecosystem can provide insight into the health and condition of that ecosystem. To that end, we compared diversity of culturable, heterotrophic soil bacteria between winter 2011 and winter 2012 to establish a winter bacterial profile for the sampling area and determine possible causes of any observed differences between the sampling years. A subset of bacterial isolates collected from winter 2011 and winter 2012 was phylogenetically identified using 16S rDNA analysis. Isolates representing five phyla and 26 families were identified. Distinctions between the two sampling years could be made at the phylum and genus levels, although similarities were also identified. Bacterial diversity analysis at the level of operational taxonomic units (OTUs), the prokaryotic equivalent of “species,” supports that there was comparable bacterial diversity in winter 2011 and winter 2012. Rarefaction analysis supports that sampling saturation was not reached for either sampling year, indicating that more unique OTUs could be discovered at the sampling sites and that our current winter bacterial profiles are incomplete. Overall, our findings suggest that a characteristic winter soil bacterial profile may exist, but differences may be observed from year to year due to environmental or experimental factors.

Soil bacteria play many integral roles in ecosystem dynamics including the cycling of nitrogen, carbon, phosphorus, sulfur, and cations such as boron, copper, iron, manganese, molybdenum, and zinc.<sup>1-4</sup> Some soil bacteria can also synthesize growth factors and antibiotics that may affect the growth of other organisms in the environment.<sup>5</sup> Soil bacteria contribute to soil formation and development by mineralizing organic matter, oxidizing and reducing inorganic compounds, and contributing to the formation of microaggregates, which form the elementary functional units of soil.<sup>5</sup> For these reasons, assessing soil bacterial diversity can provide insight into the health of an ecosystem. Through the context of several studies, baselines of soil bacterial diversity during the summer and fall have been established for Abernathy Field Station, Washington, PA.<sup>6,7</sup> Until recently, the soil bacterial profile that prevails in this region during the winter had not been studied.

Papale et al. were the first to study soil bacterial diversity in the winter at Abernathy Field Station.<sup>7</sup> In conjunction with data gathered and analyzed by Kohler et al. as well as several

unpublished studies, Papale et al. provide evidence for seasonal shifts in soil bacterial diversity.<sup>6,7</sup> Seasonal changes in soil bacterial diversity have also been reported by Smit et al. in a study that used culture-based and molecular methods.<sup>8</sup> Seasonal changes may help explain how, when, and to what degree soil bacteria execute their myriad of ecological functions. Currently, our knowledge of winter soil bacterial communities at Abernathy Field Station is incomplete and based on one previous study.<sup>7</sup> Our study remedies this situation and adds to the archive of winter soil bacterial communities in this ecosystem. Winter bacterial profiles from two consecutive years will allow us to make more reliable inferences about seasonal changes in soil bacterial communities.

In addition to the vital roles played by soil bacteria, their ecological importance is emphasized by the magnitude of their presence in the soil. In fact, one gram of dry soil is estimated to contain 106 – 109 bacteria.<sup>5</sup> However, despite this abundance, it is commonly accepted that not all soil bacteria may be culturable in laboratory settings.<sup>9-11</sup> Although culture-independent methods are available to identify bacterial soil components, the inability to culture certain bacterial representatives hinders the characterization of soil bacterial diversity at large. Despite the glass ceiling that seems to exist for culturing different soil bacterial representatives, Janssen et al. demonstrated that previously uncultured soil bacteria could be cultured using simple techniques.<sup>12</sup> Indeed, different types of media can be used to isolate distinct bacterial representatives, whose colonies can be analyzed morphologically to aid in identification. R-2A agar was used successfully by Papale et al. to isolate soil bacteria collected during the winter of 2011 at Abernathy Field Station and has been used in other studies.<sup>7,13,14</sup> R-2A agar was used in this study in order to compare results to those obtained by Papale et al. in 2011. Soil extract agar and low concentration nutrient agar were used by Joseph et al. to isolate soil bacteria that were previously thought to be unculturable.<sup>15</sup> In light of the previous success with these media, R-2A agar, soil extract agar, and 1% nutrient agar were used in this study in an attempt to isolate novel soil bacteria from Abernathy Field Station.

The goal of this study was to attempt to compile a characteristic winter soil bacterial profile for Abernathy Field Station, as well as account for any differences observed in winter soil bacterial diversity from year to year, by comparing culture-dependent results from winter 2011 and winter 2012. To do this, we used three different types of media and two incubation temperatures to isolate soil bacteria from soil samples collected from three locations within Abernathy Field Station which were previously sampled by Papale et al.<sup>7</sup> Isolate colonies were analyzed for morphology and taxonomically identified using PCR-amplified

16S rDNA analysis. 16S rRNA sequences are highly conserved phylogenetically, which makes analysis of 16S rDNA sequences a valuable tool for taxonomic and phylogenetic characterization of bacterial species.<sup>16-18</sup> Our results enrich what is known about winter soil bacterial communities at Abernathy Field Station and help bring to light implications of observed differences in winter soil bacterial profiles that apply to the study of soil bacterial diversity as a whole.

## Materials and methods

### Soil sample collection and plating

Soil samples were collected from three locations within Abernathy Field Station, Washington, PA on February 9, 2012: Abe's Creek (N 40° 7.883', W 80° 11.010'), Jefferson's Run (N 40° 8.046', W 80° 11.059'), and land (N 40° 7.900', W 80° 10.973'). Soil samples for Abe's Creek and Jefferson's Run were taken from the stream beds. Prior to sampling at the land location, leaf litter was cleared from the site and a soil sample was taken from between 3 and 7 cm below the surface. Samples were withdrawn by hand using sterile 50 mL centrifuge tubes to collect the soil. At the lab, soil samples collected from the stream beds were centrifuged for 2 min at 3,300 rpm to pellet the soil; the supernatant was discarded. One gram of soil from each location was suspended in 100 mL of sterile, deionized water and agitated at 200 rpm for 15 min at room temperature. The soil suspensions were then serially diluted down to 10<sup>-6</sup> in sterile, deionized water. The diluted samples were mixed at 50 rpm for 10 min. After mixing, 200 µL of each dilution were transferred onto Petri plates containing R-2A agar, 1% nutrient agar, or soil extract agar. R-2A agar was prepared as described by the manufacturer (Fluka Analytical) and the 1% nutrient agar was prepared using Bacto-Agar (Difco) and nutrient broth (Difco) at a final concentration of 1% in 1 L of deionized water. Soil for the preparation of the soil extract agar was obtained from Abernathy Field Station on February 3, 2012 near the land sample site. Soil extract for the soil extract agar was prepared as described by Burlage et al. with the following modifications: the soil and tap water mixture was centrifuged at 3,400 rpm for 10 min in the centrifugation step and was filtered through a paper towel as opposed to Whatman #4 filter paper after the freeze-thaw step.<sup>19</sup> The soil extract was supplemented as described by HiMedia Laboratories with the following modifications: glucose [0.1% wt/vol], dipotassium phosphate [0.02% wt/vol], Bacto-Agar (Difco) [1.5% wt/vol].<sup>20</sup> Two hundred sixty mL of soil extract were added to 1 L of tap water. The medium was autoclaved for 40 min prior to pouring.

Dilutions from each soil sample (one sample from each of the three locations) were plated in duplicate on each medium. One set of plates was incubated at room temperature while another set was incubated at 4°C.

### Bacterial isolation and characterization

Plates were analyzed visually for morphologically distinct bacterial colonies. Additional morphology characteristics were observed using a light microscope. Individual colonies were analyzed for color, size, shape, margin, and elevation, as well as any other distinguishing characteristics. Pure subcultures were made on nutrient agar plates that were prepared according to manufacturer's instructions (Difco; Carolina Biological Supply Co.).

### Bacterial genomic DNA extraction

Genomic DNA was extracted using the method described by Sait et al. and modified by Kohler et al.<sup>6, 21</sup> Bacterial colonies from pure subcultures were suspended in 200 µL of sterile, deionized water and briefly disrupted with glass beads (0.1 mm diameter; BioSpec Products) for 1 min on the mix setting of a mini-beadbeater (BioSpec Products). The lysates were then boiled for 10 min in a water bath, cooled on ice for 10 min, and centrifuged at 14,000 rpm for 10 min. The supernatants containing the genomic DNA were either used immediately for PCR-amplification of 16S rDNA or stored at -20°C until further use.

### PCR-amplification of bacterial 16S rDNA

PCR was used to amplify the 16S rDNA region of genomic DNA. A 25 µL PCR reaction was prepared using 2X PCR master mix (Fermentas), 0.6 µM UnivF primer (GAG TTT GAT YMT GGC TC), 0.6 µM UnivR primer (GYT ACC TTG TTA CGA CTT), and 3 µL of genomic DNA. PCR was conducted using the following program: denaturation at 94°C for 5 min, 32 cycles (denaturation at 94°C for 1 min, annealing at 55°C for 2 min, and elongation at 72°C for 3 min), followed by a 72°C hold for 10 min and a 4°C hold for indefinite time. PCR products were stored at -20°C until further use.

### Purification and analysis of PCR products

PCR products were purified using QIAquick PCR purification kits (QIAGEN) according to manufacturer's instructions. Purified PCR products were eluted into sterile, deionized water and either used immediately for analysis via gel electrophoresis or stored at -20°C until analysis could be performed.

Purified PCR product from each isolate was run on a 1% agarose gel at 100 V for 30-40 minutes. Ethidium bromide (AMRESCO) was either added to the gels directly at a concentration of 5×10<sup>-4</sup> mg/mL gel solution or to the running buffer at a concentration of 5×10<sup>-4</sup> mg/mL when gels were prepared at least one day prior to analysis. Gels were imaged

	Winter 2011	Winter 2012	Total
<b>Bacteria isolated</b>	140	185	325
<b>Sequences obtained</b>	127	128	255
<b>Sequences analyzed for taxonomy</b>	83	107	190
<b>Sequences analyzed for OTU analysis</b>	83	103	186

Table 1. The number of isolates processed at each stage of the study is listed for winter 2011 and winter 2012 with total counts for both winters calculated in the fourth column.



	Winter 2011	Winter 2012	Total
OTUs	30	31	56
ACE richness estimate	50.491	73.053	148.583
Chao1 richness estimate	47.143	51.000	95.545
Shannon diversity index	2.836	2.846	3.429
Simpson diversity index	0.099	0.085	0.046
OTUs:number of sequences analyzed for OTU analysis	0.361	0.301	0.301

Table 2. Bacterial diversity indices. All diversity indices were calculated at the 97% similarity threshold using isolate sequences and mothur (v 1.24.1).<sup>23</sup> ACE richness estimates were calculated as described by Schloss et al.<sup>23</sup> Other measures take their standard definitions in the literature

using a UV transilluminator and assessed for the presence or absence of a single band in each lane corresponding to 16S rDNA (~1500 bp). The remaining purified PCR product was stored at -20°C until needed for sequencing.

The nucleic acid concentration (in ng/μL) of each purified PCR product was measured using a Nanodrop 2000 Spectrophotometer (Thermo Scientific). The absorbance spectrum for each isolate was also observed to assess sample purity. Samples with a nucleic acid concentration of 20 ng/μL or higher were considered to be of acceptable quality for sequencing.

Taxonomic, diversity, and phylogenetic analysis

Purified 16S rDNA was sequenced at the Genomics Core Facility at West Virginia University, Morgantown, West Virginia. Sequences with short continuous read lengths and/or poor trace scores were eliminated from the data set prior to taxonomic, diversity, and phylogenetic analysis. Sequences from bacteria isolated during winter 2012 and winter 2011 were analyzed using RDP Classifier (v 10.28) for bacterial taxonomy and mothur (v 1.24.1) for diversity analysis.<sup>22,23</sup> A phylogenetic tree was constructed

using “Advanced

mode” of the platform Phylogeny.fr (MUSCLE [v 3.7] for multiple alignments, GBLOCKS [v 0.91b] for alignment refinement, PhyML [v 3.0] for phylogenetic tree construction, and TreeDyn [v 1.98.3] for phylogenetic tree visualization using the maximum likelihood method with 500 replicates for bootstrap values).<sup>24</sup> Branches with branch support values less than 0.50 were collapsed.

## Results

We used three different kinds of media and two incubation temperatures in an attempt to isolate as many types of soil bacteria as possible from three collection sites at Abernathy Field Station. Indeed, we identified previously uncultured representatives of the soil bacterial community at Abernathy Field Station and further characterized the winter soil bacterial community in this ecosystem. We also compared the winter soil bacterial profiles for two sampling years to ascertain whether or not a characteristic winter soil bacterial profile could be determined and account for any observed differences between the sampling years.

### Winter 2011 and winter 2012 exhibited similar bacterial diversity and bacterial profiles

A total of 325 bacterial isolates were cultured between winter 2011 and winter 2012. (See Table 1.) The number of isolate sequences of suitable quality for taxonomy analysis using RDP Classifier and OTU analysis using mothur was greater in winter 2012 than in winter 2011.<sup>22,23</sup> Despite this difference, winter 2011 and winter 2012 exhibited similar bacterial diversity as measured using ACE richness estimate, Chao1 richness estimate, Shannon diversity index, and Simpson diversity index. (See Table 2.) To obtain these measures of bacterial diversity, mothur compares 16S rDNA sequences from each isolate to each other to determine how similar the sequences are.<sup>23</sup> An isolate with a sequence determined to be distinct from the other analyzed sequences (i.e. it does not meet the specified similarity threshold to be included in the group) is defined as a new operational taxonomic unit (OTU), the prokaryotic equivalent of “species.” The number of OTUs isolated for each sampling year is also similar. (See Table 2.) The ratio of OTUs to the number of sequences analyzed by mothur for OTU analysis indicates that for both winter 2011 and winter 2012, about one in every three sequences analyzed represented a novel OTU.<sup>23</sup>

RDP Classifier was used to identify the bacterial taxonomy of the isolates.<sup>22</sup> For the most part, the same bacterial phyla were

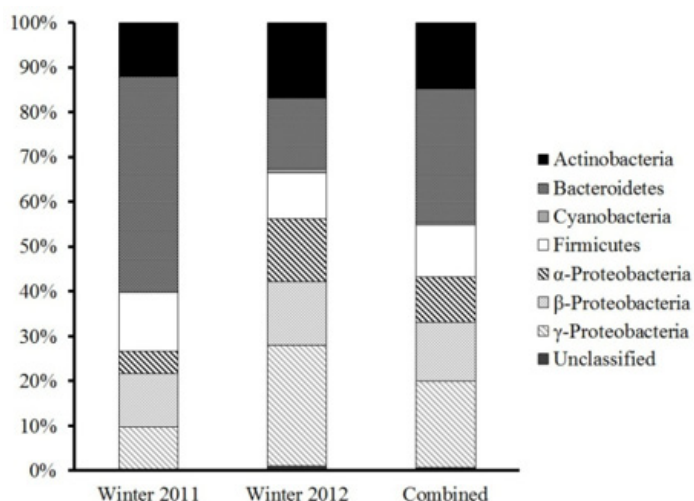


Fig. 1. Phylum distribution of soil bacterial isolates. Sequences for winter 2011 and winter 2012 were analyzed using RDP Classifier (v 10.28) to determine bacterial taxonomy.<sup>22</sup> An isolate was determined to be “unclassified” if the RDP Classifier assignment value for phylum was less than 70%. Phylum Proteobacteria is represented with class level affiliation (RDP Classifier assignment values greater than or equal to 83%).

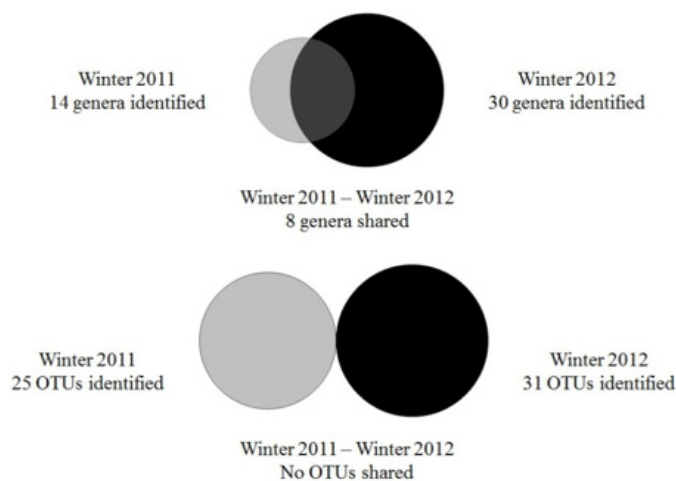


Fig. 2. Venn diagrams depicting the overlap in culturable bacterial genera (top panel) and OTUs (bottom panel) between winter 2011 and winter 2012. 16S rDNA sequences were analyzed using RDP Classifier (v 10.28) to determine the number of genera shared between each sampling year and mothur (v 1.24.1) to determine the number of OTUs (at the 97% similarity threshold) shared between each sampling year.<sup>22, 23</sup> Included genera had RDP Classifier assignment values greater than 70%.

observed between winter 2011 and winter 2012: Actinobacteria, Bacteroidetes, Firmicutes, and Proteobacteria. (See Figure 1.) Proportions of Actinobacteria, Firmicutes, and  $\beta$ -Proteobacteria were similar between sampling years, but the proportions of Bacteroidetes,  $\alpha$ -Proteobacteria, and  $\gamma$ -Proteobacteria differed substantially (by more than 5%). Namely, there was a decrease in the proportion of Bacteroidetes between winter 2011 and winter 2012 and increases in the proportion of  $\alpha$ - and  $\gamma$ -Proteobacteria between winter 2011 and winter 2012. A member of the phylum Cyanobacteria was only isolated in winter 2012. Taking both sampling years into account, Proteobacteria was the most commonly represented phylum.

Sequences were analyzed using RDP Classifier to determine the genera shared between each sampling year and mothur to identify the OTUs shared between each sampling year.<sup>22,23</sup> (See Figure 2.) At the genus level, 14 genera were identified in winter 2011 and 30 genera were identified in winter 2012; 8 genera were shared between the two sampling years. In winter 2011, 25 OTUs were identified while 31 OTUs were identified in winter 2012; no OTUs were shared at the 97% similarity threshold.

#### Rarefaction analysis indicated that sampling saturation was not reached

Rarefaction curves representing the number of OTUs (at the unique, 97%, and 95% similarity thresholds) found per number of isolates sampled across both sampling years were generated using mothur.<sup>23</sup> (See Figure 3.) For all rarefaction curves at all displayed similarity thresholds, the upward trend of the curves indicates that sampling saturation was not reached for the sites.

#### Winter bacterial isolates represented 26 families from 5 phyla

Multiple sequence alignments of 16S rDNA sequences

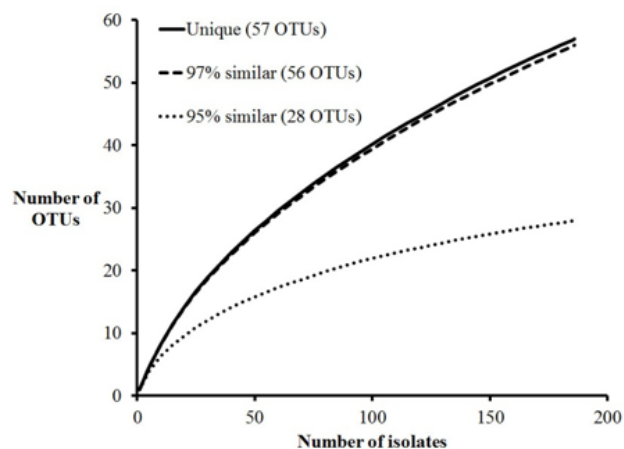


Fig. 3. Rarefaction analysis of winter 2011 and winter 2012 OTUs. Rarefaction curves were generated using mothur (v 1.24.1), which utilizes a randomized re-sampling without replacement procedure (1,000 randomizations).<sup>23</sup> The number of OTUs found per number of isolates sampled is depicted at the unique, 97%, and 95% similarity thresholds. The number of OTUs found at each similarity threshold in our data set of 186 sequences is provided in parentheses in the legend.

from winter 2011 and winter 2012 isolates were analyzed and a phylogenetic tree was constructed using the platform Phylogeny.fr.<sup>24</sup> (See Figure 4.) A representative sequence from each bacterial family found between winter 2011 and winter 2012 was used for the construction of the tree; the bacterial family classifications were obtained using RDP Classifier.<sup>22</sup> Representative sequences were chosen on the basis of sequence quality and length. Across both sampling years, representatives from a total of 26 families across five phyla were isolated.

## Discussion

Soil bacteria play many crucial roles in terrestrial ecosystems, which include contributing to soil formation and development and participating in the cycling of nitrogen and other nutrients.<sup>5, 3, 4</sup> Characterization of the number and diversity of soil bacteria in a particular ecosystem, therefore, provides a better understanding of the dynamics of that ecosystem. Although it is generally accepted that not all bacteria, including types of soil bacteria, are culturable, there has been some success with using simple, culture-based methods to isolate previously uncultured representatives or even new members of certain bacterial lineages.<sup>9-12, 15</sup> Thus, culture-dependent methods were utilized to further characterize winter soil bacterial diversity at Abernathy Field Station with a focus on comparing soil bacterial diversity between winter 2011 and winter 2012.

Between winter 2011 and winter 2012 a total of 325 bacterial isolates were cultured from three locations within Abernathy Field Station. The samples included stream bed soil samples from Abe's Creek and Jefferson's Run as well as a sample taken from land between the two streams. From this original pool of isolates, 190 were of suitable quality for taxonomic analysis using RDP Classifier; 186 of these were suitable for diversity analysis using the platform mothur.<sup>22, 23</sup> (See Table 1.) Across both winters, 56 OTUs were identified (at the 97% similarity threshold), and

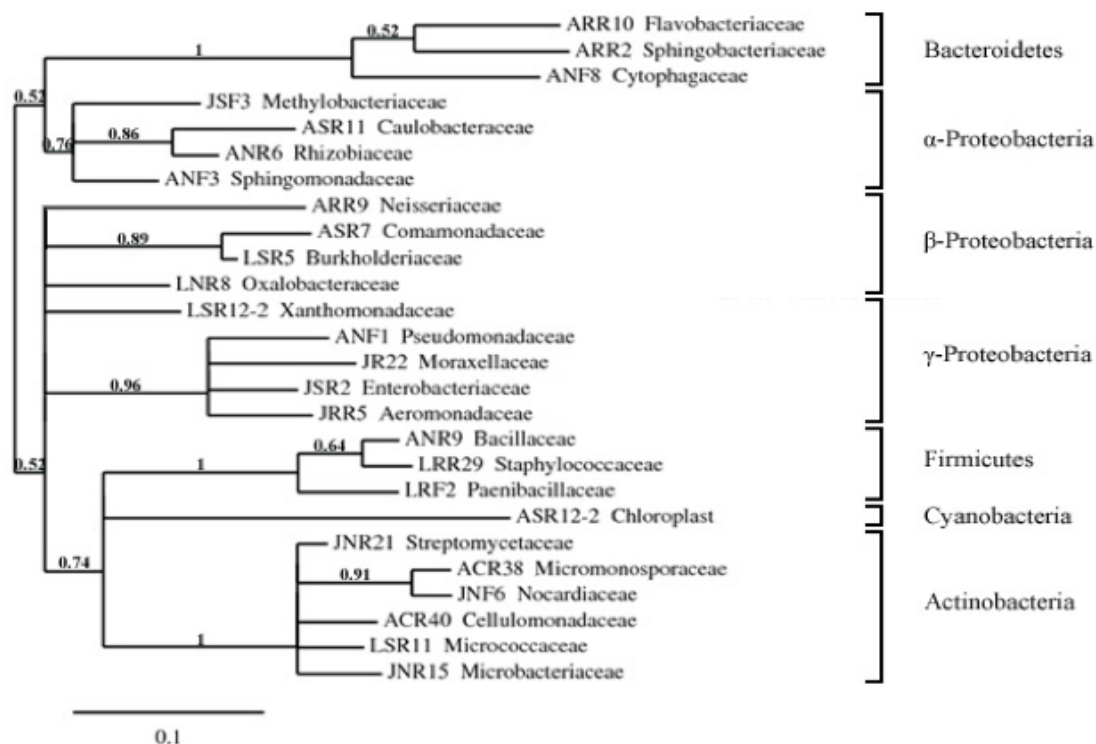


Fig. 4. Phylogeny of soil bacteria isolated during winter 2011 and winter 2012. Multiple sequence alignments of 16S rDNA sequences and a phylogenetic tree were constructed using “Advanced mode” of the platform Phylogeny.fr (MUSCLE [v 3.7] for multiple alignment, GBlocks [v 0.9.1b] for alignment refinement, PhyML [v 3.0] for phylogenetic tree construction using the bootstrapping procedure with 500 replicates for the statistical test for branch support, and TreeDyn [v 198.3] for phylogenetic tree visualization).<sup>24</sup> Branches with branch support values (displayed at the nodes of the tree) less than 0.50 were collapsed. Family affiliation for each isolate is indicated next to the sample name. Phylum affiliation is indicated using brackets with the name of the phylum written to the right of the bracket. Phylum Proteobacteria is represented with class level affiliation. RDP Classifier assignment values for phylum, class (if applicable), and family were greater than 70%.<sup>22</sup>

close to one out of every three bacterial isolates was determined to be a new OTU. (See Table 2.) The similar values of the calculated bacterial diversity indices support the conclusion that soil bacterial diversity was comparable between winter 2011 and winter 2012.

At the phylum level, the majority of the isolates fell into the same four phyla, namely, Actinobacteria, Bacteroidetes, Firmicutes, and Proteobacteria, and the phylum distributions for both winters showed some degree of similarity as well. (See Figure 1.) Despite the similarity in overall bacterial diversity, novel bacterial genera were identified for each sampling year. A moderate overlap between winter 2011 and winter 2012 was observed at the genus level, but there was no overlap in OTUs at the 97% similarity threshold. (See Figure 2.) This suggests that winter seasons may share common bacterial phyla and genera, but each winter season may have a distinguishing bacterial profile that potentially results from changing environmental conditions from year to year.

In winter 2012, a previously uncultured representative of the phylum Cyanobacteria was cultured and analyzed, which supports the conclusion that culture-dependent methods can still be used to isolate previously uncultured soil bacteria from Abernathy Field Station. Rarefaction analysis also indicated that sampling saturation was not reached for the sampling sites. (See Figure 3.) This supports the conclusion that more unique species could be isolated from the sampling sites and from Abernathy Field Station at large. Papale et al. made similar conclusions regarding sampling saturation at the same sites in winter 2011.<sup>7</sup> In light of the commonly held belief that not all soil bacteria are culturable, the

detection and identification of soil bacteria present at Abernathy Field Station may be enhanced in future studies by using culture-independent methods.<sup>9-11</sup>

Analyzing the phylogeny of soil bacterial isolates allows for the evolutionary relationships of the represented soil bacteria to be observed. It also serves as an indicator of the accuracy of taxonomic classifications determined using RDP Classifier.<sup>22</sup> Across both winters, a total of 26 bacterial families from five phyla were represented: Actinobacteria, Bacteroidetes, Cyanobacteria, Firmicutes, and Proteobacteria. (See Figure 4.) The families fell appropriately into their respective phyla, thereby supporting the use of RDP Classifier as a tool for taxonomic determination.

Although both winters had isolates representing the same phyla (with the exception of the Cyanobacteria representative isolated in winter 2012), a shift in the phylum distribution was observed between the two winters. (See Figure 1.) Namely, winter 2011 showed a much higher proportion of Bacteroidetes than winter 2012 while winter 2012 exhibited a higher proportion of Proteobacteria than winter 2011. Within the phylum Proteobacteria, larger proportions of α- and γ- Proteobacteria were observed in winter 2012. The differences in soil bacterial profiles may represent a shift in bacterial diversity between winters of different years. Seasonal shifts in soil bacteria diversity have been observed by several research groups and may be of ecological importance during the changing of seasons.<sup>8, 25, 26</sup> For example, Schmidt and Lipson believe that bacteria under the snow act as a sink and then a source for nutrients necessary for plant growth as the winter wanes into the beginning of the growing season.<sup>27</sup> They

also imply that soil microbial populations are responsible for the metabolism of alleochemicals released by decomposing plants in the fall or winter before the start of the growing season in the spring. Other groups suggest that differences in soil bacterial diversity may be the result of environmental disturbances and/or historical ecological or evolutionary events.<sup>28,29</sup> Further research is needed to assess the contributions of these factors to soil bacterial diversity at Abernathy Field Station.

These observed differences in the phylum distribution of soil bacteria across the sampling years may also be partially the result of media bias, where the media used each year may have allowed for the isolation of some bacteria over others. In this study, we used soil extract agar in addition to the two media used by Papale et al. in winter 2011, that is, 1% nutrient agar and R-2A agar.<sup>7</sup> Using the same media used by Papale et al. was critical, as we wanted to be able to compare the bacterial profiles between sampling years. The difference in results between winter 2011 and winter 2012 may also be due, to some extent, to colony selection bias, as morphologically distinct bacterial colonies were identified visually.

As mentioned previously, there was a much higher proportion of Bacteroidetes observed for winter 2011 than winter 2012, 48% of total isolates compared to 16%, respectively. According to a meta-analysis study of 32 published soil bacterial clone libraries conducted by Fierer et al., the relative abundance of Bacteroidetes in bulk and rhizosphere soils is around 5%.<sup>30</sup> In the cases of both winter sampling years analyzed in this study, the proportion of Bacteroidetes isolated was higher than the average calculated by Fierer et al., which supports the suggestion made by Fierer et al. that Bacteroidetes, and  $\beta$ -Proteobacteria for that matter, may be overrepresented in culture collections relative to their actual abundance in soil.<sup>30</sup> Other studies also support the general conclusion that discrepancies may exist between the relative abundances of certain types of bacteria calculated using culture-dependent or culture-independent methods due to the inherent nature of these methods.<sup>8,31</sup> The previously mentioned biases may have contributed to the higher relative abundances for Bacteroidetes observed during winter 2011 and winter 2012, although Fierer et al. did concede that levels of Bacteroidetes are highly variable among clone libraries.<sup>30</sup> To determine the extent to which media or colony selection bias may have been a factor, bacterial profiles were compared between winter 2011 and winter 2012 using only winter 2012 isolates from 1% nutrient agar and R-2A agar plates incubated at room temperature (data not shown). The proportions of Firmicutes, Actinobacteria, and  $\alpha$ -Proteobacteria were more similar across both winters given this analysis (data not shown). However, the disparity between the proportions of Bacteroidetes observed during winter 2011 and winter 2012 increased; both sampling years still had proportions of Bacteroidetes that were higher than the average calculated by Fierer et al.<sup>30</sup> The disparity in the proportions of  $\gamma$ -Proteobacteria between winter 2011 and winter 2012 also increased. Although proportions of  $\beta$ -Proteobacteria were similar when all winter 2012 isolates were included in the analysis, the proportions became less similar when only isolates from 1% nutrient agar and R-2A agar plates incubated at room temperature were included. In light of these findings, the predominant bias that may have influenced the results from winter 2011 and winter 2012 may be colony selection bias more than media bias. It is important to note that these biases may have affected our results for winter

2012 as well. Thus, additional studies need to be conducted to discriminate the effects of colony selection or media bias from what truly constitutes the winter soil bacterial profile at Abernathy Field Station.

The results of our study contribute to what is known about winter soil bacterial diversity at Abernathy Field Station and can be used to further characterize seasonal shifts in soil bacterial diversity, which will enhance our knowledge of soil bacterial functions. Our study also highlights many of the issues that characterize the study of bacterial diversity in general. One such issue concerns the use of culture-dependent and/or culture-independent methods in diversity studies, as these methods can yield different fractions of overall soil bacterial diversity at a given sample site.<sup>8,31</sup> For example, culture-dependent methods yield members of soil bacterial communities that are culturable and viable at the time of sampling, whereas culture-independent methods may detect members that are no longer living/replicating, as these methods rely on the detection of bacterial DNA only. Each of these methods also has certain inherent biases: culture-dependent methods are influenced by media and colony selection bias, and both culture-dependent and culture-independent methods are influenced by sampling method and PCR primer selection. When designing soil bacterial diversity studies, Dunbar et al. stress the importance of considerations of sample size and use of species abundance models and of designing sample collection and data analysis around the specific goals of the study.<sup>32</sup>

In future soil bacterial diversity studies at Abernathy Field Station, the aforementioned considerations and biases should be taken into account. It may also be beneficial to utilize culture-independent methods alone or in addition to culture-dependent methods (which could be expanded to include additional media and incubation conditions). Both types of methods are good indicators of overall species diversity and are capable of indicating seasonal changes in bacterial diversity at a given site.<sup>25,31</sup> In light of our results and current theories of the factors influencing soil bacterial diversity and how bacterial diversity is assessed, additional research is needed to assess the significance of the observed trends in winter soil bacterial diversity at Abernathy Field Station, and soil bacterial diversity at the field station at large.<sup>28,29,32</sup>

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Lisanne Spilgies was born in Berlin, Germany, and is currently following the Master's program of Molecular Life Science at the Radboud University Nijmegen, The Netherlands. Besides her interest in the challenging research field of molecular biology and tumor immunology, Lisanne enjoys to travel and discover other cultures, therefore she organizes a study tour for her fellow students to Turkey this spring. This paper arose when Lisanne was studying a semester abroad in the Washington, Pennsylvania. In future she wants to explore more different countries to perform research and eventually become a researcher in molecular immunology.



Katie Steider graduated summa cum laude and Phi Beta Kappa from Washington & Jefferson College (Washington, PA) in 2012 where she majored in Cell/Molecular Biology and Spanish. She is currently completing a year-long emerging infectious diseases fellowship at the Wadsworth Center (New York State Department of Health, Albany, NY) where she is developing a genotype assay for monitoring drug resistance in HIV-2-infected patients. Katie's interests include traveling, staying active, and reading novels. Katie will be starting in the PhD program in the Department of Infectious Diseases and Microbiology at the University of Pittsburgh Graduate School of Public Health (Pittsburgh, PA) in Fall 2013.

# The Cybernetic Organism and the Failure of Transhumanism in Samuel Beckett's *Endgame*

Andrew Bell

University of York

## Abstract

The following essay examines the notion of transhumanism and its relevance to a critical understanding of Samuel Beckett's *Endgame* (1957). It will be argued that the play explores the possibility of permanently refining the human form by technological enhancement, before finally rejecting such a possibility as ultimately sinister and, to some extent, fruitless. In order to do this, contexts for *Endgame* and the Huxlian notion of transhumanism will be provided before I examine the effects of technology on the human condition and the role of the cybernetic organism within the context of the play. Lastly, the way in which *Endgame* notionally rejects such transhumanist aspirations will be discussed.

Under the influence of modern evolutionary synthesis theory<sup>1</sup>, biologist Julian Huxley predicted a near future in which human physicality could find a meaningful and permanent form of refinement. According to Huxley, the human condition – as well as social conditions everywhere – would improve through the progress of the natural sciences and through the discovery of new, innovative technologies to combine the organic and the inorganic. In *New Bottles for New Wine* (1957), Huxley defines an ideology that had recently been gaining attention:

Scientific and technical explorations have given the Common Man all over the world a notion of physical possibilities [...] The human species can, if it wishes, transcend itself [...] We need a name for this new belief. Perhaps transhumanism will serve: man remaining man, but transcending himself, by realizing new possibilities of and for his human nature [1].

Huxley's belief that the next step in human evolution would inevitably be a product of man's own design is a sentiment that necessarily presupposes the notion of the cybernetic organism<sup>2</sup>. Defined by Donna Haraway as "a hybrid of machine and organism" [2], the merging of the organic with the artificial can serve a number of purposes; however, in most cases, the intended outcome involves the improvement and extension of human life. Impermanent alterations of the human form have already become prominent in the domestic setting: Elaine Graham has dubbed such technology as increasingly "commonplace," being an expression of the way in which "humans and machines are increasingly becoming assimilated and interdependent" [4]. It is also noteworthy that Beckett himself maintained a prominent interest in the discoveries of evolution and the future progress of

human physicality. Daniela Guardamagna and Rossana Sebellin provide commentary on the playwright's heavily worn and annotated copy of Darwin's *On the Origin of Species*, identifying its influence on Beckett's work by the numerous allusions to Darwin's caterpillar<sup>3</sup> made in *Murphy*, *Watt* and the lesser known "Echoes Bones" [5]. In the context of Beckett's dramatic works, Yoshiki Tajiri also notes the playwright's interest in the debilitating effects of prosthetic technology on the human form, particularly regarding the partially subsumed bodies in *Play*; the recollections of a disconnected machine in *Not I*; and the stage directions that compare Lucky's cognitive process with a malfunctioning machine in *Waiting for Godot* [6].

Arguably, however, it is *Endgame* that shows the greatest preoccupation with the progress of human physicality and transhumanism. Contemporary with the release of Huxley's publication and defining of the term, *Endgame* was first performed in 1957 and features a cast of characters that appear to be products of transhumanist preoccupations. Such characters demonstrate a pronounced reliance on various forms of constitution-altering technology, either for their survival or for the enhancement of their natural abilities. As operator of dark glasses, a gaff, a whistle, and even a catheter, Hamm is the most technologically reliant and ultimately at the center of *Endgame*'s transhumanist investigations. Most crucially, it is his relationship with his wheelchair that commits the character most effectively to the role of cybernetic organism. Described as "in an armchair with castors [...] a rug over his knees" [7 pp.92-93], Hamm is quite literally half man and half machine. From the knees down, he is rigidly affixed to the wheelchair, and has become fully dependent on this machine for any sense of mobility. *Endgame*'s second central character forms an interesting contrast within a transhumanist context: Clov is a more organic figure and, when not climbing a ladder, appears to retain his autonomy of movement without the assistance of anything mechanical. However, various forms of technology still play a crucial role in Clov's life, the most important being a telescope, which grants him artificially enhanced sight: "[He gets up on the ladder, turns the telescope on] Let's see. [He looks, moving the telescope] Zero... [he looks]... zero... [he looks] ...and zero" [7 p.106]. The majority of critical responses to this sequence have been fairly general and inconclusive, with Ashkan Shobeiri stating simply that Clov's numerical statement reflects a "featureless landscape without any signs to guide them" [8]. However, when placed within a transhumanist context, this moment becomes less enigmatic. While operating this ladder and telescope, Clov embraces his momentary state as a cybernetic organism as he appears to communicate with Hamm in binary, a mechanical language that expresses the desolation that lies outside the walls of their enclosure. Additionally, given that Clov's movement is staggered and stiff [7 p.92] and he has a tendency to



complain about “the pains in [his] legs” [7 p. 115], this character’s demonstration of arthritic symptoms draws attention to the limitations of organic composition and its tendency to degrade gradually to become a source of immobility and suffering. These properties are indeed the antithesis of the Huxlian vision. Therefore, while not being as visibly reliant upon the mechanical as Hamm, Clov demonstrates a pronounced integration with various kinds of constitution-altering technologies, thereby representing a crucial embodiment of a degrading organic form.

While their cybernetic nature initially appears positive due to its ability to compensate for human shortcomings, each of the main characters develops uneasiness with the transhumanist vision. Clov, in particular, exhibits a complex and contradictory relationship with cybernetic technology. At one point, he demonstrates an affinity for mechanical transportation by reminding Hamm, “When there were still bicycles I wept to have one. I crawled at your feet” [7 p. 96]. Here, he reflects upon his strong desire for a bicycle and the advantages associated with owning one much as he revels in the use of his telescope. Later, though, Clov appears at odds with transhumanism and with the notion of improvement via the cybernetic organism, as he reverses his attitude toward the telescope. He claims that there is “No need of the glass” [7 p.105] despite Hamm’s demand and, similarly, demonstrates sudden indifference toward the possible construction of an artificial raft. As the play progresses, Hamm adamantly proposes, “Let’s go from here, the two of us! You can make a raft and the currents will carry us away” [7 p.109]. Initially, Clov delights in the proposition and in the possibility of obtaining artificially-enhanced mobility on water. Critics have interpreted the raft to be symbolic of numerous things, though the predominant view is that this moment is “derived from the biblical narrative of Noah’s ark” [9], with such a device potentially allowing the characters to escape from their present surroundings and their associated misery. Yet, despite the obvious advantages of such technology, both characters bizarrely seem to lose interest in it; this is apparently due to the improbability of being attacked by sharks.

Nagg and Nell demonstrate a similarly complex relationship with prosthetic, constitution-altering forms of technology. Paralleling the technological interests of Hamm and Clov in cycling and sailing, the elderly couple reminisces humorously about the time that they “crashed our tandem and lost our shanks” [7 p.100] as well as when they “went out rowing on Lake Cuomo” [7 p.102]. However, their appreciation for transhuman machinery appears merely notional and a product of nostalgia as Nagg’s struggle with his own encasement is described in troubling detail: “Nagg’s hands appear, gripping the rim. Then the head emerges” [7 p.116]. This anxious and strained emergence from the ashbin illustrates Nagg’s very corporeal struggle with his own constitution as a cybernetic organism. Indeed, “the head” depersonalizes the character, abstracting the individual from his physical constitution and his bodily extremities. This moment is particularly disquieting for its demonstration of the traumatizing effect of technology on the constitution of the human body. Ultimately, each character (excluding the small boy discovered by Clov [7 p.130]) appears reliant on some form of cybernetic technology, and faces a struggle between appreciation and discontentment with his or her artificial alteration<sup>4</sup>.

Certain moments in the play question the value of the cybernetic state directly. One example is Hamm’s eccentric ride

around the extremities of the stage: “Take me for a little turn. [*Clov goes behind the chair and pushes it forward*] [...] Right round the world!” [7 p.104]. The ride is not only depicted as entirely absurd, but also as a source of irritation for both characters. It seems that Hamm’s wheelchair and its ability to provide him with limited mobility are largely pointless, as the wheelchair only grants him the trivial ability to traverse his immediate area – with assistance – while not providing more effective means for an escape. In addition, Nagg and Nell’s ashbins become examples of primitive, inhibiting cybernetic technologies, as they are artificial and permanent appendages to these characters’ otherwise organic constitution. Such devices protect the characters from their cold surroundings and ensure their survival (“I’m freezing. [*Pause.*] Do you want to go in?” [7 p.100]), but ultimately appear ridiculous for their inhibition of physical movement. *Endgame*’s representation of Nagg and Nell as artificially enhanced is not just absurd, however, but also sinister. Indeed, G. Farrell Lee has recognized the elderly couple’s ashbins as an ominous symbol, representing the disposability of human life [10]. It is entirely appropriate, then, that Nagg and Nell rely so heavily on their ashbins in order to stay warm and extend their own lives. However, their encasements ultimately prove to be debilitating, rendering the couple immobile and isolated: “[*Their heads strain towards each other, fail to meet, fall apart again*]” and then “[*They turn painfully towards each other*]” [7 p.99]. While they are able to extend their lives by these artificial means, the devices also inhibit their physicality, isolating them from the outside world and quite literally entombing them by the play’s conclusion: “[*Clove lets go of her hand, pushes her back in the bin, closes the lid*] [...] She has no pulse” [7 p.103]. These moments effectively demonstrate the shortcomings of the cybernetic form, highlighting the way in which human physicality can be dismantled and compromised by artificial means. And so, despite the characters’ ability to realize the transhumanist aspiration of life-extension, this perceived benefit appears to come at a perturbingly high cost.

Given that cybernetic technology is generally employed for the purpose of the extension and improvement of human life, the ultimate goal of the transhumanist vision should be the attainment of eternal life by these artificial means. According to Michael McNamee, the infinite extension of human life can be a meaningful way of improving the human condition and creating a greater sense of well-being in the individual: “According to the extreme transhumanism programme, technology can be used to vastly enhance a person’s intelligence; [...] to lengthen their lifespan, perhaps to immortality; and to reduce vastly their vulnerability to harm” [11]. *Endgame* critiques this aspiration, however, depicting characters who struggle with their own infinite existence: “Will you never finish? [*With sudden fury.*] Will this never finish?” [7 p.103]. Indeed, Josie Barth has observed that the characters’ anguish is due, in no small part, to the interminability of their existence, claiming that “all action and dialogue in the play consist of the characters’ attempts to distract themselves from waiting for an end that will not come [...] [they are] trapped endlessly in the same argument” [12]. Nagg and Nell are particularly noteworthy in this context, as they represent the extension of life through artificial means, with their ashbins protecting them from the lethal cold. Given the fact that the characters’ very existences appear to be the source of their suffering, the transhumanist aspiration to live longer, or even forever, appears absurd. Indeed, the play seems to emphasize

that wellbeing is not guaranteed just by the artificial extension of human life, but that it is often better to terminate existence rather than to extend it artificially. The transhumanist aspiration of immortality is thus depicted as undesirable because of its ability to become a source of suffering in the cybernetically enhanced individual, thus defeating its own attempt at improving the human condition.

While *Endgame* does criticize the transhumanist ideology through its depiction of the pointless and sinister pitfalls associated with cybernetic enhancement, the characters themselves also articulate a conclusive rejection of transhumanism. Early in the play, Nagg is shown retreating into his bin, thus avoiding the deathly cold outside of the encasement. Crucially, however, Nell utters, "I am going to leave you" [7 p.101] before defiantly exposing herself to her frigid surroundings. This self-destructive gesture represents a decisive denunciation of the cybernetic technology that has come to surround her organic body. She chooses to abandon the safety of her ashbin and allow nature to take its course, terminating her own life. Hamm makes a similarly defiant gesture towards the end of the play: "*He throws away the gaff [...] He tears the whistle from his neck [...] He throws the whistle towards the auditorium*" [7 p.133]. He is seen abandoning the various forms of ability-enhancing technology that he was once reliant on. Even more rebelliously, Hamm attempts to liberate himself from his own mechanical constitution: "Perhaps I could throw myself out on the floor. [*He pushes himself painfully off his seat, falls back again*]" [7 p.126]. Given that his wheelchair has come to represent the main technological constituent of his physical body, Hamm's attempt at escaping from it represents an attempted escape from his state as a cybernetic organism. Ultimately, he is unsuccessful, failing to sever his connection to the wheelchair. Yet despite this apparent failure, the character can still be seen rejecting notionally the artificiality of his own physical form. Nell, similarly, also fails to become liberated from her cybernetic condition, but the gesture itself remains apparent. Thus, by the play's conclusion, these characters have rejected the cybernetic form and the aspiration to achieve a transhumanist state, and have demonstrated that those are ultimately sinister and absurd.

Beckett's *Endgame* grapples meaningfully with the possibility of physically enhancing the human body through technological means. Indeed, through the uneasy attitudes of the play's central characters toward the notion of cybernetic enhancement and through the depictions of such technology as both absurd and sinister, *Endgame* raises questions surrounding possible next steps in the human body's evolution. Beckett's menacing depiction of what would soon be known as cybernetic technology is indeed prescient, as it effectively anticipates the debate over transhumanism that came to command widespread interest throughout the following decade.



Andrew Bell is a final year undergraduate of BA English & Philosophy at the University of York [UK]. Bell's academic interests include the analytic philosophy of the 20th century, as well as theoretical integrations of man and machine in literature of the Modernist period. Bell has held the positions of Treasurer and Pro Bono Officer at the University Amnesty and Law Societies respectively, also taking part in debating and studying formal logic in his free time. Bell is unsure about what the future holds, but is optimistic nonetheless!

1. Modern evolutionary synthesis is the contemporary notion of evolution held by modern geneticists based primarily on the discoveries of Charles Darwin and Gregor Mendel. Notable for its prioritization of natural selection as the prominent evolutionary mechanism, it emphasizes historical and geographical factors in its model of gradual genetic change.

2. While the term "cybernetic organism" was first coined by Manfred Clynes and Nathan Kline three years after the play's début, the concept itself has had a presence in literature since at least the mid-nineteenth century [see Edgar Allan Poe's "The Man That Was Used Up" (1839)]. This essay will, therefore, employ the term retrospectively in order to refer to an idea that was well-known at the time of the plays composition.

3. "As in repeating a well-known song, so in insects, one action follows another by a sort of rhythm; if a person be interrupted in a song, or in repeating anything by rote, he is generally forced to go back to recover the habitual train of thought: so P. Huber found it was with a caterpillar, which makes a very complicated hammock; for if he took a caterpillar which had completed its hammock up to, say, the sixth stage of construction, and put it into a hammock completed up only to the third stage, the caterpillar simply re-performed the fourth, fifth, and sixth stages of construction" [3].

4. Beckett suggests that even Mother Pegg has become reliant on technology, her survival being directly contingent upon the amount of "oil for her lamp" (Beckett 129).

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# “Stitching Together Pieces:” Gender, Genre, and the Figure of Peter in Gaskell’s *Cranford*

Sierra Eckert

Swarthmore College

## Abstract

*Cranford*’s is often misread as merely “a woman’s book about a woman’s place,” (Dolin 180). Yet within this Amazonian “utopia” of a Victorian novel, Elizabeth Gaskell makes the pointed inclusion of a cross-dressing male figure: Peter—later, Aga—Jenkins. Peter’s gender-defying deviation is dramatized as the novel unfolds. Turning from gender to genre, we see a different kind of heterogeneity in the makings of *Cranford* itself. Published serially, the author appears anonymously in the journal *Household Words*, under the male editorial figure, Charles Dickens and is only later reconfigured into a novel. By examining Gaskell’s representation of the reconfiguration and ambiguous gendering in the figure of Peter alongside the novel’s serial production, I will argue that Peter, as a fragmented-then-cohered subject, becomes metaphoric means for Gaskell to engage in the politics of production. The interplay between gender and genre reveals the dynamics of material alteration within *Cranford* as articulations of a complex struggle for authorial control.

Elizabeth Gaskell’s *Cranford* begins “in the possession of the Amazons” (3), likening the elderly spinsters who own property and populate the chapters of the novel to a tribe of masculine women warriors. The narrative goes on to loosely follow the episodic life of this “Amazonian” English township during the changes of the mid-nineteenth century. Within this “female utopia,” however, Gaskell includes a notable variation on the virago Amazon. In a scene where Miss Matty narrates family history, a feminine male figure emerges in the form of her cross-dressing, estranged brother, Peter, and the story of his expulsion from *Cranford*. The scene is brief, its inclusion in the narrative incongruous. Yet the dark dramatization of Peter’s deviation colors the rest of the narrative in unsettling undertones.

Criticism surrounding *Cranford*, generally speaking, falls into two categories: readings that see it as merely “a woman’s book about a woman’s place” (Dolin 180) with a “homogenously pleasant tone and dismissively trivial content” (Schaffer 221), and those that read its realism as mask for a “panic about change” (Schor 85), male dominance, Orientalism, or class discontents. Hilary Schor’s characterization of the novel’s “flux” (119) gets closer to this dialectical complexity, yet even her reading remains bound to the binary of masculine/feminine spheres, and thus fails to capture the complexity of Peter as a fluidly-gendered anomaly who becomes central in wrapping together the plot of *Cranford*. Looking closer at the arc of his transformation reveals its striking

similarities to *Cranford*’s own transformation from serial text to novel, shedding light on a second gender dynamic: that of Gaskell and her editor, Charles Dickens. In what follows, I analyze how Peter’s dynamic gender serves as a metaphoric commentary on the generic construction of *Cranford*. Through Peter’s illusory unity, Gaskell subtly subverts the notion of coherence, blurring the lines in both categories to reveal the fictionality of homogeneity.

In *Cranford*’s third installment, Miss Matty Jenkyns rediscovers an old letter, plunging the narrative into past family history. As she reads and recollects, the figure of Peter Marmaduke Arly Jenkyns emerges: an inadequate son overshadowed by his sister Deborah’s comportment. “Poor Peter’s” first act of disobedience toward gender conventions comes as he impersonates a female admirer of his father’s sermons. Dressed up as a lady, he goes unrecognized by his father, dramatizing a duality of personas when he is then forced to copy out sermons for “the lady.” Peter’s “practical-joking” continues as, later,

[...] he went to her [Deborah’s] room, it seems, and dressed himself in her old gown, and shawl, and bonnet; just the things she used to wear in *Cranford*, and was known by everywhere; and he made the pillow into a little - you are sure you locked the door, my dear, for I should not like anyone to hear - into - into a little baby, with white long clothes. It was only, as he told me afterwards, to make something to talk about in the town; he never thought of it as affecting Deborah (52-53).

His decision to then parade himself down the lane marks a turning point. For his actions, Peter is mercilessly flogged by his father, an action Carolyn Lambert reads as “symbolic rape” (78), and then disappears off to India.

The story ends abruptly. Interrupted by the sound of Martha and Jem “kissing—” outside, we are brought out of the unlit, locked room and back into *Cranford* present. Layers of removal mediate this encounter: we hear Peter’s story from letters, narrated by Miss Matty, and finally told by Mary Smith, the telling occurs behind a locked door, and during her narrative, Miss Matty puts out the light— all these details code the scene as family history layered in secrecy, guilt, and unease.

The cross-dressing—quickly smoothed over—could be seen as merely another anecdotal tale, like the cow in flannel or the lace-eating cat; yet its troubled undertones and Peter’s reoccurrence later compel a closer reading. In the *Cranford* “panic,” Helen Kuryllo points out “gender ambivalence” (102) in the description of a woman as “masculine-looking - a perfect virago; most probably a man dressed in woman’s clothes” (Gaskell 95). This

woman, later identified as Signora Brunoni, leads the narrative back to Peter. The signora says while in India, she was aided by one “Aga Jenkyns” (109). The presence of this gender ambiguity and the “panic” about masculinity/intersexuality in Cranford, forces us to reconsider the role of heterogeneity in Peter’s figure, a divided nature that, as Alyson Kiesel notes, inspires “textual hybridity” in Mary’s letter that functions as both a personal appeal and a private one (1013). Together, these seemingly insignificant details signify the narrative’s high ambivalence toward gender.

It is Peter’s transformation in the text that is crucial. After Gaskell introduces the rather romantic possibility that Aga Jenkyns could be the lost Peter, he reappears nearly 100 pages (and 14 months) later, as “Aga himself” (147) in Cranford. His apparent transformation unites Cranford, as he regales the ladies with stories, smoothes over tensions between Mr. Jamieson and Mrs. Hoggins, and appears a benign, masculine force of order working to ensure harmony in Cranford. And yet, evidence of Peter’s past remains in a letter in a locked, dark room. Like Peter, Gaskell seems to wink at us here, tacitly and ironically acknowledging, as in the first chapter, that “she knew that we knew, and we knew that she knew that we knew” (5), that there is more to his appearance.

Critical approaches to *Cranford’s* subversive depictions of gender have, ironically, remained rooted in the rigid binary of gendered spheres. Schor, in her reading, characterizes *Cranford* as a narrative “on the way *women* read,” (110; emphasis in the original) and write. Schor, despite her desire not to replicate readings that perpetuate *Cranford’s* “delicacy,” paints a rather domesticated picture of the novel. Though she notes *Cranford’s* form illustrates “fluidity, the movement between expectation and reality,” Schor insists that it “hold[s] that flux steady for us” (119) as a distinctly feminine mode of writing and reading. To categorize *Cranford* as merely “a woman’s text” is to re-assert that which the text pushes up against: the novel’s capacity to produce, as Nancy Armstrong theorizes, “oppositions that translated the complex and competing ways of representing human identity into a single binary opposition represented by male versus female” (Armstrong 474). In approaching the text, critical camps have tended to create still frames of what is, in fact, a dynamic work where Gaskell, more subtly, contorts and disrupts the very notion of uniform genre or gender.

We see disruption stylistically as Peter causes fragmentation in the text’s language. Two personas battle in his letters: “They were of a highly mental description, giving an account of his studies [...] but now and then, the animal nature broke out in such a little sentence as this [...]: ‘Mother dear, do send me a cake, and put plenty of citron in’” (49). In this fractured fragment, the “animal” and the “mental” aspects here become intriguing entwined, as his emotional appeal to his mother is combined with an intellectual “account”: the recipe-like enumeration of what to put in the cake. His language dramatizes the strangeness of this fracturing and results in an ambiguous and fuzzy portrait. Even Miss Matty, as she recounts the story, becomes confused. She switches the gender pronouns: “for her–him, I mean–no, her, for Peter was a lady then” (51). In narrating her brother’s actions, Miss Matty’s speech becomes increasingly fragmented and broken. Her description of Mr. Jenkyn’s reaction is a single, 174-word-long sentence filled with dashes and parentheticals that interrupt the narrative build toward the story’s climax, where Mr. Jenkyns “lifted up his cane, and flogged Peter!” (52). Peter’s

language, and the language of characters around him, reveal the interruptions he engenders. Linguistically, he fractures the placid front of domestic dynamics.

In Peter, we see the ironic twisting of gender as means for artistic production. Peter’s plays with the “art” of deception as he dresses up and “performs” himself as Deborah. Peter’s “hoaxes” dramatize the distinction between Peter’s biological sex and the gender he performs. After the flogging, “he turned to where the people outside the railing were and made them a low bow” (53). Peter’s performances play on the dramatic irony of appearance vs. actuality, turning on the fact that, *underneath*, he in fact, Mr. Jenkyns’s son and not the daughter or female admirer he performs himself as. His bowing after “playing” Deborah seems to signal the end of a fictional play and the return to the “reality” of his male gender.

Yet, Peter’s fictional performances constitute a significant part of his “real” identity. From the beginning, he crafts fictions and stories: Miss Matty describes him as a lover of “practical jokes” and “hoaxes,” and, even after returning from India, Miss Smith notes that “for all his grave face, he was at his old tricks” (157) in telling tall tales and in setting up a magic show in order to bate Mrs. Jamieson. Thus, fictional, ironic interplay is one of the “real” components of his character. The narrative internalizes this dramatized irony, and incorporates it into his physical description to such an extent that, when he finally returns, Miss Smith recognizes him by the incongruity of his “foreign” and his “oddly contrasting” features (148). Elsewhere in the novel, Miss Matty repeatedly resorts to analogy to describe her brother. She first compares him to the Captain: “He was like dear Captain Brown in always ready to help any old person or a child” (51), switches to describe him “dressing himself up as a lady” (51), and finally to “looking haughty as any man–indeed, looking like a man and not like a boy” (54). The shifting comparisons between male and female referents illustrate the complex heterogeneity in Peter’s character. It is Peter’s “tricks” and fiction that, paradoxically, come to form the “reality” of his character.

Through his bold and explicit cross-dressing hoax, Peter displays the construction of gender differentiation. In the moment of his performance, he exists as a multiplicity, embodying both himself and Deborah. The figure of patriarchal authority, the rector, strips Peter of “bonnet, shawl, gown, and all,” reveals him as a man, and beats him back into his masculine role. At face value, the scene illustrates a reassertion of traditional gender order after a deviation. Peter’s fragmentary identity and its destruction exemplify the phenomenon Jacques Lacan termed the “mirror stage”:

The mirror stage is a drama whose internal thrust is precipitated from insufficiency [...] and which manufactures for the subject caught up in the lure of spatial identification, the succession of phantasies that extends from a fragmented body-image to a form of its totality that I shall call orthopaedic (Lacan 1288).

As Peter’s gender instability is punished, he is forced into rigid, “orthopaedic” gender structures. The Oedipal tensions at these points create a complex relationship between Peter and the sister that he impersonates.<sup>1</sup> His actions seem overdetermined:

<sup>1</sup> The original text of *Household Words* describes Peter’s departure as “the last time he saw father or mother,” (207; n.58)

after failing to live up to his father's expectations as a son, he masquerades as his sister; his "charade" (Lambert 79) functions as both a rebellion and an attempt to regain his father's favor by imitating Deborah's masculine traits<sup>2</sup>.

It is this act of transvestism that dissolves the Jenkyns family domestic ideal, creating instability in the text and in the domestic realm. Peter refuses to cohere; as Lambert observes, he does not merely resist masculine gender conventions, in his action he "is challenging constructs of both masculinity and femininity" (77). Kiesel reads Peter's departure as a "violent rupture" (Kiesel 1002). Yet, in arguing that "his parting seals Cranford off from the rest of the world and locks it in a timeless, changeless Eden" (1002-1003), Kiesel fails to account for the active processes that it sets in motion. His action brings to the surface existing familial tensions, establishing the strictly "feminine" domain spheres of Cranford and the "masculine" world beyond. By departing, Peter dramatizes the gender divisions already present within the rector's household, as his departure causes them to determine the demographic of Cranford and, in so doing, creates destabilizing contradictions. Though *Cranford*, is, ostensibly, gendered "female," we see that each installment curiously contains a male presence—the Captain, Mr. Holbrook, Peter, Mr. Mulliner, Signor Bruno—revealing, implicitly, the township's multifarious nature.

Gaskell's inclusion of Peter and his gender confusions in Cranford can be illuminated by examining *Cranford*, the text itself, as a divided body. Thus, on this abrupt note, we send Peter away and examine the letter of the novel, with the hope of bringing these two disparate pieces together to shed light on one another.

Like Peter, the material form of *Cranford* has undergone several transformations. First conceived as the 1849 sketch "The Last Generation of England," in which Gaskell makes the disclaimer that "classing the details ... will be impossible from their heterogeneous nature" (15), the text was originally published serially in Charles Dickens' journal, *Household Words*. Thomas Recchio, in his study of the novel's history in print, notes that Cranford was published in nine parts and in irregular intervals between December 13, 1851 and May 21 1853 (45). Initially, Gaskell did not conceptualize the work as a novel at all. She writes that "The beginning... was *one* paper in Household Words and I never meant to write more" (Gaskell, *Letters* 747-748). What we have are "fragments and small opportunities" that are "gathered together to make a pot-pourri" (Gaskell 17). As it was a serial fiction, reader's first interactions with the text would have been with these fragments. The novel is temporally and physically fragmented, the text parceled out in discreet packages, creating "a continuous story over an extended time with enforced interruptions" (Hughes and Lund, *Victorian Serial*

which reads as an error, given that Peter does return briefly, lauded by his father. Though later editions also included it, Birch here changes it to mother. This original version, however, presents an interesting possibility; namely a far harsher separation between father and son, and no return as the proud son. We might read that Gaskell initially intended this reading, but changed it to reflect a more normative gender dynamic with Peter as the favored child, as during this visit: "Deborah used to smile... and say she was quite put in a corner" (59).

<sup>2</sup> While Mr. Jenkyns accepts Deborah's "intellectual" pursuits and domineering nature, it is important to note that Deborah nonetheless conforms to the expectations of feminine behavior, never *appearing* in the text as "masculine."

2). Such serialized fiction allowed for a more immediate reading experience: "a work's extended duration meant that serials could become entwined with readers' own sense of lived experience and passing time" (8). Like foreign dispatches, the Cranford sequence comes to readers produced in distinct parts, dramatizing the rapid consumption of text in an industrializing print market. The Peter sequence—spread over two chapters in the novel form: "Old Letters" and "Poor Peter"—occurred compartmentalized as single installation (Gaskell xxvi) which Dickens titled "Memory at Cranford" (Recchio 45). Looking at this scene, along with the representation of male characters in other installments, we see the serial form allows for the most dramatic aspect of Peter's story to be compartmentalized, contained, and thus, artificially cordoned off as distinct from Cranford writ large. Divided thusly, the reading experience was inherently episodic and discontinuous, despite the illusion of continuous narration.

Each installment of *Cranford* exists imbedded within the contextual thicket of other texts in *Household Words*. An early reader might have read it like Recchio, "reading each Cranford installment as it originally appeared, half-reading/half-browsing through the rest" (28). The journal comprised a "heterotopic" assortment. A reader navigating the text would have found it juxtaposed with a poem, an essay, a history, and a journalism piece (46). Though united by location and the papers, *Cranford* "had no clear title and no clear generic status" (2). Unlike "The Last Generation of England," a "history," the "Cranford Papers" were not even titled comprehensively. Lorna Huett argues that "the form of Cranford, like that of Household Words [...] echoes that of the Exhibition" (37). The episodic sketches at once function as individual units, yet are also loosely connected as part of a collection of assorted tales. Reading *Cranford* at its contextual edges, we see that it exists not as a self-contained called a "novel," but as an ambiguous assortment in dialogue with other texts in the journal (Recchio 27) in generic limbo.

Issued serially, *Cranford's* production was not just a prefatory and separate stage to the novel, but rather, integrated within a role in the reception. Self-aware of this fact, *Cranford* dramatizes the consumption and reading of texts. Physical text is scattered throughout the novel itself: we get to know Peter mediated through letters, Captain Brown is killed reading the *Pickwick Papers*, the ladies pass around the *St. James Chronicle*, Miss Jenkyns prepares for a party by "cutting out and stitching together pieces of newspaper" (Gaskell 15), and as Mary visits Miss Jenkyns for the last time, the latter rambles long enough "for Flora to get a good long spell at the 'Christmas Carol,' which Matty had left us on the table" (24). The references to real texts provide "paper paths" for Gaskell's readers to walk on, signaling the text's awareness not just of the external world, but its own print medium. The prominence of paper *scraps* calls attention to the disrupted materiality of the serial novel. As a fragmentary form that develops as it is published, *Cranford* situates itself as a text among texts, wholly conscious of its status as a work "publishing in parts" (10).

Against this backdrop is Charles Dickens. While authors such as Gaskell write anonymously, Dickens' name appears on the masthead as "conductor" of *Household Words*; Schor notes that "his imprint was everywhere" in the journal (92). His faith in progress (Recchio 37) and desire for Household Words to impart a certain social message drove the selection of texts. Schor characterizes this as the "Dickensian train" (97) in Cranford, barreling forward with texts hurtling at industrial speeds. *Cranford's* seemingly



innocuous references to *Pickwick Papers*, “Boz,” and *Christmas Carol* appear to be tacit nods to Dickens, looming, literally, above the text. Dickens resembles the Rector. He, not Gaskell, had authority to title the installments (Recchio 45). As Elsie Michie describes it: “his function as editor is to be a disciplinarian; he must keep Gaskell’s professional behavior within the limits of what is proper” (86–87). The critical picture that emerges paints Gaskell as writing under the domineering shadow of the male literary figure. This reading, while acknowledging the reality of the power dynamic between the editor and the author, gives Gaskell’s writing little agency. Taken together, these small details about reading help create *Cranford* as a text not only aware of its reading public, but aware of its relationship to Dickens’ journal as a “literary daughter” (Schor 93).

The body of the manuscript becomes the space in which the fraught literary relationship between Gaskell and Dickens plays out. The latter makes several significant revisions to Gaskell’s text, converting references to *Pickwick Papers* (Cranford 10, 11, 24, 110) into “Hood’s poems” and *Christmas Carol* into “Miss Kilmansegg and her Golden Legg” (Recchio 46). Though claiming “modesty,” the fact that he references it as the place “where the captain was killed” (46), suggests a discomfort with allowing Gaskell the freedom to make Dickens himself an interpretable object. At the end of the first installment, “Our Society at Cranford,” Dickens adds an extra line: “Poor, dear, Miss Jenkyns! Cranford is Man-less now.” This addition, as Recchio notes, destroys some of Gaskell’s subtlety (47); even more, Dickens’ editing pen marks the text, explicitly delineating *Cranford* (and Gaskell’s subsequent installments) as a textual space gendered female. In removing his own name and adding the sentence drawing attention to the absence of men, Dickens reduces the complicated, intertextual dynamic that Gaskell establishes. Though in his 1853 novel, Gaskell restores the *Pickwick* references and removes Dickens’ addition, in this first version, it is Dickens - not Gaskell - who ends the first installment.

The addition of “man-less,” Recchio observes, causes a heightened contrast between the story and the decidedly masculine news piece that follows: “The ‘Merchant Seaman’s Fund.’” Here, Dickens puts Gaskell into a corner. Just as he retaliates for the train killing by distorting Gaskell’s text, we might read the knotty portrait of gender in *Cranford* as Gaskell striking back.

In *Cranford*’s “Panic,” a scene seemingly concerned with the intrusion of men, Gaskell explores the possibility of a far more intermixed conception of gender. After hearing the gossip and visiting the dentist, Miss Pole goes on the following “diatribe against the sex”:

“[M]en will be men [...] If you will notice, they have always foreseen events, though they never tell one for one’s warning before the events happen [...]”

“Now, only think,” said she. “There, I have undergone the risk of having one of my remaining teeth drawn (for one is terribly at the mercy of any surgeon-dentist; and I, for one, always speak them fair till I have got my mouth out of their clutches)” (95-96)

At first glance this curious passage appears to merely espouse gender differences. Through Miss Pole, Gaskell gets her “mouth out of [Dickens’] clutches” and speaks freely. Couched as a frivolous panic over ghosts, Gaskell inserts a pointed commentary

about gendered sensibility. She writes that hidden underneath this domestic bed there might be “a man concealed, with a great fierce face staring out at you” (97). Looking to *Cranford*’s context, this passage’s self-consciousness serves as an expression of panic over Dickens, a “surgeon dentist” with his editing pen, lurking behind the text,<sup>3</sup> and a subsumption of his presence. This scene comes bookended by Peter’s first appearance and the reemergence of Aga Jenkyns. Though Peter isn’t explicitly in this passage, we had, just a few paragraphs above Miss Pole’s diatribe, the mention of the “virago,” echoing the image of intermixed genders. Like so much of *Cranford*, Gaskell ironically emphasizes turmoil behind its simple veneer. Though she speaks about men’s and women’s separate spheres, Gaskell’s comment points to the fact that the text of *Cranford*, itself, is, itself, a composite of Gaskell and Dickens, a dialogism possessing “gender ambivalence.” *Cranford*’s obedient literary daughter, Deborah Jenkyns, has died. Enter, stage right: “poor Peter.”

Peter, in the wake of this preliminary dispute, becomes a complicated figure onto which the literary battle is inscribed. Peter is inextricably connected to the written word: the narrative links his story to material texts in the form of letters to his family, sermons, and in Mary Smith’s letter (VP 71). Peter, as a cross-dressed and composite form makes a curious analogue to Gaskell’s text, a collection of stories by a female author inside the male-edited journal. Just as Peter rebels in Oedipal struggle with his father figure, by impersonating a female admirer, Gaskell’s critique of Dickens comes cloaked in praise. Though an attempt to parse authorial intention is inevitably impossible, the juxtaposition with Peter’s man-dressed-as-a-woman antics offers several layers of meaning in light of the author’s textual tensions. Peter is both Dickens masquerading as Gaskell, subtly inserting his own text into her fiction and Gaskell herself, creating a gender-binary defying character. In refusing to abide by the conventional boundaries of gender, Peter becomes the site where the textual tradition is played out.

In the third installment, Peter’s arrival marks a turn for both the content and the material form of *Cranford*, as with his introduction, Gaskell begins to negotiate narrative form in the serial. Up until this point, the episodes have been scattered, the plot not progressing forward in a linear fashion. With Peter, we begin to see Gaskell becoming more conscious of a plot; instead of killing off this male character like the captain, she only writes that they “believe he is dead” (59). By the time the fifth installment, “The Great Cranford Panic: Chapter the Second” (Chapters 10-12) ends, the possible link between Aga and Peter generates a cliffhanger and a feeling of suspense that propels the plot. Along with Mary, the readers of *Cranford* feel Peter’s absence in the novel’s temporality—we feel the real distance in the time it takes from the first mention of Peter to the sending of the letter, to, finally, his arrival. The form of serial fiction lent itself to an eroticism defined by “waiting, anticipating, anxiety” (Hughes and Lund, VP, 112). By placing the serial anticipation and plot motivation onto Peter, the estranged son, Gaskell further contorts generic expectations; the object of readerly desire here is not a woman but a cross-dressing man.

3 An interesting reading, one not possible in the scope of this paper, would put Gaskell’s relation with Dickens in dialogue with Gaye Tuchman’s *Edging Women Out: Victorian Novelists, Publishers, and Social Change*, and examine it alongside changing trends in authorship.



Under the pressures of generic conformation, *Cranford* re-shapes itself as a novel; or, at least, it does on the surface. Its form “imagines” the “re-union” of the text (Schor 105-106) by assembling them into a single entity. The tentative title “Cranford Papers” is shortened to “Cranford,” signaling a shift from plural multiplicity to monologic entity. Likewise, the separate fragments of the novel are gathered, homogenized and stitched together, first, to conclude the serial fiction, and second, to form a single novel. *Cranford* was printed first by Chapman & Hall in 1853, reprinted later that year with “minor edits,” and then as a “cheap edition” in 1855 immediately following the publication of the last installment (Recchio 63). In addition to reinstating the original text, the chapters were re-divided. Instead of nine installments, there are now sixteen chapters. Peter’s story now occurs over the span of two chapters. This addition of more chapters to the material text, introduces more divisions while, interestingly, smoothes over interruptions, as these sections of text are no longer separated in time as they would have been in serial form. Taken together, these details indicate the formal reconceptualization of the work as a novel; yet in “stitching together” this “pot-pourri,” its fragmentation still pervades.

*Cranford* wears only a thin scrim of unity. The 1855 Manchester Library “cheap edition” copy includes double quotation marks around the final chapter, “Peace at Cranford,” within the chapter heading, while the other “cheap edition” at the British Library erroneously includes no punctuation marks (Collin 83, 85). I point to the dropped punctuation marks because it gets at the question of the divided readings surrounding *Cranford* “peaceful” and cohesive ending and its publication. Read without the quotations, it evokes a pastoral “re-union” of *Cranford*’s serial fragments; read with them, the chapter title suddenly becomes ironic.<sup>4</sup> The “peace” and “old friendly sociability” restored at the end that wrap up the novel.

Against the façade of unity, it becomes easy to forget Peter’s transvestism. His scenes of cross-dressing are relegated to a single installment, thus “contained” within a single unit. None of the later illustrated versions of *Cranford* include images of Peter cross-dressing (Recchio 102; n. 7). It is as if his actions are invisible, smoothed over in the re-tellings of the text. By bringing Peter back in the end, and by drawing subtle parallels between his consolidation and the material consolidation of the novel, Gaskell invites their comparison. The narrative opens up possibility that, like the transformation of Peter, the novel’s narrative conformity is the result of corrective forces and “performances.” His apparent reformation internalizes the novel’s generic struggle as, by the end, his gendered struggles are sublimated. Though early in the text, Mary refers to him both as “the Aga” and as “Peter,” by the novel’s close he metamorphoses into the official, public, “Mr. Peter.” Peter “[s]omehow or another” stitches together the company at *Cranford*, and Mary’s closing remarks, “I somehow think we are better when she is near us” end the novel on a sentimental, *feminine* note (158). Thus, in Peter we seem to see the process of categorical “formalization” dramatized in the gradual consolidation of genre and gender. Yet, looking back to the previous sentence, we see that this “Peace at *Cranford*” is the result of Peter’s lie to Mrs. Jamieson. While the female utopia

4 The only other chapter title to have quotes around it is “Your Ladyship,” which surrounds the drama of manners in preparation for the decidedly unladylike Lady Glenmire (Gaskell).

is stabilized by a male presence, it is, ironically, Peter “at his old tricks” (157) as a transgressive<sup>5</sup> fiction-weaver that leads to domestic tranquility.

Reading the trajectory of Peter’s behavior as a metaphor for the genre of the novel further illuminates his erratic characterization in the text. First incarnated in the epistolary form, his generic instability and heterogeneity reflects that of novels during the 18<sup>th</sup> century (Garside 21). Hughes and Lund observe that Peter embodies central elements of the archetypal “fallen woman’s story” (VP 89). Like the novel, Peter’s actions straddle that of private, inner family life and that of the public gaze: this struggle is encapsulated in Peter’s performance as he parades “half hidden by the rails, half seen” (Gaskell 53). The unmasking of Peter as male enacts the novel’s concern with female purity while his journey to India, as Cass notes, parallels imperialism’s incorporation of the “Oriental Other” (Cass 425).<sup>6</sup> In his quasi-metaphoric role, Peter appears to function like Henry James’ Daisy Miller, as an allegory for the novel itself. The fact that Peter is *not* the eponymous female heroine infuses his allegoric function with irony: while “performing” the form, he dramatizes a novel tradition grounded in restrictive and artificial structures.<sup>7</sup> *Cranford* is a text about writing, yet one that pushes radically toward a conception of writing not confined by genre or gender. As an artificially re-shaped material body, Peter shows the realist novel’s work of re-imaging itself as whole and homogeneous.

Yet Gaskell does not entirely erase Peter’s fraught multiplicity. In the final chapter, Gaskell presents an image of autonomous female subjectivity: Mary and Miss Matty, sit “quiet, each with a separate reverie for some little time,”—a picture of harmony quickly punctured by the clause that follows: “when Mr. Peter broke in—” (153). Even as the text slips into the novel’s clothes of coherence, Peter’s presence reinserts a sense of fragmentation, an interrupting force reminding the reader that, in the seemingly “feminine” end to the text there is also “a man concealed.” *Cranford*, like Peter, cannot escape its heterogeneous past. Stitching together the narrative transformation of Peter and the material transformation of the serial segments, we see that in her textual tensions with Dickens and categories of gender/genre, Gaskell does not strive, as Schor suggests, to “reinvent the novel for women” (119) but instead, explores the possibility of the genre as metaphorically “intersex.” Even when collated as a uniform body of text, the figure of Peter in *Cranford* illustrates the internalization of the serial form’s multifarious and dynamic nature into the text itself.

5 I read Peter as “transgressive” in light of his father’s response. It is important to note Elizabeth Grosz’s point that, “There is no pure sexuality, no inherently transgressive sexual practice, no sexuality beyond or outside the limits of patriarchal models” (181) and not merely read Peter’s potentially “queer” behavior as inherently deviant.

6 In relegating my discussion of India to a footnote, I perpetuate Gaskell’s own narrative exclusion in *Cranford*, where India is reduced to the exotic margins of the text; however, the role of Peter as “Oriental Other” as another type of heterogeneity must be noted as needing further examination. Such analysis, unfortunately, is beyond the scope of this paper.

7 Peter, as a man-in-women’s dress, also echoes a trend Marilyn Kahn observes in eighteenth century novels: “narrative transvestism” which she describes as the “use by a male author of first-person female narrator” (2).

Through the manipulation of expectation and reality in the realm of gender, Gaskell's problematizes the notion of categorization even as it undergoes the process. Gaskell's cross-dressing narrative warps the gendered spheres as Armstrong theorizes them, illustrating the artifice and production of both genre and genre with Peter's transvestism in an Amazonian novel that is never, truly "man-less."

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Sierra Eckert is a junior at Swarthmore College. She is an Honors English literature major and Honors interpretation theory minor, with a mathematics course minor and a creative writing concentration. When she's not writing or editing *Nacht* literary magazine, she's researching for her thesis on archives, new media historiography, and Walter Benjamin's *The Arcades Project*. Her work has appeared in *The Susquehanna Review*, *Plain China 2012*, and *Small Craft Warnings*.

# The Time and Place of Faith:

Does the fact that some people have (had) comparatively-less access to Christian beliefs and practices tell against the existence of the Christian God?

Ian Martin

University of Oxford

## Abstract

It is often claimed that the Christian religion faced an epistemic crisis upon the first European encounter with the New World in 1492. Modern commentators recognise that the discovery of entirely unknown people groups and vast uncharted territories in the Americas—apparently completely unaccounted for in the text of the Bible—posed a threat to the church’s claims of universal truth. Subsequently, in what many would see partly as a result of this destabilising realisation, pluralism and tolerance have become the chief virtues of Western society. Now, as previously unfamiliar cultures and religions intermingle, it is seen as disrespectful and backward to make claims of religious exclusivity [1]. Unlike the medieval church, we are now aware that for much of the world Christian beliefs are either inaccessible or viewed as culturally irrelevant. This makes the doctrine of the eternal condemnation of adherents of other faiths, many of whom seem to lack the opportunity to make a free response to the gospel, appear to be incoherent with the Christian concept of a loving and just God. In light of vast cultural diversity, the atheological argument from divine hiddenness—that if God existed he would make himself sufficiently apparent so as to prevent all reasonable non-belief—is claimed to be further strengthened by the fact that not only does God hide himself, but he seems to be more hidden to some than others. This essay will analyse the claim that this lends weight to the atheist position, evaluating theistic objections and attempting to determine the internal coherence of the Christian worldview on this point.

## Schellenberg’s Argument from *Divine Hiddenness*

It was J.L. Schellenberg’s influential book *Divine Hiddenness and Human Reason* (1993) which first attempted to lay out an argument against the existence of God based on the proposed inconsistency of an all-loving deity who allows himself to remain hidden to his creatures. This work has been the focus of much scholarly debate centring on whether these two aspects of God’s nature can be reconciled. In expounding his argument from divine hiddenness (ADH), Schellenberg argues that a personal, omnipotent and omnibenevolent God would ensure that all creatures capable of meaningful relationship with him would be able to participate in such a relationship “just by trying to”, and that God would provide all the necessary conditions to sustain that capacity unless the creature chooses to reject them [2]. Since

belief that God exists is one of the necessary conditions to sustain relationship, and assuming the “involuntariness of belief”, part of God’s obligation would be to provide “evidence causally sufficient for belief” [3]. Humanity’s experience of God’s presence would therefore be as a “light that—however much the degree of its brightness may fluctuate—remains on unless they close their eyes” [4]. If this were the reality then there could never be an instance of reasonable non-belief—which is to say, non-belief which one is rationally justified in holding [5]. However, since there is an abundance of what Schellenberg holds to be reasonable non-belief in the world, his conclusion is it follows that such a God does not exist.

## Maitzen’s Argument from the Demographics of Theism

Although Schellenberg’s argument has been widely discussed on both sides, Stephen Maitzen in ‘Divine hiddenness and the demographics of theism’ (2006) proposes an addendum in support of ADH which at the time of writing has not yet received much scholarly attention (the only direct response written to date will be assessed below). In this article Maitzen presents the idea that the uneven demographical spread of theistic belief across the world lends further weight to ADH. The claim is that not only does God hide himself and fail to prevent non-belief in general, but his hiddenness seems to be unequally spread across nations and people groups with the majority of individuals inculpably predisposed to disbelief by nature of their location or background.

Maitzen gives the example of Saudi Arabia, which is 95 percent Muslim and theistic, and Thailand, which is 95 percent Buddhist and therefore atheistic, and points out that even if God were to allow non-belief to occur, there seems to be no plausible reason as to why he would allow it so unevenly between cultures and people groups [6]. He argues that such demographic data are more readily accounted for by naturalistic explanations than on any plausible theistic model, thus lending weight to the atheist position. Apart from this, the idea that these individuals are offered less opportunity to make a free choice to believe makes the thought of their eternal condemnation appear incongruent with the notion of a just and loving God. Thus Maitzen aims to show that both on inference to the best explanation and on moral grounds the uneven demographical spread of theistic belief seems to count against the existence of the Christian God.

Both ADH and Maitzen’s argument from the demographics of theism (ADT) [7] therefore make the claim that in light of the apparently innocent disbelief of vast swathes of people across the world, Christianity is faced with an inconsistency between the doctrine of exclusivism on the one hand and God’s benevolent nature on the other. In this way the arguments seek to show the

unlikely of the existence of God by pointing out what they see as an internal contradiction in the Christian worldview.

### **A Question of Justice: Salvation as Supererogatory Grace**

But one response which could be made from the Christian viewpoint is that it is not unjust for God to condemn to hell, as his sovereignty means he is not obligated to save anyone at all. In Christian teaching, anyone who is saved is saved by the free gift of grace and through no merit or special distinction of their own [8]. Humanity has fallen short of the glory of God and therefore stands condemned in the presence of his holiness [9]. It is only by God's mercy that he provides a way of salvation through Jesus Christ and therefore those who reject this offer of peace condemn themselves to eternity excluded from God's presence. William Lane Craig, a leading theist of contemporary philosophy of religion, defends this position stating that "those who make a well-informed and free decision to reject Christ... shut out God's mercy and seal their own destiny. They, therefore, and not God, are responsible for their condemnation, and God deeply mourns their loss" [10]. It is God's unmerited grace which allows for any to be saved and this benevolent act of God is wholly supererogatory. In this way it can be argued that there is no injustice in the notion of God condemning to hell those who reject his free offer.

However, Maitzen's argument from the demographics of theism in particular makes the case that the freedom of many to make what Craig calls a "well-informed and free decision to reject Christ" is hampered by circumstances beyond their control. Whether by virtue of their upbringing, education, time in history or location on the planet, they are placed at a disadvantage when it comes to hearing the message of salvation. It would appear therefore that many never consciously reject God's love as they are deprived of the opportunity to do so—yet God still condemns them. Although humble gratitude at God's generosity is indeed to be the posture of any believer, as he is saved by grace and not by merit, where does this leave the one who disbelieves through no apparent fault of his own and is condemned? How could these individuals be judged culpable—if they are in fact to be judged equally—alongside those who have indeed made a free decision? One might indeed claim that God is not technically obligated to save everyone, but as Schellenberg argues, we would naturally expect a perfectly good being to do so [11].

### **Salvation Through General Revelation**

In response to this question, Craig argues that God does in fact desire the salvation of all humankind [12], and that God has provided general revelation of his existence through nature and conscience [13]. This seems to be the thrust of Romans 1:19-20:

For what can be known about God is plain to them, because God has shown it to them. For his invisible attributes, namely, his eternal power and divine nature, have been clearly perceived, ever since the creation of the world, in the things that have been made. So they are without excuse [14].

Although humanity is left without excuse, given this general revelation there is scriptural precedent to suggest that although not possessing explicit faith in Christ, some will potentially be saved according to their response to the light they have been given in nature and their inner conscience:

For when Gentiles, who do not have the law, by nature do what

the law requires, they are a law to themselves, even though they do not have the law. They show that the work of the law is written on their hearts, while their conscience also bears witness. (Romans 2:14-15)

It might therefore be argued that ADT does not present a defeater to the coherence of the Christian worldview, and by implication its God, in this respect as scripture seems to allow for the possibility of salvation for those disadvantaged in their lack of opportunity to hear the gospel. This would suggest that each will be judged according to the measure of their obedience to the light that they had. Although Craig rightly points out scripture's indication that the "mass of humanity does not even respond to the light that they do have" [15] in general revelation, the very fact that God would judge those who have not heard to a lower standard refutes ADT's charge of injustice. Maitzen claims that he only intends to show that the demographics of theism are better explained by naturalistic causes than by theistic ones. Yet the contention that this tells against the existence of God rests upon the assumption that God's condemnation of the epistemically disadvantaged would be unjust. However, in the above way, it has been shown that according to wider Christian teachings, this is not the case.

### **A Question of Benevolence**

But even though God, in hiding himself more from some than others, may perhaps be cleared of the charge of injustice, his unequal hiddenness still seems to be contrary to his loving nature. Even if he judges those who've never heard of him to a lower standard, isn't it still unloving to allow them to remain ignorant of his special offer of salvation? Maitzen's argument would suggest that God's love is meted out unfairly along demographical lines. Schellenberg would concur that for God to allow this proves that if he exists he is not loving [16]. Yet, as ADH points out, since it is a necessary truth of God's maximal greatness that he must be unsurpassably loving, this proves that there cannot be a God. Craig also recognises that God's love is at the heart of the issue, stating, "God is supposed to be omnibenevolent, and it seems difficult to deny that He would be more benevolent if He were to save all persons rather than just some" [17]. It is this emotional aspect of God which must be defended by the theist, especially if he is to be convincing of anything more than logical possibilities.

### **Marsh's Proposed Molinist Solution**

One scholar that has attempted to mount a defense against Maitzen's argument is Jason Marsh, who presents a theistic response to ADT in 'Do the Demographics of Theistic Belief Disprove Theism? A Response to Maitzen'—the only direct response published to date. [18] Marsh argues that the demographics of belief, far from exhibiting a lack of divine love or justice, by adopting a certain philosophical perspective on the omniscience of God, can in fact be argued to prove the opposite. His contention is that by adopting a Molinist perspective on the nature of omniscience it can be argued God prevents certain individuals from hearing the gospel as an act of loving mercy in order to maintain their innocence for the chance of conversion at a later time—either pre or post-mortem. Molinism, also known as middle-knowledge, seeks to reconcile the problem of human free will and divine omniscience by proposing that both may be maintained if God acts in knowledge not only of what

a human *will* do, but of what he *would* do freely in any given situation [19]. Marsh assumes that God's promise to finally defeat evil means that all will eventually be saved, and that one of the means of achieving this end is through the so-called "grouping strategy" in which souls resistant to the gospel are gathered into geographical regions where inculpable non-belief can be more easily maintained [20]. He claims to thus offer a way to reconcile the problem posed by ADT, stating that Maitzen's failure to view the issue through a Molinist lens prevents him from seeing that "a certain degree of lopsidedness, far from an oversight on God's part, may be the providential mechanism through which things get smoothed out in the end" [21].

However, when it comes to explaining the demographics of theism, many might find it hard not to agree with Maitzen that the Molinist perspective argued by Marsh, although logically possible, seems at least more complicated at face value than naturalistic explanations such as politics or culture. Apart from the controversial assumption of universalism that Marsh's Molinist argument requires, it also entails the serious implication that God would create individuals destined irreconcilably for perdition—a question potentially shared with any position that holds to both restrictivism and God's foreknowledge. But although Marsh admits that his approach is "more than a little bit messy" [22], he nonetheless succeeds in showing that a theistic answer can be conceived of, contrary to Maitzen's assertion that ADT "confounds any [theistic] explanation" [23]. The Molinist strategy thus demonstrates the possibility of a coherent theistic explanation; but as Marsh admits, not all will be convinced of the plausibility and—it must be added—Biblical orthodoxy of the one offered thus far.

### The Demographical Limitations of the Incarnation

From a different perspective, another possible answer to ADT might stem from the Christian teaching that God's ultimate revelation was in human form and thus necessarily restricted to a certain historical moment and geographical location. By the incarnation of Jesus, God chooses to limit his omnipresence and constrain himself to time and history. By choosing the particular time and culture in which he was to be incarnated, it follows that Jesus necessarily excluded others. With regards to the reasons for doing this, it can be claimed that in the Great Commission of Matthew 28:19, God partnered with humanity in the project of salvation, charging them with the mission to extend his message of salvation to every culture and people group. Just as God had extended divine creative authority to humankind in the command to "fill the earth and subdue it" (Gen. 1:28), he now extended the mission of redemption to his children as well. In light of this, it could be claimed that we should not be surprised at the demographic unevenness of theistic belief because the project of spreading the message of the gospel is still underway. Indeed, the imbalance provides Jesus' disciples with greater impetus to reach the uttermost parts of the globe with his message. To pursue this course, it would need to be explored why incarnation would represent the ultimate method of revelation and also the reasons for which partnering with humanity in the project of salvation might be a special grace. Of course, the implications of the above answer to ADT deserve much fuller treatment, but suffice it to say that this constitutes another possible theistic approach which might answer Maitzen's argument.

### Conclusion

In sum, we have seen that both ADH and ADT present what appear to be formidable challenges to the Christian worldview, claiming that the concept of a just and loving God is incompatible with the phenomenon of non-belief and the uneven demographic spread of non-belief in particular. However, by showing that God's offer of salvation is entirely supererogatory and that Christian scripture allows for the possibility of salvation via response to general revelation in nature, we have seen that the charge of injustice in the condemnation of unbelievers is successfully overcome. By contrast, the more serious implications of ADT have to do with the question of whether or not, in this light, God's benevolent character still can be said to remain intact. Maitzen claims that ADT fits better with naturalistic explanations and that no theistic reason is forthcoming. Indeed, he adds that it is hard to see how any theistic response could account for the data. However, although Marsh's Molinist response is perhaps more complicated than naturalistic answers, he nonetheless shows that a theistic explanation is possible and worth pursuing. Finally, it has been suggested that the implications of the incarnation might provide a further line of enquiry for the theist in response to this argument. It could be argued that the space-time limitations inherent in God becoming man may hold explanatory power for the demographic unevenness of theistic belief. All in all, it has been shown that although the argument from the demographics of theism does present a challenge to belief in the Christian God, contrary to Maitzen's claims, there is nothing to suggest that a strong theistic answer cannot be formulated, and neither can it be claimed to present a defeater to theism in light of the wider arguments in its favour.

### Endnotes

1. Craig, 1995
2. Schellenberg, 2005a: 202
3. Ibid: 203
4. Ibid: 203
5. Ibid: 206
6. Maitzen, 2006: 181
7. Acronym mine. Maitzen himself does not name his particular argument.
8. Ephesians 2:8-9
9. Romans 3:11-18, 23
10. Craig, 1989
11. Schellenberg, 2005a
12. 1 Timothy 2:4
13. Craig, 1989
14. All scripture references taken from *English Standard Version*, (Collins, London: 2002)
15. Craig, 1989
16. Schellenberg, 2005a: 204
17. Craig, 1995
18. Email correspondence with Dr. Maitzen revealed that a new article responding to ADT is due to be published in August 2012: Mawson, T.J, 'The Rationality of Classical Theism and Its Demographics', in *Scientific Approaches to the Philosophy of Religion*, ed. Yujin Nagasawa, (Palgrave Macmillan).
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20. Marsh, 2008: 468
21. Ibid, 468
22. Ibid, 468
23. Maitzen, 2006: 177



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18. Schellenberg JL. 'The hiddenness argument revisited (II)'. *Religious Studies* 2005; 41:287-303.
- 19.



Ian Martin was born in Pennsylvania but has spent the majority of his life as a 'Third Culture Kid' growing up in Spain and the United Kingdom. After enjoying a successful undergraduate career in Hispanic Studies at University College London (2011), where he was twice awarded the Alcalá-Galiano Prize and honored to receive the prestigious Dean's List award upon graduation, last year Ian went on to gain a Distinction in Theology and Christian Apologetics at Oxford University. His interests include traveling with his wife Celina, working for charity in Betel International, and writing, producing and recording hip-hop music under the name Neuma.

# British Genre Painting of the 19th Century:

An Analysis of *Through the Fog, English Channel* (1886), and *Innocent Amusements* (1891)

Judith Pelpola

Stanford University

## Abstract

This paper explores how together two British paintings *Through the Fog* by Julius Price (1896) and *Innocent Amusements* by John William Godward (1891) reflect the changing dynamics of the late Victorian era. The 19<sup>th</sup> century was characterized by a great deal of socioeconomic change due to Britain's rapid industrialization. This change is reflected in the artwork of the time. The paper analyzes the use of detail, use of space, and use of perspective in each painting to depict the Victorian world, both psychological and real. *Innocent Amusements* shows the world as many Victorians wished it to be, while *Through the Fog* gives a more realistic depiction of the late 19<sup>th</sup> century. The paper finds that despite being radically different with regards to subject matter, intended audience, style, and composition, each painting questions the place of the Victorian lifestyle in the upcoming 20<sup>th</sup> century, a concern that was common among the late Victorians.

The 19<sup>th</sup> century in Great Britain was a period of political, economic, and social change, especially in its last few decades. As Britain industrialized, the middle class gained considerable economic power, blurring class distinctions.



Fig. 1.

This challenge to the dominance of the upper class made it increasingly important for the upper class to reassert itself as the highest rung of Victorian society. As Jeremy Black and Donald MacRaid argue, “a feeling of insecurity helps to explain that, in so far as there was an aristocratic establishment of cultural and political hegemony, it was in part bred from elite concern, rather than from any unchallenged sense of confidence or complacency,” (Black, 4). This anxiety manifested in artworks such as *Innocent Amusements* (1891) by John William

Godward (Figure 1), a Roman genre painting that extolled the life and leisure of the upper class. However, changes in Britain's demographics, and subsequently the lives of the middle and lower classes, did not go unnoticed. Cities began to attract large numbers of the rural working class, who left the countryside in an attempt to escape poverty (Steinbach, 13). Thus, the presence of working class individuals in urban spaces became increasingly commonplace. This was reflected in works like *Through the Fog, English Channel* (1896) by Julius Price (Figure 2), which appealed to new middle class patrons as it reflected everyday urban life and the presence of both the working and middle classes in public spaces. *Through the Fog* reflects late 19<sup>th</sup> century Britain in a way easily relatable to the viewer.

The notion of separate spheres also dominated much of Victorian society, both in terms of private versus public life as well as male versus female (Steinbach, 113). A woman's sphere was private, distinct from and made possible by her male counterpart (Steinbach, 134). Even prostitutes, those women who operated in the public sphere, could only do so with the support of men. Society expected women to reside solely within a domestic sphere, which was kept distinct from the public sphere of men. However, by the late 19<sup>th</sup> century, women began to take on more public roles in society. This becomes important particularly in the upcoming World Wars when women are forced to take on the responsibilities of men. Traces of this change in the social sphere of women are reflected in both *Innocent Amusements* and *Through the Fog*.

It is interesting that two paintings, radically different with regards to subject matter, intended audience, style, and composition, were painted only five years apart. By examining Godward and Prices' use of details, interpretation of space, and use of perspective, it becomes clear that together, the two paintings tell two sides of the same story, that of late 19<sup>th</sup> century England. Both question the place of Victorian values in the late 19<sup>th</sup> century and beyond. While depiction of class distinctions, gender roles, and everyday interactions between individuals differ in each painting, each acknowledges the changing atmosphere of 19<sup>th</sup> century Great Britain. Though *Innocent Amusements* looks wistfully to the past as an example of beauty and the ideal life for the upper class, it is clear that the past remains impenetrable. *Through the Fog*, rather than looking to the past, finds dignity and grace in the everyday interactions of the ordinary 19<sup>th</sup> century individual. Together, these paintings reflect a period of transition in Victorian society and place the observer in the flux of a changing era. While reflecting on their relationship to the past, Victorians began to question their relationships to each other. Morality and hierarchy, which together formed the foundation of



Fig. 2.

most Victorian values, were tested as the 20<sup>th</sup> century approached, which brought significant change to both the class structure and place of women in English society. Both *Innocent Amusements* and *Through the Fog* are witnesses to and commentators on the social dynamics of Late Victorian England.

### Use of Detail

The use of details in works such as *Innocent Amusements* and *Through the Fog* reveal deeper, perhaps even unconscious meanings that speak to the zeitgeist of Victorian England. According to Julian Treuherz, author of *Victorian Painting*, “in pictures like these [Victorian paintings], meaning and emotion are quietly conveyed, to be read from small clues like wedding rings, letters, the language of flowers and understated gestures,” (Treuherz, 110).

Godward’s use of details in *Innocent Amusements* emphasizes the past as an idyllic time to which Victorians can look back nostalgically. A young lady, who has put aside her sewing, balances a peacock feather on her finger (Figure 3) (Swanson, 39). Her gaze, as well as those of the two young girls on the left of the painting, is fixed on the feather, thus directing the viewer’s gaze to the feather and centering the entire composition of the painting on this one detail. Though a seemingly ordinary object, the feather highlights the leisure with which the young lady extends her arm. This action is the axis upon which the world of *Innocent Amusements* turns. Because the world of the painting is one of leisure, idleness and free time, it would have catered to the aristocracy and bourgeoisie, which was the only class that had the time for such leisurely activities. In art and painting, according to Treuherz, “prosperous Victorians could imagine they saw their own lives flatteringly mirrored,” (Treuherz, 173). Thus, upper class Victorians preferred works that mimicked their ideal lives and depicted a world of leisure, one without worries. *Innocent Amusements* reflects the upper class’s desire to live in a world where something as inconsequential as a peacock plume is given so much importance, a world where worry and hardship have no place.

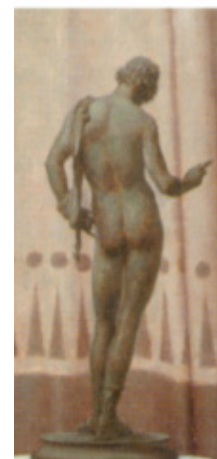
The use of Roman statuary in the painting further contributes to its wistful and nostalgic atmosphere. The statue on the right is turned away from the viewer with an arm raised in a seemingly admonishing gesture (Figure 4). Because the statue is not fully visible to the viewer, it has an almost mysterious aura, rendering it unidentifiable. Another statue is located slightly off center in the painting (Figure 5). This statue is covered partly by a curtain. Again, because it is partly hidden from the viewer’s gaze, there



Fig. 3.

is a sense of the unknown, an untouchable quality of the statue, which gives the viewer a feeling of disconnect with the painting. There is little sense of realism in the painting, preventing the viewer from truly relating to it. According to Treuherz, “these pictures [roman genre paintings] attracted a public nostalgic for a mythical pre-industrial golden age of lost elegance and leisure,” (Treuherz, 170). The key words here are mythical and lost. The world of the painting is impenetrable; the viewer is denied access. While the painting can be looked at as part of a desire to return to the times of leisure and idle activity, there is a subtle yet inescapable sense that the past has no place in the future other than on canvas. The most the Victorians could do was own the past, by way of works of art, books, and artifacts; they were limited to admiring the past, wishing it to be real again. Thus, the use of detail in *Innocent Amusements* suggests that Victorian ideals belonged in the past.

The use of detail in *Through the Fog* creates a very different viewer-painting relationship than that created with *Innocent Amusements*. Art collecting and patronage shifted in large amounts to the middle class due to economic growth after the industrial revolution (Treuherz, 34). The rise of this new class of art collectors opened up new opportunities for artists in terms of subject matter and style as artists often catered paintings for their new middle class patrons. According to Treuherz, “these patrons [middle-class] liked recognizable subjects rather than remote allegory,” (Treuherz, 34). This marks a contrast with the taste of upper class patrons, who preferred flattering allegories of their own lives. Middle class patrons, on the other hand, preferred more realistic works that directly reflected different aspects of their lives. Price’s use of recognizable signage on the ship makes the painting easily relatable to a middle-class patron in and around urban centers such as London. For example, the red sign located on the right side of the painting advertises Madame Tussauds

Fig. 4. (top)  
Fig. 5. (bottom)



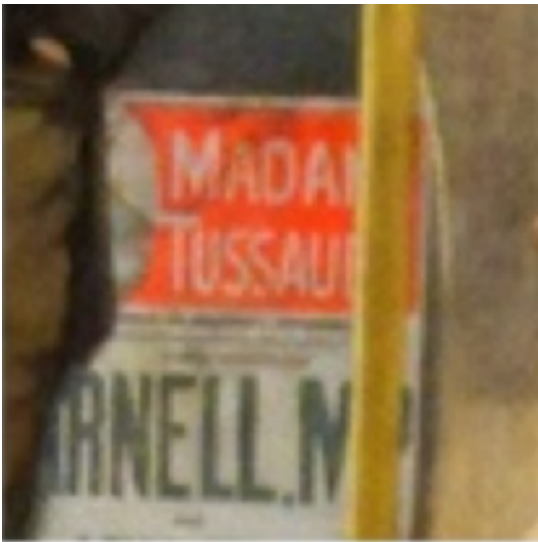


Fig. 6.

Wax Museum, a popular tourist attraction that would have been known to the viewer (Figure 6). Another sign on the left of the painting advertises the Daily Telegraph, a newspaper that would have been read by the viewer (Figure 7). Depicting everyday signs and advertising makes the painting extremely current and relatable to the observer. Advertising had become an important means of communications. Contemporary viewers would have instantly recognized the signs as those they would see out on the street and on penny steamers similar to that depicted in the painting.

The bundle of tools in the painting emphasize the setting as one to which the viewer can easily relate (Figure 8). Located on the left side of the painting next to a man smoking his pipe, it contains a variety of workman's tools, identifying the man as a working class individual. This kind of bundle would have been what many factory workers would have carried with them on their way to work. The presence of this working class individual sets the painting firmly in everyday late 19<sup>th</sup> century England. This is consistent with the rise of the middle class art collector. For such patrons, art was a reflection of the reality of their world as well as an invitation for thought. The presence of a working class individual in a public space is something that many middle class individuals would have seen, particularly in urban settings. *Through the Fog* tells a story of the ordinary individual, from the



Fig. 7.

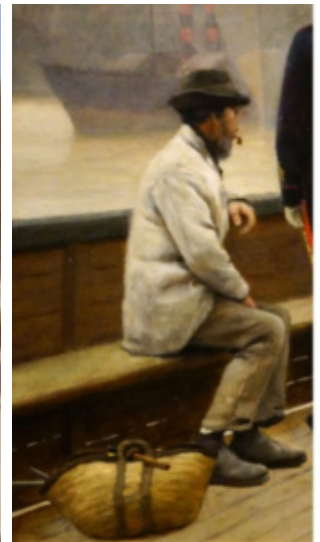


Fig. 8.

laborer to the mother depicted in the center of the painting, from the working to the middle class. It is an acknowledgment not of an untouchable past but of the reality of 19<sup>th</sup> century Britain suggesting an increasing awareness of present and future changes in Victorian society.

In examining the use of detail in *Innocent Amusements* and *Through the Fog*, it becomes clear that each painting establishes very different viewer-painter relationship, one where the viewer must look to a fictional past, and the other where the viewer sees a plausible present. Together, the uses of detail in these paintings hint at the changing dynamics of late Victorian England.

### Use of Space

The use of space in each painting reveals how Victorians saw their relationships to each other with regards to class as well as gender roles in the late 19<sup>th</sup> century. According to Steinbach, "in the Victorian period, spaces became separated, with city and country and public and private particularly distinct from one another" (Steinbach, 11). The distinction drawn between public and private space, where every space had a specific function and a defined boundary, reflected the similar distinction between public and private life.

In *Innocent Amusements*, each group of figures has its own defined space (Figure 1). The young lady is placed clearly in the foreground, the two younger girls in the middle ground, and the two men in the background. There is little interaction between the three groups. Each group of figures engages in a specific activity that does not interact with any of the other groups. The two men in the background engage in business without any perceivable regard for the women inside the home. The two women in the middle ground of the painting gaze at the peacock feather. They do not seem to pay much heed to the woman in the foreground beyond the balance of the peacock feather. The woman in the foreground is focused on the peacock feather, seemingly oblivious to the other groups of figures in the painting. This separation of space between the groups of figures is not uncommon in Roman genre paintings of



Fig. 9.

the Victorian era.

Godward further distinguishes between the home, a private space, and the outdoors, the public space. He frames the door of the home with the entryways leading into the home, which creates a funneling effect that makes the outside world seem even farther from the internal space of the home. This is consistent with the perception and appeal of the rural space by many Victorian patrons. “One immediate response to urbanization was the growth of the notion of the ‘pastoral’... [there was] idealization of rural space as beautiful and unspoiled... of rural society as a quickly disappearing one,” (Steinbach, 13). The separation of the public and private comes as a response to the growth of cities, particularly the shift in demographics as the rural poor migrated to urban centers while the wealthy left the city and escaped to the disappearing rural countryside. The countryside therefore became a symbol of status and wealth that the wealthy attempted to use to reassert their distinction from lower classes. By setting the painting in a countryside home, Godward depicts the home as a retreat from the world, reflecting a similar desire of the upper class to retreat into the country from the urban world.

However, there are signs that the outside world is beginning to invade the home. Godward’s chooses to focus on the atrium of the house, its most ‘public’ space as it is the most open to the outdoors. For example, the vines and leaves on the roof of the home creep like weeds along the roof and begin to descend down into the interior of the home (Figure 9). This suggests the influence of outside forces within the home. Another example of an invasion of the interior space is the presence of pigeons in the home, which fly in from the outside (Figure 10). Pigeons are characteristic of urban centers. As a symbol of the city, their presence in the atrium of the home gives the sense of an invasion of the outside world. Much like with his use of details, there is a feeling of change in the painting, a slight sense of insecurity when it comes to classical Victorian values, consistent with the changing dynamics of the late 19<sup>th</sup> century. Despite the outside



Fig. 10.

world being so far away, its influences can be felt within the home, which is considered one of the most private spaces in Victorian England. According to *Innocent Amusements*, true retreat from the world and its influences seems to be impossible.

The distinction of space, where every space has its own function and role in society, also separated people beyond class. Gender was an important distinction between people to the point where men and women had separate spheres in society. This distinction played an important role in limiting women to

private spaces. “The notion of ‘separate spheres’ dominated women’s lives,” says Black (245). The space of women was deemed to be the home; women were not meant to roam far from it (Steinbach, 133). This separation of space between man and women is yet another example of Victorian compartmentalization in social structure. Like in the class structure, gender was viewed as a distinguishing factor between social groups, each of which required a distinct space in the overall social order. In *Innocent Amusements*, the women are firmly within the space of the home, where they engage in leisurely activities. The men of the painting are located in the background, where they deal with worldly matters (Figure 11). Their placement close to the door associates the men with the public space as does the scroll in the right man’s hand. The two seem to be conducting some form of business, which associates them with the public sphere.



Fig. 11.

An interesting point of comparison is the respective gestures of the young lady with her peacock feather and the man with the scroll (See Figures 3 and 11). The man holds his arm with a sense of purpose; there is tension in the movement as he gestures to his fellow. This gesture gives a sense of seriousness to whatever it is that the men seem to be discussing. On the other hand, the young girl in the foreground of the painting extends her arm with a grace that directly contrasts the gesture of the man. Her task is one of leisure, not of business or necessity. The contrast between the gestures further highlights the separation of space between the men and women of the painting. According to Steinbach, “men made the domestic sphere possible through their work, but were rarely physically present in it,” (Steinbach, 134). Thus, while one space could not really exist without the other, boundaries were still drawn between them. *Innocent Amusements* highlights this idea both in the placement of the figures in the painting as well as in the gestures of the young lady and right-most man in the background. The man, by engaging in business matters, provides the financial stability, which makes it possible for the woman with the peacock feather to engage in such a leisurely activity without worry of the outside world. Thus with regards to gender, the painting lends weight to the idea that the spheres of men and women are distinct, rarely interacting except by contrast. While *Innocent Amusements* seems to insist on separate spheres for men and women, the connection between the two gestures, the two arms extended forward, relates the man and woman to each other. While they exist in separate spheres, they interact with each other by the contrast of their gestures. There exists a relationship between the man and woman. This coupled with the outside influences in the interior of the home subtly suggests a challenge to Victorian values of distinct spheres of space.

The use of space in *Through the Fog* contrasts firmly with that of *Innocent Amusements*. Instead of distinctly compartmentalized spaces, there is one continuous space in which all the figures reside (see Figure 2). Most figures are touching at least one other figure in the painting. Even the one solitary figure in the painting,





Fig. 12.

the working class man sitting on the bench towards the front left of the painting, is related in a way to the rest of the figures with regards to space (Figure 12). The bench he sits on leads the eye into the crowd of figures, giving the man a connection to the other figures of the painting. According to Steinbach, “most people sought not to break barriers or rise as high as possible, but to find happiness at the level at which they found themselves,” (Steinbach, 115). Social mobility, per Victorian values, was not feasible at the time, and thus acceptance of one’s social status was easier than attempting to move up in the social ladder. However, while the man is isolated in terms of class, he still, by way of the bench, shares space with the other figures of the painting, thereby blurring the boundaries between classes. The working class man also relates to the front-most woman wearing a blue dress, who appears to be middle class. Both are painted in similar positions, hunched a little forward and turned slightly away from the viewer. Thus in a way, they occupy a similar, yet separated, space. The way the figures of the painting occupy the total space of the painting suggests the viewers’ awareness of the world in which they live, one where different classes can occupy the same space. The painting challenges the idea of clear and distinct classes by relating a working class man to middle class individuals in a public space.

There is also a difference between the two paintings in the treatment of gender roles, where women begin to occupy the same spheres as men, again threatening the old social order. On the right, both man and woman entertain the crowd, each performing the same role (Figure 13). The crowd contains both men and women watching the performers avidly. An interesting point of comparison is again between the woman in blue and the working class man on the left. Looking at this from a gender perspective, it recalls the similar arm gestures in *Innocent Amusements*. It is clear that here there is a sense of unity in the postures of the figures. Each figure, regardless of gender, occupies a similar space, suggesting that both man and woman can command similar roles in society and foreshadowing the upcoming changes in the roles of women, particularly when World War 1 occurs and women take on what used to be male responsibilities.

*Through the Fog* challenges Victorian values and reflects the changes of the late 19<sup>th</sup> century while *Innocent Amusements* acknowledges the changes but still wishes for the past. In both

paintings, traditional boundaries are tested by the changes impacting late Victorian society with the once hard-line divisions between spaces becoming increasingly indistinct.

### Use of Perspective

The use of perspective in each painting further reflects the mindset of Victorian England in the late nineteenth century. According to Patience Young, “the artist who observes the natural world may convincingly convey every nuance of a time and place – not only the physical surroundings, fashions, and hairstyles, but also the atmosphere which suggests sounds, aromas, the weather. These elements give the picture a sense of immediacy, helping the viewers to feel they are actually at the scene,” (Young, 1). Atmospheric perspective is thus particularly useful in connecting the viewer to the painting, as it is most mindful of the volume of objects and air and the effect this has on the optics of the viewer, (Young, 3) In a sense, atmospheric perspective enhances realism in painting by presenting a more accurate reflection of the perspective of the viewer.

However, in *Innocent Amusements*, linear perspective is dominant in the painting, vanishing slightly off center to where the men are speaking. This allows the viewer to see the degree of separation between the outside world and the inner atrium. The perspective used is mathematical, reminiscent of Renaissance techniques. This mathematical rationality in the painting again gives it an untouchable quality, almost as though it is too real to be true. Furthermore, the narrowing of depth into the painting as the door is framed by the opening to the atrium give the painting a slightly shallow quality because so little of the area behind the atrium is shown (Figure 14). Though there is some use of atmospheric perspective in the depiction of the countryside, most of the



Fig. 13. (top) Fig. 14. (bottom)

painting is done in crisp detail. The use of linear perspective fails to account for the volume of objects as well as the blurred look of objects far from the viewer. This gives the painting an extremely rational and slightly unreal feel.

*Through the Fog* makes use of both linear and atmospheric perspective, giving it a sense of incidental banality that is missing in *Innocent Amusements*. In *Through the Fog*, the vanishing point is located near the harp on the right side of the painting (Figure 15). This extremely off-center vanishing point gives the painting a sense of depth not present in *Innocent Amusements*. It is as though the viewer can walk straight into the painting and become part of that world. *Through the Fog* also uses atmospheric perspective to give the painting a sense of mass and depth. Price's use of the smoke and steam of the industrial processes occurring within the painting makes more distinct objects appear shadowy and farther away. He mimics the way Victorians would have seen such a scene, masked by smoke and steam, hazy and indistinct. The use of atmospheric perspective gives the painting a more natural feel to which viewers can relate than possible with *Innocent Amusements*. The painting strives for a more communal or collective relationship to the viewer by reflecting the world in which the viewer lives.

The difference between the two paintings' treatment of perspective reflects a transition in the mindset of the late Victorians. With regards to "unpretentious depictions of daily life," (Treuerherz, 178) "whilst detail was still an important factor in a work's public appeal, the late Victorians also liked to be moved," (Treuerherz, 179). Thus, more realistic representations made possible through the use of atmospheric perspective became increasingly popular among late Victorian patrons. *Through the Fog* reflects late Victorian changes in the mindset of art with regards to the relationship to a painting. *Through the Fog* becomes part of the world of the viewer, while *Innocent Amusements* remains an idyllic object of the past, distinct from the world of the viewer. The uses of perspective in these two paintings suggest an overall tension



Fig. 15.

in how Victorians viewed the changing dynamics of late 19<sup>th</sup> century England, some praising the idyllic past, while recognizing its place in the past, and others looking to the realistic present.

### Conclusion

The late 19<sup>th</sup> century was a time of change in the mindset and outlook of the Victorians. While some chose to look wistfully to the past, others chose to accept the present. *Innocent Amusements* and *Through the Fog* reflect these contrasting views, one of the higher class, who

preferred the past in which they had dominated English society, and the other of the rising middle class, which began to prosper as part of late 19<sup>th</sup> century changing economic and social dynamics. When compared together, the tension observed between the two paintings reflects the tension noted by scholars within Victorian society. According to Black, "the century closed with defeat abroad and social tension at home," (Black, 14). This tension came not from classes directly challenging each other but from the question of how Victorian values have to change or adapt in the new century as class distinctions and gender spheres began to blur.

However, as seen in *Innocent Amusements*, while the use of detail, space, and perspective held fast to classic Victorian ideals of both painting and societal values, there remains a subtle acknowledgment of the inaccessibility of these Victorian ideals. This same idea is emphasized in *Through the Fog* through Price's use of detail, space, and perspective, which reflects everyday late 19<sup>th</sup> century England. Both paintings reflect how once rigid Victorian ideals of order, hierarchy, and gender separation are challenged as the world entered the 20<sup>th</sup> century. While the two paintings take starkly different approaches, they stem from the same idea of changing social dynamics. Thus, in looking at these two paintings, the viewer can sense the societal turmoil Victorians went through in trying to find a place in a very new world. The fact that there are these two paintings, which serve as mirrors of the same society but depict different images, gives the viewer not only a sense of change in 19<sup>th</sup> century Great Britain, but also more importantly how Victorians viewed their changing society.

Ultimately, each painting questions, and makes its late 19<sup>th</sup> century viewers question, the place of Victorian values in the new emerging world.

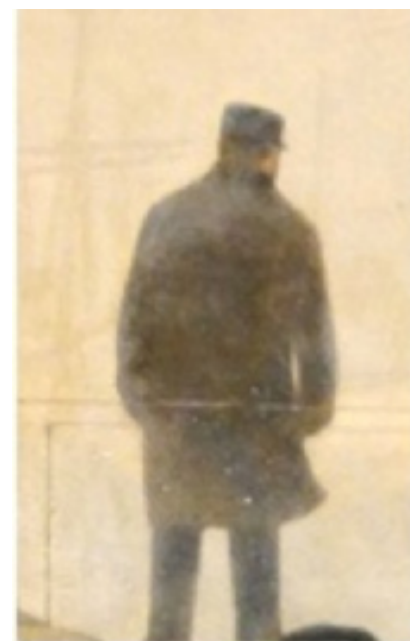


Fig. 16.

*Innocent Amusements* suggests 'the past', which it idealizes. *Through the Fog*, on the other hand, simply suggests 'not here' and proceeds to reflect the transition of these values into late 19<sup>th</sup> century Britain. Both the paintings and the Victorians, like the man at the top of *Through the Fog* (Figure 16), are left looking towards an indistinct and hazy future. The changing social dynamics to which these paintings are witness are vital; they are the foundations upon which the 20<sup>th</sup> century builds upon. Further research into this particular era, a time of slow yet significant social change as seen in these two paintings, may help shed light on the mechanisms by which later changes, from the women's rights movement to the rise of economic and subsequent social mobility, came to be. More generally, it can help scholars further understand how exactly social structure is adapted to changing economic and

social dynamics as well as the implications this may have on the present day individual.

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Judith Pelpola is a sophomore at Stanford University majoring in Biology with a concentration in Microbes and Immunity and minoring in Art History. Her research interests include social disparities in healthcare access and neuroimmunology, with a focus on pediatric care. Judith is also interested in art history as a means to study the social atmosphere of different cultures in response to changes such as war and technological innovations. She will be studying neuroimmunology and British art and architecture while abroad at Oxford in Spring of 2013. She is currently on the core of FLIP (First-Generation, Low-Income Partnership) and is a Practice section and graphics editor at the Stanford Journal of Public Health.



# Predicting Edit Locations on Wikipedia using Revision History

Caitlin Colgrove, Julie Tibshirani, Remington Wong

Stanford University

## Abstract

We explore a novel problem in automatic task design: when a Wikipedia user is viewing an article, which sections would he be most interested in editing? To address this question, we develop a probabilistic model that incorporates both lexical features drawn from a user's revision history as well as simple features of the candidate paragraph. Through experiments on held-out revision histories, we find that the model can accurately predict which paragraph a user is likely to edit. We examine the contribution of different features in the classifier to determine which characteristics of the paragraph are most predictive, and arrive at the somewhat surprising conclusion that most Wikipedia users are copy editors as opposed to content editors.

There has been increasing interest in the machine learning community in automatic task design. In a collaborative problem-solving setting, how can we best break up and assign tasks so as to optimize output? Huang et al., for example, considered the problem of effectively assigning image-labeling tasks to Amazon Mechanical Turkers [1]. In the realm of Wikipedia prediction, Cosley et al. created a successful system for recommending articles a user might be interested in editing [2]. Nicknamed SuggestBot, the system makes use of co-editing patterns and articles the user has previously edited to predict new articles of interest. This system represents a success in automatic task design: deploying SuggestBot increased a user's edit rate fourfold on average.

We consider a complementary problem in Wikipedia task design: given that a user has chosen an article to view, what sections would he be most interested in editing? Our initial hypothesis is that, similarly to article recommendations, a user's personal edit history can help determine which sections he will be most drawn to in the future. When viewing an article about the United States, for example, a politically-oriented user might hone in on sections about the government as opposed to cultural or geographic information. Wikipedia edit history has already shown to be useful in other contexts such as predicting the semantic stability of articles [3], [4]. And in the task at hand, it seems to provide a rich source of personalized training data.

## Contributions

There has been little to no published work on the task of recommending sections in a Wikipedia article. Moreover, SuggestBot did not leverage machine learning in making its predictions. Our main contributions, therefore, lie in formulating

the problem, preparing the relevant data, and exploring a plausible machine learning approach based on the user's edit history. Our final contribution is perhaps negative: the hypothesis that a user's edit history will help us recommend sections does not seem to hold. We ultimately find that while revision history may help in predicting what article a user chooses to edit, once a user has settled on an article, attributes pertaining solely to the section itself are the biggest predictors of whether he will edit that section.

## Data

Using Wikipedia's API, we downloaded the entire revision histories of five Wikipedia users: Hammersoft, JerryOrr, SF007, Tangledorange, and The\_Egyptian\_Liberal. We chose these users because they had substantial edit histories and because they had been editing articles recently. These revision histories contained the diff between the edit and the previous content of the article, as well as information about the text immediately surrounding the revision. For each user, we also downloaded the entire text of his ten most recently edited articles. Each of these articles represented the most recent version of the article available.

From the revision information, we needed to determine which section the user had edited in each of the ten articles. First, we parsed the articles into sections using regular expressions, including a special regex designed to capture the Infobox as a single section. We then tokenized the text of the revision using the Stanford NLP parser [5] and compared it to each section using the Jaccard similarity coefficient to pick the best matching section. Because Wikipedia articles can change a great deal over time, we used only very recently edited articles in an attempt to ensure that there would be a well-matched section.

## Methodology

### Multinomial Naive Bayes

The core of our approach is to train a Multinomial Naive Bayes model over a single user's entire revision history, using individual tokens as features and different sections of a test article as prediction classes. For reasons explained below, we chose to only use text that the user explicitly added or deleted. We also needed to make some modifications specific to our data. First, since revisions are typically very short, we could not obtain a reasonable vocabulary from training only on revisions. This sparseness made smoothing difficult. To remedy this, we chose the vocabulary to be all words present in the most recent ten documents, along with an additional UNKNOWN token for words that did not appear. We then applied add-alpha smoothing

User	Baseline	NB	NB with MI	NB with full context	Best with prior	Max	Average # of section
JerryOrr	0.8	0.4	0.3	0.6	0.5	0.8	15.8
Hammersoft	0.7	1	0.8	1	1	1	9.6
SF007	0.8	0.6	0.6	0.6	0.7	0.8	12.8
The_Egyptian_liberal	0.6	0.8	0.7	0.8	0.8	0.8	20.5
TangledOrange	0.8	0.8	0.9	0.8	0.8	0.9	11.7

Table 1. Fraction of test documents in which the edited section was ranked in the top three.

to the entire vocabulary.

To make a prediction on a test article, our initial classifier simply calculated the likelihood of each section given the probabilities of the words it contained. We then ranked sections by likelihood and output the ranks.

Our initial results showed that our classifier overwhelmingly favored short paragraphs. We therefore introduced length normalization to all of our models, taking the geometric mean of the product of probabilities. We also experimented with changing the prior. Instead of assuming a uniform distribution over sections, we tried modeling edits as being uniform over words. The new prior is then given by the number of words in the  $i$ th section divided by the total words in the document. Concretely, let  $n_i$  denote the number of words in the section and  $T$  be the total number of words in the document. Then our prediction for each document is given by

$$c = \operatorname{argmax}_i \frac{1}{n_i} \sum_{j=1}^{n_i} \log p(\text{word } j) + \log \frac{n_i}{T}$$

The probabilities are calculated using the usual maximum likelihood estimates. In particular, letting  $m$  represent the number of revisions,  $R_i$  be the words in revision  $i$ , and  $V$  be the vocabulary we have

$$p(\text{word } j) = \frac{\sum_{i=1}^m I_{\text{word } j \in R_i} + \alpha}{\sum_{i=1}^m |R_i| + \alpha|V|}$$

To clarify,  $I_{\text{word } j \in R_i}$  takes value 1 if word appears in revision  $i$ , and otherwise takes value 0. Our baseline model is based on this new prior, and simply predicts the longest section in the article.

### Mutual Information

Related to our preference for short sections, we hypothesized that the likelihoods for long sections were being swamped by uninformative words. Therefore, to improve accuracy and correct for length of sections, we introduced a mutual information metric to select features. More formally, the mutual information for a word is given by

$$MI(\text{word } j) = \sum_{w \in W} \sum_{c \in C} p(w, c) \log \frac{p(w, c)}{p(w)p(c)} = \sum_{w \in W} \sum_{c \in C} p(w|c) \log \frac{p(w|c)}{p(w)}$$

where  $W = \{\text{present, not present}\}$  and  $C = \{\text{revised, present in a document but not revised}\}$ . We chose the top tokens most predictive of whether or not a section would be edited, as determined by the mutual information calculation (we settled on  $n = 1000$ ). Using the selected features, we recalculated the Naive Bayes scores, now only considering the most predictive tokens.

### Context and Document Weighting

Because revisions are so sparse, we experimented with the

inclusion of two other types of text. The revision information we downloaded contained both the lines actually edited and a few lines surrounding the change. We tried including this edit context to increase the amount of training data. We also experimented with the use of text from the entire article when it was available, introducing a discount factor for words that appeared in the article but not in the revised paragraph (after some tuning we set  $\gamma=0.7$ ). Letting  $D_i$  represent the document associated with revision  $i$ , our new maximum likelihood estimates become

$$p(\text{word } j) = \frac{\sum_{i=1}^m I_{\text{word } j \in R_i} + \gamma I_{\text{word } j \in D_i} + \alpha}{\sum_{i=1}^m |R_i| + \gamma|D_i| + \alpha|V|}$$

### Testing

We trained separate models for each of our five users. To test our results on a particular user, we performed leave-one-out cross-validation on the user's ten most recently edited documents. More specifically, our training set was comprised of a user's entire revision history (except for those diffs pertaining to the test document), and for certain models also included text from the 9 documents that were not left out. During testing, we ran the model on the left-out article and outputted the predicted ranking of each section in the left-out article. To evaluate our output, we considered the rank of the highest-ranked section that was actually edited by the user (the great majority of the time there

was only one, but occasionally there were many edited sections).

### Results

While we ran many experiments on our data, we can represent our main findings through the results of five different classifiers: (1) our "longest section" baseline, (2) pure Naive Bayes, (3) Naive Bayes with feature selection, (4) Naive Bayes using context and downweighted document text, and finally (5) the best out of the previous three with our new prior based on section length.

Considering a "success" to be ranking the correct section in the top three, our algorithms performed very well (see Table 1). However, the new prior was the largest contributor to this success. In most cases, our baseline – which makes predictions solely based on section length – was able to successfully predict the section edited in eight out of the ten test documents. In two out of our five users, this baseline gives arguably the best results of any method we tried (Figure 1). Naive Bayes did improve somewhat on this baseline for two of the other three users (Figure 2) and matched it on the third.

After noticing that some documents were quite short, we ran several trials in which we chose the ten most recent documents with ten or more sections, and we saw that the results were significantly worse than the results on the long documents in our original training set. However, because finding these ten longer



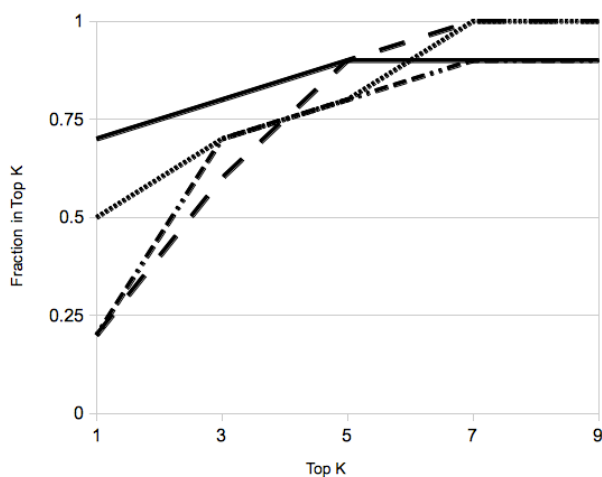


Fig. 1 Results for SF007

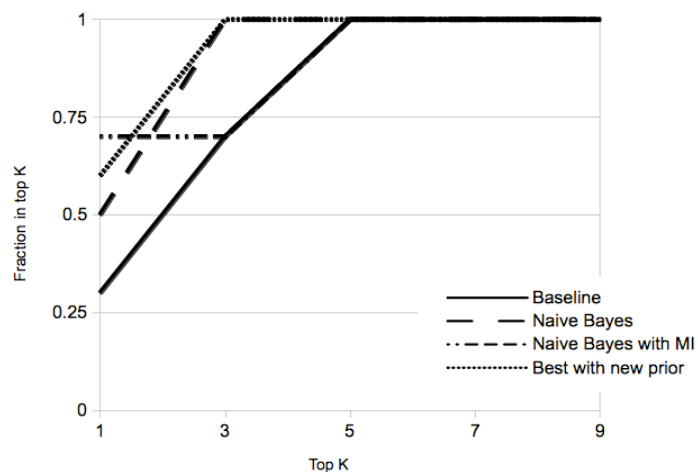


Fig. 2 Results for Hammersoft

documents meant using much older revisions, the accuracy of our matching was worse, and thus likely negatively impacted the overall prediction.

### Error Analysis and Discussion

Our models overall performed well on all users, but different versions performed better for different users. For example, Naive Bayes worked quite well on Hammersoft because his edits followed a distinct trend: he often focused on correcting factual information in Infoboxes and taking down images that did not comply with Wikipedia standards. This meant that tokens common in Infoboxes and image links were highly predictive (indeed, the top features selected by mutual information for Hammersoft included the Infobox markup tokens “{”, “}”, as well as “.png”).

On the other hand, while SF007 frequently edited articles about software, he did not display a similar interest-based preference as to which sections he edited. For users like these, it seems as though modeling the overlap in content between a user’s previous edits and the test section is not the best approach. Moreover, while using this overlap to predict which articles a user will edit may be effective, the sections within an article are already semantically similar. It is very difficult to capture semantic content in such a fine-grained way so as to make accurate distinctions between sections.

In many cases, then, it seems that attributes pertaining only to the section itself have the most predictive power. Indeed, we achieved a startlingly good performance with our baseline using a single, simple attribute of each section. These observations also help explain why adding the context around an edit and using the full text of the revised document did not significantly improve our results.

While most attempts to deal with length problems had some beneficial effect, using mutual information did not seem to produce the same improvements. Using only a few features seemed like a natural way to make sure that all the words being counted were of high quality. However, this approach suffered from the fact that our training data was already sparse, and so discarding terms meant losing some of the little information we had. As a result of this sparsity, if a paragraph had none of the words we determined to be important, it would immediately be ranked very low even if it had a significant number of moderately

informative words.

### Future Work

Our error analysis strongly suggests that many users do not edit for content, so accounting for this difference in editing patterns could significantly improve accuracy. One plausible interpretation is that some users are “copy editors,” while others are “content editors”. It seemed that most of our users, especially SF007, were copy editors and simply focused on paragraphs that were poorly written or not well-cited, while a few users – like Hammersoft – had a distinct preference for editing tabular and visual content. Adding features based on the section itself, such as the previous number of additions, deletions, and revision reverts; the number of distinct users that have edited the section; and perhaps some sort of “controversy rating” could greatly improve accuracy on our copy editors.

A more sophisticated model would posit a latent binary variable representing the user’s editing style. Based on the value of this variable, certain features would be weighted differently: for content editors, the user’s revision history would play a larger role in comparison to copy editors, for whom attributes of the section itself would become more important. Elaborating on this idea of user profiling, another idea is to cluster users into groups based on editing behavior. Then, when making predictions for a particular user, we could also take into account the revision histories of other users in the same cluster. Such clustering could also solve the problem of sparse revision text.

Finally, we spent a good deal of time on data collection, and there are a number of logistical issues that could be resolved. In particular, this paper we matched each revision to a corresponding section in the latest version of the article, which forced us to consider only recent revisions in the testing set. In future work, we would expand our testing set by downloading the actual version of the article that the user saw when making the particular edit.

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Caitlin Colgrove graduated class of 2012 with a BS and MS in Computer Science from Stanford University, with concentrations in Theory and Artificial Intelligence. Outside of academics, Caitlin enjoys playing clarinet and spent four years with the Stanford Wind Ensemble. She is currently working as a software engineer at Palantir Technologies in Palo Alto, CA.

Julie Tibshirani is a master's student in computer science at Stanford University, and this paper was written while she was a senior studying math (also at Stanford). Her academic interests lie mainly in machine learning and databases, and she is currently a member of Stanford's Natural Language Processing group. She loves to teach and has worked both as a tutor and teaching assistant. In addition to computer science, Julie enjoys dancing, hiking, and reading philosophy.



Remington Wong is a second-year coterminial student in computer science. His main academic interests are systems, artificial intelligence, and theory. He enjoys coding and teaching, and has written several Web applications that help CS 103 students learn about finite automata and regular expressions.

# Detecting Associations between Knee Rotational Laxity and Kinematics in a Healthy Population

Mahta Baghoolizadeh and Alison Keiper

Stanford University

## Abstract

Passive knee laxity, which is determined by the soft tissue and articular structures of the knee, allows for translation and rotation of the knee. While laxity increases following soft tissue injury, there is a lack of clinical evidence demonstrating a relationship between increased passive laxity and subsequent clinical problems such as osteoarthritis. However, there is increasing evidence that abnormal active rotational kinematics during walking are a potential risk factor for osteoarthritis (OA) initiation and progression. Establishing a relationship between passive knee laxity and active knee kinematics is therefore clinically important, but at present there is a paucity of information on this interaction between passive and active knee movement. The purpose of this study was to test for correlations between passive knee laxity and active knee rotational movement.

Active knee kinematics of 15 healthy subjects was evaluated during walking and jogging, and translational and rotational passive laxity was tested with the KT1000 and custom Knee Rotation Device (KRD), respectively.

The results showed that increased rotational laxity correlated with increased knee rotation during the stance phase of walking ( $R^2 = 0.41$ ,  $p = 0.03$ ), but this relationship was not significant during the stance phase of jogging ( $R^2 = 0.19$ ,  $p = 0.17$ ). There was no correlation between translational and rotational knee laxity ( $R^2 = 0.06$ ,  $p = 0.26$ ) or translational laxity and rotational kinematics ( $R^2 = 0.03$ ,  $p = 0.25$ ). These results suggest that the structures of the knee that determine passive rotational laxity influence rotational motion while walking more significantly than while jogging, possibly because of the stronger influence muscle activation has on knee rotation while jogging.

In conclusion, the correlation between rotational laxity and kinematics may explain why ACL deficient and reconstructed individuals, who display abnormal rotational knee motion during walking, develop early-onset osteoarthritis.

Recently, the medical and scientific communities have shown heightened interest in understanding knee laxity and its impact on the ambulatory motion of the knee. Knee laxity is influenced by the support structures of the knee, such as the ligaments, menisci, and muscle tendons [1-2]. Knee laxity is most commonly measured during two different motions at the knee: anterior-posterior translation and internal-external rotation [3]. Translational laxity can be measured clinically by

the KT1000 device [4], but rotational laxity does not have widely adopted or useful clinical tools for measurement [5-7].

Accurately measuring rotational knee laxity is especially important because abnormal rotational laxity has been reported after anterior cruciate ligament (ACL) and meniscus tears [5, 8, 9]. The ACL functions to resist anterior translation and internal rotation of the knee [10], and the meniscus functions to disperse the weight of the body and reduce friction during movement in the knee [11]. Individuals with an ACL or meniscus tear are also at a high risk of developing early-onset osteoarthritis (OA) [12], a disease suggested to be caused by changes in the load-bearing regions of cartilage in the knee [13]. Given that abnormal rotational laxity follows these injuries, it is necessary to better understand the impact of rotational laxity in healthy knees on other knee functions and its role in altering knee loading patterns and OA development.

While studying laxity provides information on the passive translational and rotational motions of the knee, analyzing knee kinematics, provides greater insight into the active translational and rotational motions of the knee during weight-bearing activities such as walking or jogging. As with rotational laxity, significantly abnormal rotational kinematics have also been detected in individuals with meniscal tears, ACL tears, and ACL reconstructions [10, 14-16]. Kinematic data reveal the extent to which the knee rotates under load, which is relevant to understanding the initiation of OA because during altered rotation, the loading profiles of the cartilage in the knee can change. Cartilage, which has previously been conditioned for specific loading, begins to see altered loads for which it is not well adapted, which is believed to initiate the degenerative process [13, 17].

A previous study has shown that the translational laxity measured with the KT1000 can predict translational kinematics of ACL reconstructed knees [18]. However, despite many studies on knee rotational properties [1, 5-7, 16, 19-21], there remains a lack of knowledge on the relationship between knee rotational laxity and kinematics. Physicians believe that a more "vertical" ACL graft placement during reconstruction results in abnormal dynamic rotational motion [22], but there is no present clinical test to assess this relationship. A greater understanding of the relationship between passive rotational laxity and active kinematics may provide insight onto the risk factors for OA development.

A new device named the Knee Rotational Device (KRD) has recently been developed in the Stanford University Biomotion



Fig. 1. Subject with reflective PCT markers used for motion tracking with Qualysis.

laxity.

## Materials and Methods

Fifteen healthy subjects were recruited based on the following selection criteria: aged between 18 and 40 years, BMI under 28, and no previous knee injury (avg 24 years old, 1.67 m, 62 kg). IRB-approved informed consent was obtained from each subject.

Data for active tibial rotation were collected according to a previously described protocol [23, 24]. Each subject was recorded performing three walking and jogging trials at a self-selected normal speed. The point-cluster technique, a set of 21 skin-based reflective markers, was employed to determine the amount of rotation of the tibia in relation to the femur during these trials (Fig. 1). A 9-camera optoelectronic motion capture system, Qualisys, was used to collect marker motion data. The subject walked and jogged over a force plate (Bertec, Columbus OH) embedded in the floor to allow for identification of the stance phase of walking. The stance phase of the walking cycle is defined as when the foot is in contact with the ground. Stance phase knee rotation from the three trials was averaged, resulting in one rotation value for each activity per knee per subject. The absolute side-to-side difference in knee rotation was calculated for the subject, with the left knee used as the reference. The motion of the knee was tracked by relating the motion of the marker clusters to

Laboratory to measure passive rotational laxity for this purpose. The objective of this study was to assess correlations in healthy individuals between passive knee laxity and active kinematics by testing the following hypotheses: 1.) Increased rotational knee laxity is associated with increased knee rotation during walking and jogging; 2.) Increased anterior-posterior (AP) translational knee laxity is associated with increased knee rotation during walking; 3.) Increased AP translational knee laxity is associated with increased rotational knee

anatomical coordinate systems based upon bony landmarks from the reference trials. This method of motion analysis has been previously described [10, 24, 25].

After completing the walking and jogging trials, each subject was tested with the KRD to measure passive rotational laxity while wearing the reflective markers used during the gait test (Fig. 2). The KRD consists of an orthopedic boot mounted to a stable circular platform that enables rotation in the axial plane. Each subject lied down in the supine position on a mattress with one foot strapped into an ankle brace within the orthopedic boot, which limited ankle rotation. To minimize coupled femoral rotations, the knee was positioned at 25 degrees of flexion, which was measured by a goniometer, and a large strap was placed across the subject's thigh (Fig. 3). Ankle and femoral rotation were limited to allow for measurements of only the rotation of the tibia relative to the femur. Two unloaded reference trials were recorded with each subject's knee in natural alignment, followed by two loaded trials when a constant torque of 3.5 N was applied once a 1.8 kg weight was attached to the device. The weight rotated the platform axially, resulting in the isolated rotation of the tibia (Fig. 3 and 4). This torque was determined to be safe based on results from previous studies with similar or larger applied torques [5, 20, 21]. Subjects were instructed to relax the leg muscles during the loaded trial to allow for passive tibial rotation.

Individual knee rotation values were calculated for the reference and loaded trials based on the orientation of the reflective marker clusters of the tibia with respect to the femur. The amount of knee rotation was averaged for each of the two trials, and then the average amount of rotation during the reference trial was subtracted from the average amount of rotation during the loaded trial. The absolute side-to-side difference in average rotation was calculated for each subject, with the left knee used as the reference. This value was used in the following equation to calculate rotational laxity, resulting in one rotational laxity value per subject.

$$\text{Knee Rotational Laxity} = \frac{\text{Tibial Rotation (deg)}}{\text{Applied Torque (N} \cdot \text{m)}}$$

Immediately following rotational laxity testing, each subject was tested with the KT1000 device to measure translational knee laxity. In order to eliminate interpersonal variability with the device, one person conducted all KT1000 tests and measured maximum anterior translation. Absolute side-to-side differences



Fig. 2. Image of Knee Rotation Device (KRD). A weight of 1.83 kg applies a 3.51 N torque, rotating the platform axially.

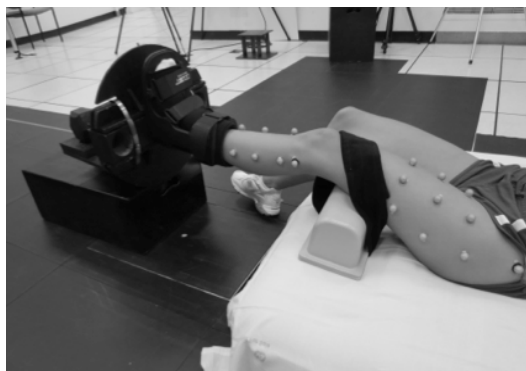


Fig. 3. Rotational laxity testing set-up with KRD. Subject lies with foot in orthopedic boot with the knee at 25 degrees of flexion. A black Velcro strap is placed over the thigh to prevent femoral rotation.



Fig. 4. Image of weight applied to KRD. Motion capture cameras detect changes in position of the reflective markers on the tibia and femur to calculate the knee rotation.

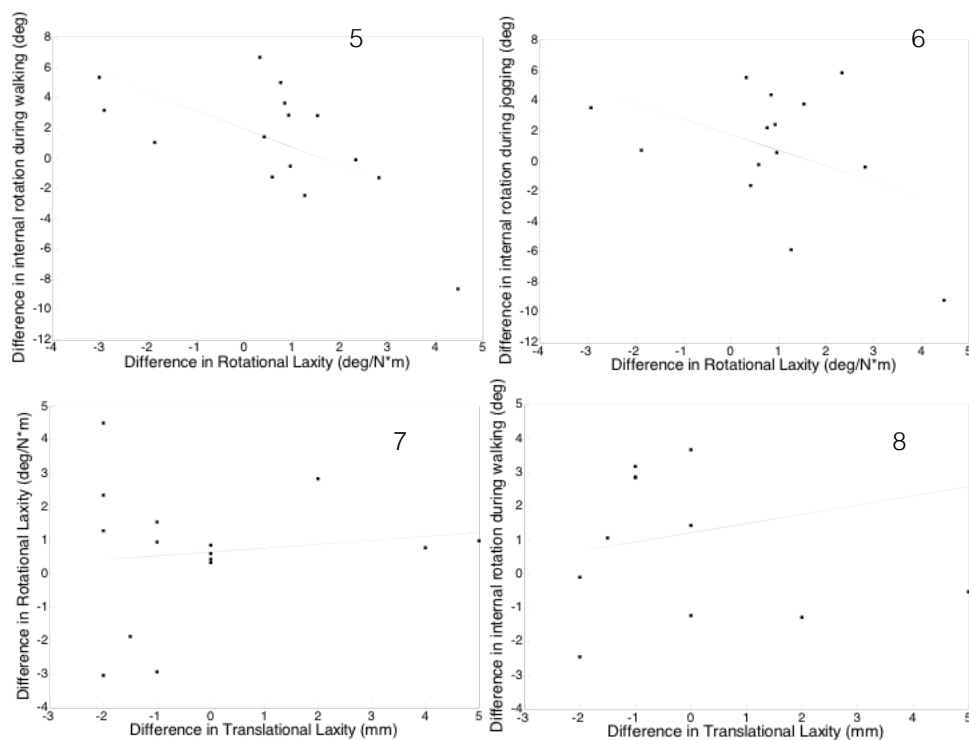


Fig. 5. Side-to-side difference in rotational laxity compared to side-to-side difference in average internal rotation of the knee during the stance phase of walking ( $R^2 = 0.41$ ,  $p = 0.03$ ).

Fig. 6. Side-to-side difference in rotational laxity compared to side-to-side difference in average internal rotation of the knee during the stance phase of jogging ( $R^2 = 0.19$ ,  $p = 0.17$ ).

Fig. 7. Side-to-side difference in translational laxity compared to side-to-side difference in rotational laxity ( $R^2 = 0.06$ ,  $p = 0.26$ ).

Fig. 8. Side-to-side difference in translational laxity compared to side-to-side difference in average internal rotation of the knee during the stance phase of walking ( $R^2 = 0.03$ ,  $p = 0.25$ ).

were calculated, with the left knee used as the reference, resulting in one maximum translational laxity value per subject.

Four linear regression statistical analyses were performed on the data sets. First was a comparison of side-to-side rotational knee laxity differences to the average amount of knee rotation during the stance phase of walking, followed by the same laxity difference compared to the average amount of knee rotation during the stance phase of jogging. Third, side-to-side differences in translational laxity were compared to side-to-side differences in rotational laxity. Lastly, these translational laxity differences were compared to the average amount of knee rotation achieved during the stance phase of walking. Significance was determined with an alpha value set at 0.05.

## Results

During the walking and jogging trials of the gait analysis, the subjects showed an average side-to-side difference in internal tibial rotation throughout stance phase of  $1.19^\circ \pm 3.82^\circ$  and  $0.85^\circ \pm 4.25^\circ$ , respectively. The average side-to-side difference in rotational laxity measured by the KRD was  $0.63^\circ \pm 2.01^\circ/\text{Nm}$ , and the average side-to-side difference in maximum translation measured by the KT1000 was 0.1 mm.

After comparing the knee rotational laxity to knee rotation during the stance phase of walking, the linear regression showed a significant correlation between greater rotational knee laxity and greater rotation during gait ( $R^2 = 0.41$ ,  $p = 0.03$ ) (Fig. 5). However, the correlation between rotational knee laxity to rotation during the stance phase of jogging was not statistically significant ( $R^2 = 0.19$ ,  $p = 0.17$ ) (Fig. 6). The amount of knee translational laxity showed no significant correlation with the amount of rotational laxity ( $R^2 = 0.06$ ,  $p = 0.26$ ) (Fig. 7), nor was it associated with the amount of knee rotation during the stance phase of walking ( $R^2 = 0.03$ ,  $p = 0.25$ ) (Fig. 8).

## Discussion

### Correlation between rotational laxity and knee rotation during walking

The results supported the hypothesis that increased knee rotational laxity is correlated with increased knee rotation during the stance phase of walking, which suggests that the structures that determine passive laxity do influence knee rotational motion during walking.

This finding that passive rotational laxity influences dynamic rotations may explain why individuals with ACL ruptures or reconstructions display a 60-90% higher risk of developing OA in their injured knee than their contralateral knee [12, 27]. While the ACL functions to resist anterior translation and internal rotation of the knee, there is increasing evidence that abnormal knee rotational kinematics is the critical factor in the development of knee OA in this population [13]. It has been reported that reconstructed knees display abnormal rotation during walking relative to the contralateral knee [16], but passive rotational laxity has yet to be studied. It is possible that the increased abnormal laxity following injury leads to abnormal rotational kinematics in ACL reconstructed knees during walking, which may be a potential risk factor for osteoarthritis. Given that physicians report that ACL grafts are often placed more vertically than the native ACL during reconstruction, this more vertical orientation may be causing abnormal rotational laxity, which may lead to abnormal rotational kinematics and eventual OA development.

This correlation may also explain why women have a greater risk of developing early-onset osteoarthritis than males. Previous studies have shown that not only do women display greater rotational knee laxity than males [5, 20, 28], but are also 1.7 times more likely to develop early-onset OA [28]. A study of female knee cadavers reported that knees with OA had significantly greater laxity than knees without OA [29]. Based on similar results, several researchers have inferred that abnormal laxity leads to premature osteoarthritis [29, 30]. The results of this laxity



study establish that increased rotational laxity is associated with increased rotation at the knee during walking, which motivate further studies on gender differences in knee rotation during walking and rotational laxity to determine if these are risk factors for osteoarthritis in women.

### Correlation between rotational laxity and knee rotation during jogging

Although increased rotational laxity was significantly correlated with increased rotation of the knee during the stance phase of walking, the hypothesis was not supported for the results of the jogging trials. There was a trend towards increased rotational laxity correlating with increased rotational kinematics during jogging, but it was not statistically significant. This weaker correlation during jogging is possibly due to greater muscle activation during jogging than during walking [31]. Increased muscle activation has been suggested to limit the amount of knee rotation [24, 32, 33], which would explain why the relationship between the passive and active motion is not as significant during jogging. Since the KRD only measures passive rotational laxity, it is understandable that rotational laxity is not correlated as significantly with active rotation during jogging than during walking.

### Correlation between translational laxity and rotational laxity

Comparing the rotational and translational laxity results showed that the two laxity measurements are not associated with each other, suggesting that one laxity measurement should not be used to predict the other. Clinicians often evaluate general body laxity by bending the thumb back to the wrist or hyperextending the fifth finger, and relating the degree of laxity present within that joint to all joints [34]. However, our findings suggest that general laxity measurements are not sufficient in describing joint laxities in all directions of motion. This suggests that translational laxity measurements of the knee would not be sufficient in predicting rotational knee kinematics, and that independent rotational laxity testing would be necessary to make this prediction.

### Correlation between translational laxity and knee rotation during walking

The fact that passive AP translation was not associated with the amount of knee rotation during walking is consistent with clinical studies that report restoration of normal translational knee laxity after surgery does not mitigate the risk of premature OA [19]. These results point to the need for an independent measure of passive rotational laxity in patients with ACL injury. The finding that the range of passive rotational laxity in a healthy population correlates with variation in dynamic rotation during walking suggests that the increased passive rotational laxity following ACL injury will be a good marker for abnormal dynamic rotation during walking since the range of rotational laxity will be greater.

### Limitations

This study had several limitations in both the laxity and kinematics testing. Although the design of the KRD attempts to minimize ankle motion, it is uncertain the extent that a subject's ankle rotated within the device. To limit this error, we used verbal

feedback from the subjects regarding their ankle motion during laxity testing and adjusted the ankle brace if they reported motion. The skin-based marker system for estimating knee kinematics may have also introduced error. The reflective markers reveal the motion of the skin and the soft tissue overlying the bone instead of the bones themselves, but the point cluster technique attempts to minimize this error [35]. Other kinematics testing methods exist, such as cine-MRI, fluoroscopy, and high-speed radiography, but skin-marker-based motion analysis still remains the most feasible and effective way of tracking kinematics during overground walking.

### Conclusion

This study demonstrated the potential to develop a clinical test to assess passive rotational laxity that can reflect dynamic function. This test could help evaluate the capacity of ACL reconstruction to restore dynamic rotation, and more importantly, the test could be used to avoid the risk of OA in the long term. Clinicians would benefit from the immediate feedback supplied by the meaningful measure of passive rotational laxity following ACL reconstruction. Future studies may include using this clinical test to determine whether small variations in ACL graft placement have an affect on active rotational kinematics that can be predicted by the rotational laxity measurements. It is possible that restoring natural rotational laxity with more native graft placement will restore normal rotational kinematics, which may reduce subsequent clinical problems following reconstruction such as OA.

### Acknowledgements

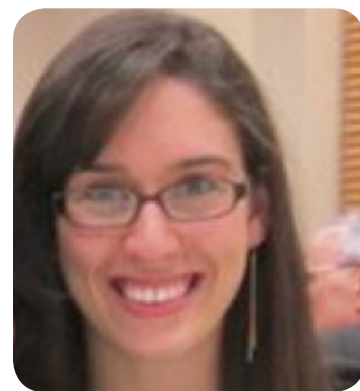
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Mahta Baghoolizadeh is a Senior majoring in Biology and minoring in History at Stanford University. Apart from being interested in the biomechanics of the knee, Mahta enjoys playing basketball and serving as the president of the Muslim Student Awareness Network at Stanford. Following graduation, she hopes to spend a year working in orthopedics and sports medicine before beginning medical school.



Alison Keiper is a Senior majoring in Biomechanical Engineering, with a specific interest in surgical robotics. She serves as the Vice President of Business Development for Stanford Students in Bidesign, and she enjoys playing tennis and listening to music in her free time. Next year, Alison will pursue a Master's in Mechanical Engineering at Stanford, following the Mechatronics track.

# Measuring Response in *Escherichia coli* to Electrical Currents Through the Repurposing of Sigma-32 Architecture

Justo Caballero, Shamik Mascharak, and Sibel Sayiner  
Stanford University

## Abstract

A large portion of advances in biotechnology over the past few decades have been predicated on the integration of genetically modified biological systems and non-biological systems. Despite the diversity of such progress, the intersection between electrical circuits or currents and synthetic biology has been incredibly under-researched, especially given the potential advances in the control of cellular dynamics. Given the extensive controls over current that have been developed, application of such complex mechanisms to cells would greatly increase engineering capabilities and control. In an attempt to address this gap, we repurposed sigma-32 architecture in *E. coli* cells to express GFP (Green Fluorescent Protein) via indirect heat shock from an electrical current. After transforming the cells and confirming the integration of our genetic construct, we ran an electric shock assay by placing cells and LB broth into a gel electrophoresis machine and applying 400 mA of current. Our GFP expression data revealed an oscillating pattern mirroring the cyclic nature of sigma-32 production in *E. coli* cells. Moreover, this expression pattern is limited to an electrical current induced heat shock and was not noted in our control tests. Thus, we posit a direct and potent connection between electrical currents and synthetic biology. Furthermore, we believe this system can be optimized for system characterization and periodic response time control.

When considering the recent advances of biotechnology, one can discern an overwhelming research focus: the integration of genetically modified biological systems and non-biological systems on both a large (e.g. tissue cultures) and small (e.g. nanobiotechnology) scale. These integrations vary from studying the effects of dead organisms on immune responses linked to food allergies [1] to using self-assembling amino acids to produce nanofibers, nanotubes, and nanovesicles [2]. One intersection of biology with a non-biological system that has yet to be deeply explored is the junction between electricity or electric circuits and synthetic biology.

There has been some progress in this field. Researchers have recently begun to encode markers, like GFP, into existing natural biological circuits [3], effectively programming on top of hardware and attempting to create standardized systems to ease genetic programming [4]—essentially a programming

language for cells. These advances allow for increased control by bioengineers, yielding the ability to create more complex systems. For example, some researchers have considered modifying biological systems to produce more energy in microbial fuel cells [5] or convert waste through microbial electrochemical processes [6]. In both cases, organisms produce energy through modified biological pathways. Unfortunately, there has been a distinct lack of study in genetically programming biology to react to electricity or an electric circuit.

Our research falls within this recently emerging subject and addresses the possibility of biological systems functioning as or within microelectronic systems. Specifically, we wished to genetically engineer *Escherichia coli* to respond to an electric signal, “turning on” a gene and expressing a given product (i.e. GFP). We believe this addresses a current gap in the research literature, namely the lack of integration of programmable electrical currents with genetically encoded cell responses. Though one study successfully spiked *E. coli* with a fluorescent voltage-indicating protein, it required a novel genetic design focused solely on cell membrane electric potential and a specific product that is not easily standardized; however, it suggests the important fact that bacteria could be electrically regulated and, therefore, is critical to further research into the connection between electric potential and cellular response [7].

Thus far, there has been research on the electrostatic potential of the entire *E. coli* genome, as well as patterns of specific promoters that can be affected by sigma factors [8]. This research culminates in a study noting that myoelectrical activity (generated by the small intestine smooth muscle) can induce heat-shock response in *E. coli* [9]. A fundamental limitation of the Fluorescent Voltage-Indicating Protein route is that it doesn’t allow for decoupled sensing/actuating. Despite having the same input (voltage), the output is a fixed fluorescent response. On the other hand, cells modified with a sigma-32 induced response pathway are far more flexible and allow for a wide range of desired responses. Any number of fluorescent proteins can be coded for in the sequences following the sigma-32 activated sensor (i.e. a repurposed sigma-32 induced promoter), allowing for a number of different emission wavelengths and greater optical flexibility. Taking advantage of this existing architecture, we genetically modified *E. coli* cells to express GFP from an electrical current signal, which creates indirect heat shock. Our normalized GFP expression data followed an oscillating pattern, which we posit mirrors the cyclic nature of sigma-32 production in *E. coli* cells.

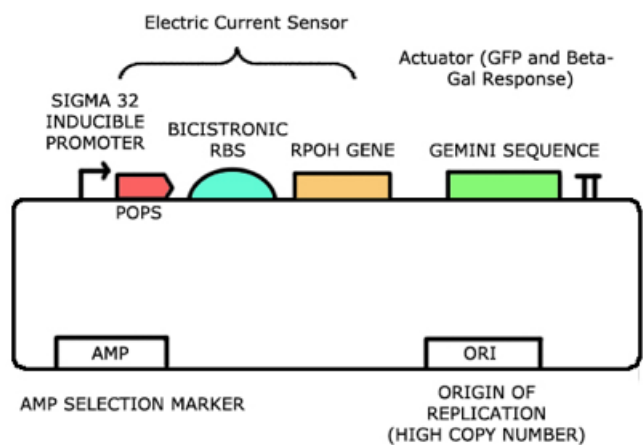


Fig. 1 A map of our plasmid design, including the various genetic components: sigma-32 inducible promoter, bicistronic Ribosome Binding Site, *rpoH* gene, Gemini sequence, high-copy number origin of replication, and Ampicillin selection marker. (Composite part number: BBa\_M36604 in PartsRegistry.org [16])

## Methods

Given the desire for a standardized sensor, we decided on utilizing PoPS signal as a means of communication between our part and any given actuator. A common gene expression signal, the flow of RNA polymerases along the DNA (PoPS or polymerases per second) is a simple standardized output signal [10]. Our genetic construct consists of a sigma-32 inducible promoter (BBa\_J45504) [11], a medium-strength bicistronic transcriptional design (BBa\_M36405) [12], a gene that produces sigma-32 (*rpoH*, BBa\_M36888) [13, 14], and, for testing purposes, an actuator system which includes the Gemini reporter (Figure 1). The Gemini sequence consists of a GFP coding region, beta-galactosidase coding region [15], and a transcription terminator. This system is integrated into a high-copy plasmid with Ampicillin resistance as its selection marker.

Our design capitalizes on *E. coli*'s natural production of sigma-32, a stress factor that reacts to heat-shock [17]. It has been noted that an electrical current can induce this heat-shock due to compounds within the cytoplasm that resist electricity, thereby acting as resistors and building up heat [18]. With regards to specific parts, we looked to existing cellular components. The sigma-32 inducible promoter is a naturally existing promoter in *E. coli* [19]; we sourced this sequence from the PartsRegistry [11]. Induction by the presence of sigma-32 then initiates transcription of the *rpoH* gene, which occurs naturally and encodes for the stress factor, thereby creating a positive feedback loop and amplifying PoPS signal. The bicistronic design is of medium strength to avoid placing too high a resource load or translational burden on the cellular chassis while allowing for detectable GFP expression via Gemini actuator. We sourced the sequence from BIOFAB [20] and added the part to the PartsRegistry [12]. The sequence for *rpoH* was first characterized and sequenced in *E. coli* by Manzanera et al [21]; we obtained a sequence from the W3110 strain at the Generic Genome Browser [22] and added the part to the registry as well [14]. As stated before, the actuator can be decoupled from the sensor, and expression will therefore depend on the specific system. In our case, the Gemini reporter was

employed. Measurements from the expression of this actuator correlate with the production of sigma-32 (see the Discussion section).

In our experimental design, TOP10 *E. coli* bacterial cells were first streaked onto agar plates and incubated overnight at 37 degrees Celsius. After overnight growth, a single colony was picked and placed into LB broth to again incubate at 37 degrees Celsius overnight. Unmodified *E. coli* stocks were preserved in 50% glycerol and stored at -80 degrees Celsius [23]. For uptake of our plasmid, *E. coli* cells were made chemically competent by a calcium soaking protocol; aliquots of *E. coli* glycerol stock were centrifuged, the supernatant discarded, and the cells subsequently re-suspended multiple times in calcium chloride before freezing in overnight storage. Cellular transformation was carried out by repeated cold-heat shocks and incubation of a cell-plasmid mixture (200-400ng DNA for each aliquot of cells) [24]. Modified *E. coli* was spread on LB (as a positive control) and LB + amp plates and incubated overnight. Finally, a single colony from the LB + amp plate was grown up and preserved in frozen glycerol stock.

To test for sensing activity, liquid cultures of unmodified and transformed TOP10 were grown up and individually added to an electrophoresis chamber filled with LB broth. The power supply was set at 65 Volts (400 mA). 5 mL of *E. coli* cells from a saturated stock of a liquid culture were diluted in 300 mL LB and then shocked in a continuous time interval. This created roughly a 1:60 dilution ratio. Our time interval was as follows: 0, 1, 3, 5, 7, 10, 13, 16, 19, 22, 25, 28, 31, 34, 37 and 40 minutes. At the end of each interval, the electrical current was shut off; 1mL of cell solution was quickly extracted; and cellular shocking was re-initiated. This extraction process was performed as quickly and consistently as possible, so as to maintain precision. Each extracted sample was measured for OD600 in a spectrophotometer. Afterwards, cell samples were transferred to an eppendorf tube, spun down, isolated and checked for GFP fluorescence via fluorometry.

Several controls were included to verify our results. In order to ensure that uptake of our construct was successful, batches of transformed cells were lysed and their DNA collected by standard Qiagen miniprep protocol [25], whose purity and concentration was measured with a NanoDrop. Next, primers specific to the sigma-32 inducible promoter region of our plasmid were synthesized and PCR amplification carried out on the collected plasmid. Included into this PCR experiment was a negative control, containing no template DNA. Finally, amplified plasmid, loading dye and 1Kb Plus DNA ladder was added to an agarose gel containing SyberSafe, and 100 V was applied for thirty minutes [26]. The bands from this gel electrophoresis test were visualized in a UV gel imager to confirm the presence of our sensor. In a separate, positive control, cells were directly heat shocked in an incubator at 44 degrees Celsius. At the end of discrete time intervals, 1mL samples were spun down and checked for GFP expression. As a final negative control, plain LB and p82 (rhamnose-induced, glucose repressed GFP expression) [15, 27] transformed *E. coli* were indirectly heat shocked with electrical current and assayed for GFP expression.

## Results

Unfortunately, the DNA received from DNA 2.0 contained deletion mutations in the *rpoH* gene (base pair number 671, G) producing a premature stop codon and rendering it impossible



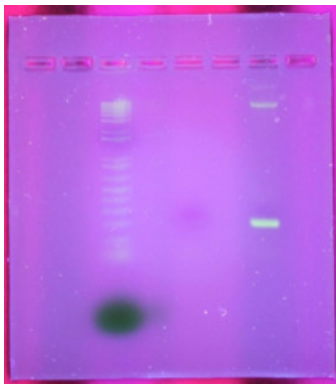


Fig. 2 Gel electrophoresis results show a predicted PCR band at 405 bp

to test our positive feedback loop. We settled, instead, with observing the cells' unamplified sigma-32. First, liquid stocks of our transformed plasmid were built, and it was confirmed that our construct—albeit mutated—was successfully transformed. PCR and gel electrophoresis results indicate that our construct was indeed taken up [28]: there is a clear band around 405 base pairs, which is the length of our promoter (Figure 2). Our negative control, which did not include any plasmid DNA, showed no bands as expected. Moreover, while our plasmid was not exceptionally concentrated, it was rather pure, as evidenced by the 260nm/280nm reading of 1.98 on the Nanodrop.

We tested several different colonies in our electrical shock assay, detailed in our methods section, to obtain GFP expression curves (Figure 3A) Because each of these colonies may have had different rates of absorption of the plasmid as well as different mutations (developed during the course of transformation or colony growth), an average is not displayed.

Three liquid stocks were tested: DNA 2.0, which was a general colony grown up from a wet colony with mutations; line C, a liquid stock grown from one isolated colony after plating the wet colony; and line 2A1, a stock grown from one isolated colony after a transformation using the powdered DNA. An oscillating pattern is noticed in the expression levels of GFP. Moreover, this oscillating pattern persists over long time-scales. In figure 3A, GFP expression is divided by the original OD600, defined as the sample after no shock was applied. Though protocol dictates division by the OD600 for each specific sample, we noticed that the OD600 value rose over time and hypothesized that the error was due to the shocking of LB media, which led to formation of

bubbles. The results of a control run, where we soaked only LB broth and took OD 600 values, confirmed this hypothesis and our decision to divide by the original OD600. In order to verify that GFP expression oscillation was specific to our genetic construct rather than an inherent property of *E. coli*, we performed another shock test assay, this time using plain LB broth and two strains of p82 transformed *E. coli* cells (rhamnose-induced, glucose repressed GFP expression) [15, 27]. Results indicated that the expression of GFP was not periodic but rather steadily decreasing over time, demonstrating that the oscillation observed was specific to our genetic construct rather than an inherent property of *E. coli* (Figure 3B). Comparing the experimental results (Figure 3A) with the control results (Figure 3B) using an unpaired two tailed t-test, we found  $p < 0.07$ , strongly suggesting that periodic, electric current-induced GFP expression did not arise by chance in our experimental assays.

Another positive control involved directly heat shocking three lines of transformed cells (lines A and B, and the wet colony with mutations) by incubating them at 44 degrees Celsius. Results of the heat shock control assay (Figure 4) indicated a response curve associated with the breakdown and production of sigma-32 while exposed to direct heat shock. After the ten-minute mark, GFP fluorescence plateaus, perhaps indicating cell death. TOP10 death occurs at 46 degrees Celsius, so exposure to this near-death temperature for an extended period of time may have proven too stressful [29]. No periodicity in GFP expression is noted in the case of direct heat shock, implying that this response is unique to electric shock induction.

## Discussion

We note an unexpected, oscillatory pattern in GFP expression of all strains successfully transformed and subjected to electrical current. Despite containing deletion mutants, a marked oscillation of similar periodicity (roughly seven minutes) and high amplitude (as large as 6000 units GFP) occurs in all experimental strains, indicating that electrical sensing via our genetic construct does not operate in a linear fashion. As GFP expression is directly dependent upon sigma-32 production within our construct, we alternatively posit that sigma-32 levels also oscillate within the cells, leading to variable GFP expression. Here, we provide an analysis of this expression behavior and its implications for further development of this system. To this end, a

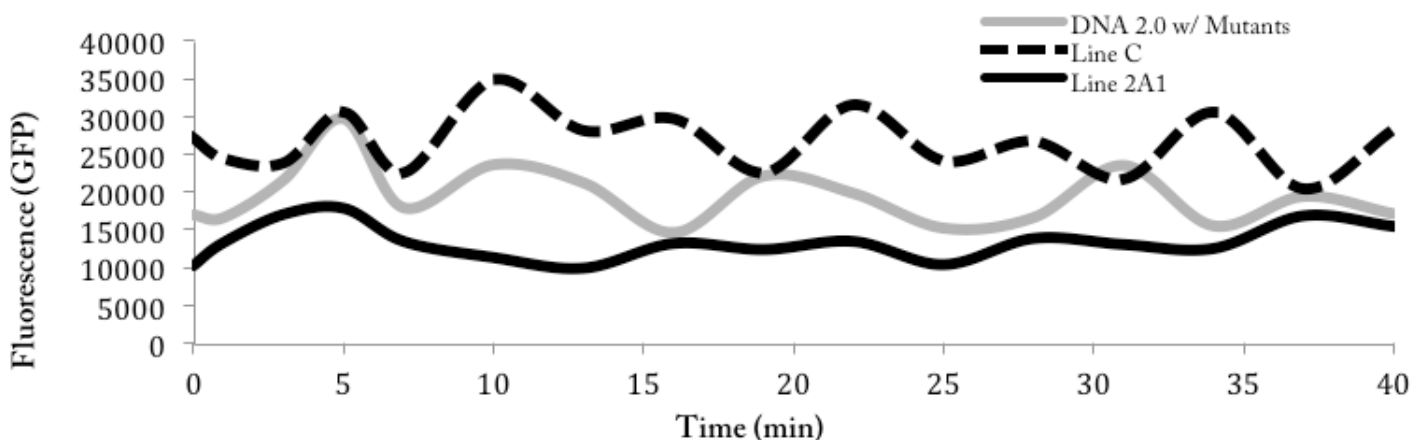


Fig. 3A. Normalized GFP Expression over Time. *E. coli* modified with our electric current sensor display oscillatory GFP expression over a time span of 40 minutes.



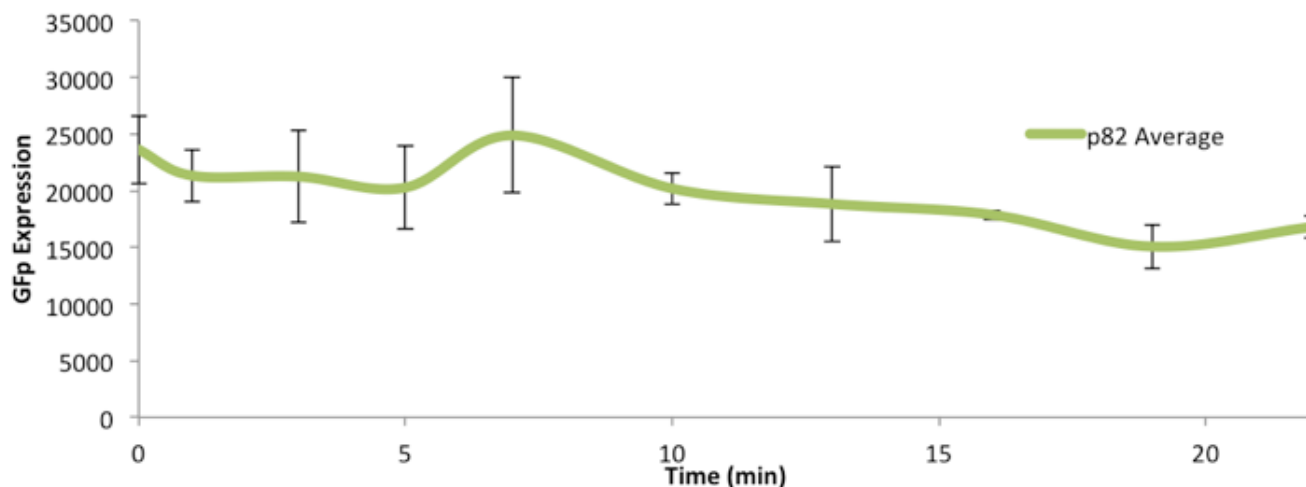


Fig. 3B. Control electric shock response. In contrast, *E. coli* modified with the p82 plasmid (no electric current response) suggests steadily decreasing GFP expression levels.  $N=2$ ; error bars for one standard deviation displayed.

few facts are important to note. First, sigma-32 is short-lived within *E. coli*, with a half-life of less than one minute [30]; this activity is controlled by the sigma-32 regulon, which initiates transcription and translation of breakdown proteins at elevated temperatures. Second, denaturation of intracellular proteins like GFP causes up-regulation of *E. coli* breakdown machinery under heat shock conditions, as controlled by various regulatory genes such as K12 [31].

We posit that oscillatory GFP expression may be explained by the natural cellular response to heat-shocked induced production of sigma-32. Within seconds of sigma-32 production, protein synthesis of heat-shock chaperone proteins like DnaK rises 13-fold. Heat-shock elements eventually comprise nearly 20% of cellular proteins, imposing a large resource load [30]. Proteins denatured by heat within the cell, including GFP, are recognized by these heat-shock chaperones and are efficiently catabolized. Production of other heat-tamping proteins eventually aids in lowering intracellular temperature, until homeostasis is reestablished. Sigma-32 is finally broken down by various pathways [30] that end the heat-shock response. Continuous heat-shock induces an oscillatory response, in which induced synthesis of sigma-32 yields the heat shock attenuation above; excess resource load and successful tamping of intracellular temperature then causes a drop-off in sigma-32 levels. This largely explains the transient nature of sigma-32 expression, as noted by various groups [30]. Oscillatory sigma-32 yields similarly oscillatory GFP expression, as actuator expression is directly dependent upon the PoPS signal from our electrical current sensor. Incoming PoPS signal is, in turn, directly dependent on the presence of sigma-32. Influx of GFP protein is thus counteracted by GFP breakdown via molecular chaperones, yielding the noted fluctuation pattern [32].

The implications of oscillating expression signal are vast, especially if such a system can be optimized to a high level of response-time control and sensitivity. Consider the following optimization schemes. First, RBS strength can be varied. By choosing a stronger bicistronic Ribosome Binding Site, expression of sigma-32 can be directly amplified, yielding GFP expression waves of larger amplitude and longer period (sigma-32 breakdown machinery will remain untouched). A weaker bicistronic RBS site will have the opposite effect, producing waves of smaller

amplitude and shorter period. Another option is the inclusion of multiple rpoH gene sequences. Although the construct tested here did not contain rpoH, and thus did not allow for feedback amplification of PoPS signal, strains containing the fully functional sensor may allow for a high level of wave tunability. Inclusion of multiple, separate rpoH cistrons could yield waves of significantly larger amplitude and especially long period. Care must be taken to not overburden cellular resources in this case. Further research into the machinery involved in terminating sigma-32 heat-shock response may similarly allow for precise control over wave features. For example, inclusion of gene sequences that code for other chaperone proteins may allow for significantly faster GFP degradation, decreasing both wave amplitude and period.

Beyond the optimization schemes above, a few follow up experiments may prove useful for further refinement of our sensor into an abstraction hierarchy. Establishing a sigma-32 saturation level for the promoter used in our construct will define a maximum PoPS signal threshold, while performing a more sensitive Beta-gal assay may define a minimum. Variation of actuators (in effect variation of output signals) and observation of any differences in oscillation may provide insight as to the effects of reporter breakdown time on wave characteristics. Finally, simple tests in

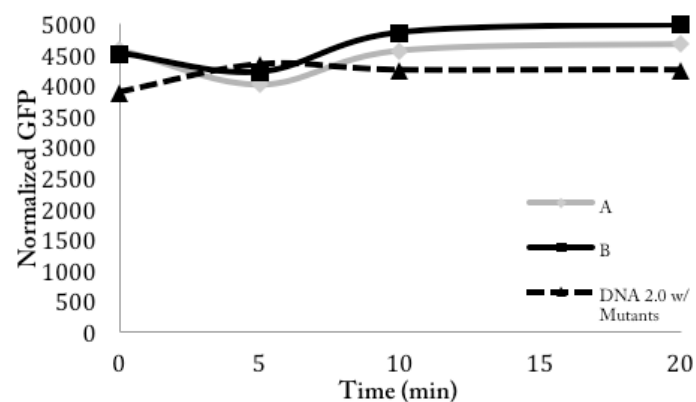


Fig. 4 Heat shock control assay. Direct heat shock of cells containing electric current sensor by incubation at 44° C causes plateauing GFP expression; as such, it appears as though the oscillatory pattern is unique to electric shock.

which one variable is tested can confirm a kill point/max resource load for TOP10 E. coli containing our construct (e.g. varying the promoter strength in a genetic construct producing sigma-32).

In conclusion, we designed a sensor system that can be easily standardized into a part and abstracted into various genetic programs. Moreover, if considering the possible future applications of such a biological system to circuit design, it becomes clear that the more cost effective the means and organism, the better: thanks to E. coli's fast growth rate and low maintenance, it becomes incredibly economically feasible and an ideal organism to program. While biological circuits are unlikely to replace mechanical circuitry, they do allow for a reconsideration of what defines a circuit and, more importantly, exist as a self-repairing, growing system. Moreover, the possible implications and applications of a biological circuit could be more computing focused, such as logic or data storage [33], or instrumental, such as in a biologically run pacemaker in which cardiac cells are genetically modified to react to electrical pulses [34]. In both of these cases, cells replace computers or electronics while maintaining the benefits of a biological system. We believe that with the proper optimization and control over our genetic system, the applications of such constructs could lead to even further productive insight from the intersection between E. coli machinery and electrical engineering.

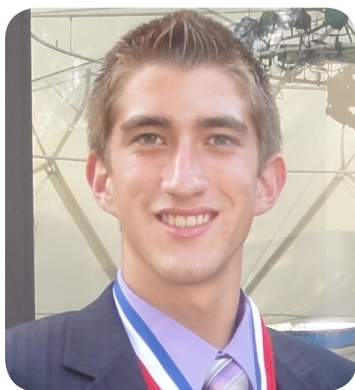
## Acknowledgements

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Justo Caballero is a sophomore at Stanford University, pursuing his B.S. in Bioengineering. Alongside exploring his scientific interests, Justo is a tutor at the East Palo Alto Stanford Academy, a member of the HAP, SPA, and CHE programs, loves to stay active, and particularly enjoys playing basketball and football. He is currently pursuing research in the Jennifer Cochran protein engineering lab on campus and is considering applying to medical school in the near future.

Shamik Mascharak has conducted research in a wide range of disciplines, and is currently a sophomore at Stanford University majoring in Bioengineering. His academic interests include biocompatible graft design, synthesis of cellular imaging probes and applications of optofluidics. He plans to one day explore the intersection of medicine and material sciences as a biomedical engineer, developing new devices that address clinical needs. In his free time, he enjoys practicing martial arts (Tae Kwon Do, Muy Thai), writing music, and recently, teaching himself guitar.



Sibel Sayiner, hailing from Austin, Texas, is a sophomore studying Bioengineering and Classics at Stanford University. Along with being passionate about genetics and bioethics, Sibel also has done research on individuals' interactions with physical spaces and the possibility to evoke creativity merely through design. Alongside pursuing her various academic interests, Sibel dabbles in spoken word poetry, competing at the College Unions Poetry Slam Invitational, and enjoys getting lost in post-modern literature.

# A MEMS Mirror Laser-Guidance System for CDMS Experiments

Fedja Kadribasic

Stanford University

## Abstract

The Cryogenic Dark Matter Search (CDMS) is an experiment to directly detect dark matter, a mysterious substance that makes up the majority of the matter content in the Universe and has so far only been observed due to its gravitational effects. CDMS uses high-purity Ge (HPGe) crystals as detectors for dark matter in the form of weakly interacting massive particles (WIMP). In order to reduce systematic uncertainties from measurements made by the detectors, Monte Carlo simulations are performed that require precise knowledge of semiconductor physics at low temperatures. The purpose of the investigation described in this paper is to study the anisotropic propagation of electrons through Ge and their inter-valley scattering. An apparatus for such experiments was made using a micro-electromechanical system (MEMS) device that controls the 2-dimensional tilt of a mirror via electrostatic attractions, thereby scanning a pulsed laser beam across the HPGe crystals. Measurements of the laser and MEMS mirror setup were made using a checkerboard-like shadow mask in front of a photodetector in the HPGe crystal's future housing at room temperature and cryogenic temperature. These data demonstrate that the mirror has a very precise and reproducible response that is exceptionally temperature-independent, and that it has a mechanical quality factor close to 106, which is indicative of extremely low mechanical losses. At the time of writing, the inter-valley scattering measurement has not yet been performed, but it will be in the near future, which emphasizes how critical it is to further investigate and perfect this cryogenic laser-scanning system to aid in solving the mystery of dark matter.

**D**ark matter is an elusive substance that so far has only been observed because of its gravitational influence on galaxies; yet it makes up around 80% of the matter content of the Universe<sup>1</sup>. Although there is much indirect evidence from observing the behavior of galaxies affected by its gravitational pull, dark matter interacts so little with ordinary baryonic matter that it has not yet been observed directly. Many recent theories suggest that dark matter is made up of particles, called WIMPs (weakly interacting massive particles), unaccounted for by the current Standard Model of particle physics<sup>2</sup>. The purpose of the Cryogenic Dark Matter Search (CDMS) is to test these theories by directly measuring the dark matter's interaction with ordinary matter.

According to these theories, as the Solar System revolves around the galaxy it moves through the dark matter in which our visible galaxy is situated. Thus, dark matter continuously passes through the HPGe crystals, and every so often a WIMP interacts with one of the crystals to produce a signal. Lead shielding protects the HPGe crystals from background radioactivity, and their extreme depth underground protects them from highly-penetrating muons and cosmogenic neutrons. This shielding is necessary to prevent ordinary matter particles from hitting the HPGe and confounding the data with collisions which resemble those of WIMPs.

The current generation of the CDMS experiment is made up of 15 high-purity germanium (HPGe) crystal detectors cooled to 50 mK in the Soudan Underground Laboratory in Minnesota. Particles entering the experiment housing from outside hit the nuclei of the HPGe crystals and excite electron-hole pairs and phonons. An electric field applied across the crystals pulls electrons to one side and holes to the other. Charge detectors measure this current and convert it to a measurable voltage. The cold temperature eliminates thermal noise and allows the transition edge sensors (TES), which detect phonons, to work. The results from the charge readout and the phonons can be used to distinguish between the different interactions taking place.

So far, there have been only 2 events consistent with a WIMP signal, which is not enough to claim that WIMPs do indeed exist<sup>1</sup>. However, the next generation of detectors, called Super CDMS, is currently being fabricated and tested; its enhanced sensitivity will allow it to clearly distinguish this signal, if it is real, from a random fluctuation. Despite the extreme precision of the results from CDMS, the main source of error is not random noise, but actually systematic error coming from the Monte Carlo simulations used to reconstruct particle collisions inside the detectors. These systematic errors stem in part from inadequate models describing the behavior of Ge at sub-Kelvin temperatures. Two of the main projects to eliminate this and other systematics and hence to improve the effectiveness of the detectors for Super CDMS are the Quasiparticle Experiment, which will measure quasiparticles in HPGe to help improve the phonon detectors<sup>3</sup>, and the Electron Propagation Experiment (EPE), which will detect intervalley scattering of the electron beam after an impact to improve the effectiveness of the charge detector data<sup>4</sup>.

Both projects need an energy deposition system that can precisely control both the energy and the location of the deposition on the crystals; however, the EPE will be the main concern in this paper. When particles interact with the Ge detectors, they produce a cloud of energetic electrons and holes. Because of the relatively uniform electric field applied across the detector, the



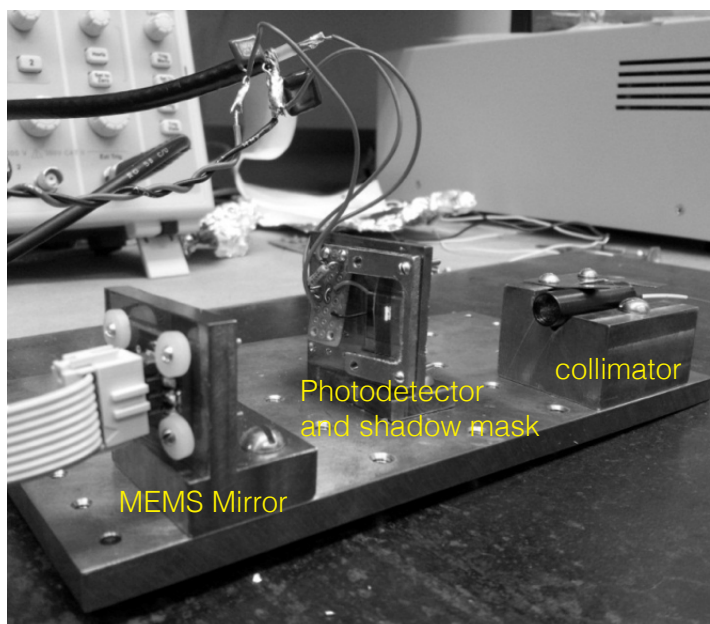


Fig. 1 Entire scanning setup showing the laser light leaving the collimator at right, bouncing off the MEMS mirror in the foreground, and hitting the checkerboard shadow mask with the photodetector underneath.

electrons get accelerated to one side and the holes to the other. The holes tend to travel as a single beam as they traverse the crystal. However, at sub-Kelvin temperatures, the electrons split into four beams because of anisotropies in the Ge crystal. The reason is that they move along potential energy minima that correspond to different directions in the crystals, which is a process called inter-valley scattering<sup>4</sup>. Because there is no experimental data on inter-valley scattering, the process is not currently taken into account in the simulations used for analyzing the data, and this is part of the reason for the systematic errors. A system to precisely deposit energy on specific sites on the crystal could be used to measure the inter-valley scattering taking place, which is one of the main purposes for the MEMS mirror scanning system. In the short term, the applications of this system would be for the Quasiparticle Experiment and the EPE, but one can imagine the device being useful for any cryogenic experiment for which one wants knowledge of position and energy of some pulsed laser scan. It is this wide range of implementations that is the main reason for conducting this study.

### Past Research

This project is the result of research conducted since the summer of 2011 to develop a cryogenic laser-scanning system. Robert Moffatt, the graduate student I have worked with, and I initially considered using orthogonal piezoelectric actuators with attached mirrors to direct the beam towards a 1 cm x 1 cm section of HPGe. Each actuator would be coupled to another actuating tine in a tuning fork configuration running at resonance, both to reduce mechanical losses and to increase stability. One of the piezoelectrics was later replaced with an undriven, thin tine that increased displacement and decreased mechanical losses even more.

This design, however, proved unfeasible at cryogenic temperatures. The actuators have a very temperature-dependent first-order resonant frequency so that the two orthogonal tuning

forks with mirrors will have different resonant frequencies at cryogenic temperatures than at room temperatures. Additionally, displacement of the piezoelectrics goes down tenfold from room temperature down to 4 K, which means that they need a driving amplitude ten times higher at 4 K than at room temperature. Considering that the cryostat in which this system will ultimately be used has a maximum cooling power of  $\sim 15 \mu\text{W}$ , any extra power dissipation from the actuators could heat up the experiment. Another issue is that their displacement angle as a function of voltage has enough creep and hysteresis that careful calibration would be necessary to make sure that the laser hits the correct point on the HPGe sample. Despite learning a lot about piezoelectrics and using the measurement techniques we developed when testing them with the current generation of scanning system, many issues with the actuators meant that we needed to find some other mechanical device for scanning the laser.

### Methods

The MEMS controller for the mirror on the scanning system, on the other hand, uses electrostatic attractions to control the 2-D tilt of the mirror. Orthogonal pairs of capacitors charge and discharge depending on the amount of deflection required, thereby causing the mirror to tilt. These MEMS mirrors seemed to hold much more promise than the piezoelectrics because capacitors are almost purely linear devices, unlike piezoelectrics which are ferroelectric materials with very nonlinear behavior.

A number of room temperature and cryogenic temperature tests were performed on the MEMS mirrors that included tests for linearity of response, laser light focus, and ringing to determine the mechanical quality factor. All of these tests were done using a checkerboard-pattern shadow mask made from a grid of ink blots on a transparency in front of a photodetector placed on the sample stage (see Figures 1 and 2). The photodetector terminals

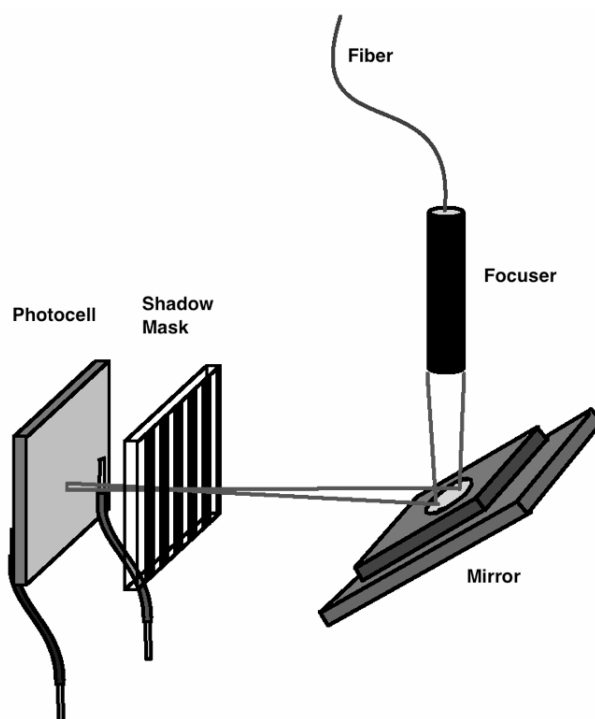


Fig. 2 Schematic showing the laser deflecting off the mirror, passing through a shadow mask, and hitting the photodetector.



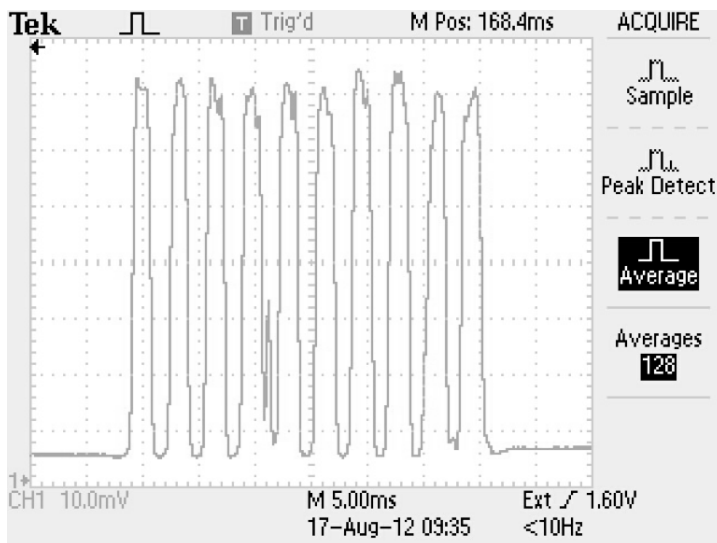


Fig. 3. Low-frequency linear response indicated by the uniform spacing between peaks and valleys.

so that, when one is scanning the laser across the grid in a straight line, one sees a train of rectangular impulses. Each voltage peak corresponds to the laser passing over a transparent section of the plastic mask, and each valley happens when the laser light is blocked by an ink blot. Not only does this allow one to approximately “see” where the laser is pointing on the photodetector, but it also means that one can make very precise position measurements if one aligns the laser so it is exactly at an interface between light and dark regions.

Tests were performed at room temperature and standard pressure, room temperature and high vacuum, and at 13 K and high vacuum. For cryogenic conditions, the experiment was thermally coupled to a 4 K 4He thermal bath using a 4He gas gap. Mostly because of the thermal impedance of the gas gap and the 2mW of dissipated laser power, the temperature stabilized at around 13 K rather than staying nearer to 4 K.

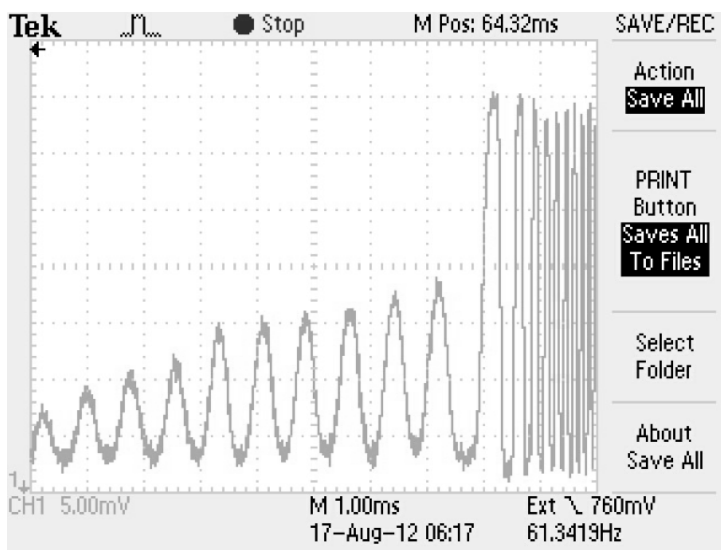


Fig. 5. Mechanical ringing noticeable at the interface between transparent and dark regions on the mask. The part at right shows the time when the mirror is scanning normally, and the part at left is the mechanical ringing when the scan stops at the interface.

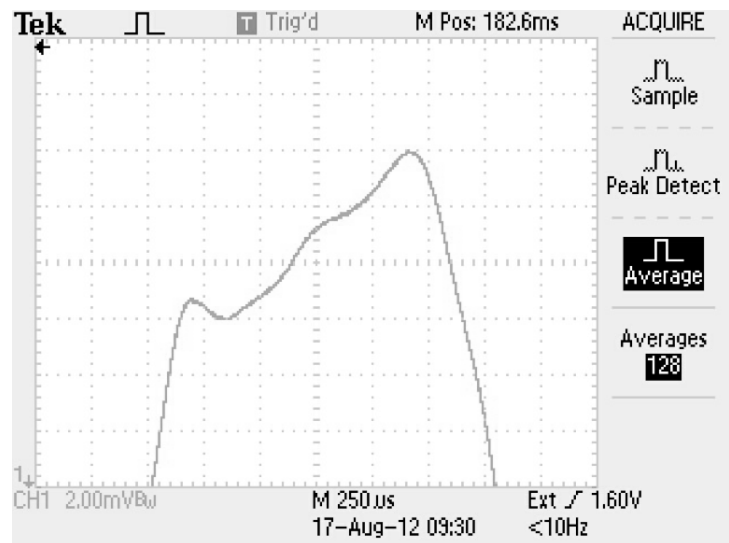


Fig. 4. High precision of position measurements at focus indicated by the small width of the peak at left.

## Results and Discussion

### Room Temperature Results

Preliminary room temperature results indicated that the laser-scanning system was not only superior to the piezoelectrics investigated earlier, but also was ideally suited for the charge propagation experiment. Figure 3 is an oscilloscope image of the photodiode signal recorded as the laser spot was scanned across the checkerboard pattern with constant velocity. The peaks have a uniform spacing throughout the scan, which indicates the linearity of the response. Only at very high frequencies and voltages was there any indication of nonlinear effects. Otherwise, the data indicate that the nonlinearities were negligible.

Figure 4 shows another oscilloscope image of the top of one of the peaks. Small ink spots cause some regions of the transparent portions to let through more light than others, which the photodetector registers as slight fluctuations in voltage. These fluctuations are displayed on the oscilloscope as small bumps whose width, in conjunction with linear scans such as that in Figure 3, can be used to determine the focal width of the laser on the substrate. Such measurements indicate that the focal width is between 15 and 30  $\mu\text{m}$ . This means that the scanning system is well-suited for the  $\sim 100 \mu\text{m}$  resolution necessary for the charge transport and electron propagation experiments.

Positioning the laser light so that it is at the interface between a transparent and dark spot allows small motions of the mirror to be detected. This can be used to find whether there are any sources of noise in the electronics or if the mirror is picking up some mechanical vibrations from the environment. A tiny vibration, most likely caused by the electronics in the mirror control device, can be seen in Figure 5 where the mirror stops the scan before turning around right at an interface on the shadow mask. By tapping the setup holding the mirror while the laser was pointed at an interface, the mechanical quality factor of the mirror was determined to be  $\sim 1000$  at room temperature and standard pressure.

### Cryogenic Results

At cryogenic temperature, in vacuum, the first two properties discussed above remained relatively unchanged. However, the

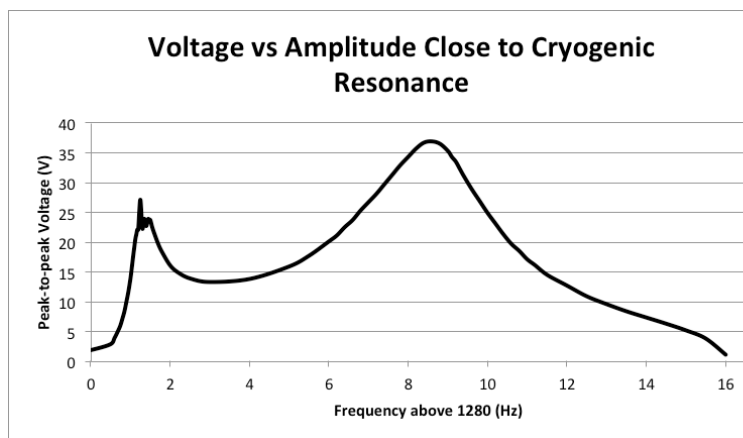


Fig. 6. Diagram indicating the two resonance peaks, the first of which has the very high quality factor.

mechanical quality factor increased to  $\sim 800,000$ , which meant that small electrical noise coming from the laboratory had enough power to set the mirror oscillating at resonance. Additionally, as shown in Figure 6, two resonance peaks were noticed, one at 1281.3 Hz and the other at 1288.5 Hz. The fact that these two peaks are so closely spaced indicates that they cannot be harmonics of each other. Instead, the first peak is the one that causes the high quality factor because it is the first harmonic in the direction that the mirror is driven. The second one most likely corresponds to the first harmonic in the orthogonal, undriven direction. However, because it is not nearly as sharply peaked as the first resonance, it is due to a small coupling between the two directions that was not noticed at room temperature. Because this effect overshadows the current primary problem with the scanning system (which is the wiring), this effect can be ignored for the time being.

## Applications

The main projects that would be affected by a MEMS mirror laser-scanning system are the Quasiparticle Experiment and the Electron Propagation Experiment. The Quasiparticle Experiment involves testing different designs and configurations for phonon sensors. It would be performed by depositing energy in the aluminum fins attached to TESs at varying positions and intensities to simulate real phonon signals. The MEMS mirror laser-guidance system could be used to precisely deposit energy at specific points on the fins, which could increase the quantity and quality of data that can be obtained from the phonon signal [3]. The other project is the electron propagation experiment, which

involves improving the precision of the data collected by the charge sensors. At low temperatures, electrons in Germanium settle into four regions known as valleys in momentum space, corresponding to local minima of kinetic energy. Each valley has a preferred low-mass direction in which an electron can move with great velocity while only gaining a small kinetic energy. In an applied electric field, electrons accelerate primarily in these low-mass directions, which are different for each valley, such that a group of electrons all starting at the same point on one side of the crystal will split into four groups that impact the side with charge detectors at four different locations. The MEMS mirror laser-guidance system could simulate particle collisions by scanning the pulsed laser across the surface of the HPGe crystals opposite the charge detectors, which would produce the electron cloud necessary for the experiment and could lead to more useful charge measurements.

## Future Directions and Conclusion

Currently the HPGe crystal and detectors are being fabricated to replace the photodetector and shadow mask setup. Preliminary data with the new setup at sub-Kelvin temperatures could indicate how viable it is for testing future generations of detectors. Another possibility is reducing the size of the scanning device so that it can fit inside the experimental chamber of the Kelvinox 15 dilution refrigerator in the lab. All of these potential future directions for the research demonstrate that the experiment is still a work in progress, but that it is still worthwhile pursuing. The very important contributions this device could bring to the CDMS collaboration would aid in building better dark matter detectors and gaining more useful information from them. With these detectors, CDMS would hopefully be able to conclusively observe dark matter and thereby help unravel one of the greatest cosmic mysteries of our time.

## References

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**Fedja Kadribasic**, a senior at Stanford University, came to the U.S. in 1998 as a Bosnian war refugee after living in Germany for 5 years. He is fluent in Bosnian, English, and Spanish and can read and write German. He is majoring in Physics and is currently performing research as a part of the Cabrera Lab Group for Cryogenic Dark Matter Search. Fedja will pursue his interest in observational astronomy and instrumentation as a PhD student next year. His other interests range from diving, hiking, and traveling to community involvement. He would like to become a research physicist and a professor able to spark curiosity and love for astrophysics in his students.