DISCUSSIONS

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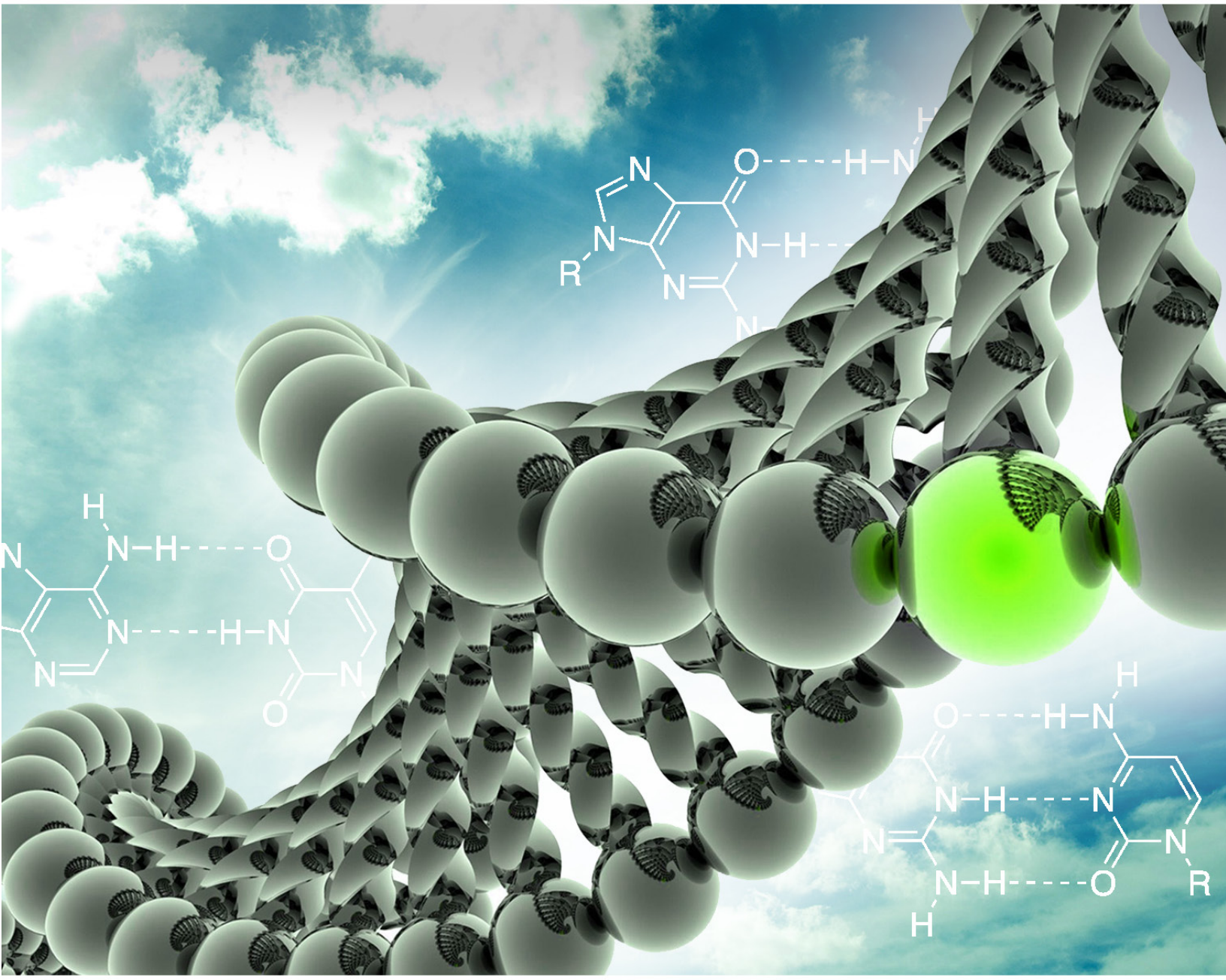

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DISCUSSIONS

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Undergraduate Research Journal of CWRU

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Letter from the Editor

Dear readers,

Since 2006, *Discussions* has brought undergraduate research to the Case Western Reserve University campus. As a continuance of our tradition and mission, it is my pleasure to introduce the newest issue of *Discussions* to you.

Let me begin by thanking you for taking the time to support *Discussions*, even by just picking up the journal. In today's society of fluid information and evolving understanding, informing oneself about current research is paramount. The articles in this journal are rich with the newest research being conducted by undergraduates from around the country. What makes undergraduate research so exciting is the fresh perspective and excitement students bring to the ongoing debates that surround their topics.

For this journal, I am very pleased to say that a record number of submissions were received. The articles we published represent the best of an extremely competitive field. Each article was hand-picked by a team of reviewers and the Editorial Board.

If you would like to see your research published in *Discussions*, our next submission deadline is **January 17, 2014**. Please check out our website at case.edu/discussions or our Facebook page for submission guidelines and more details. In addition, we would love to hear from you! If you have any feedback do not hesitate to contact us on the webpage.

Discussions is currently going through a rapid time of growth as we look to increase our distribution centers to other schools as well as across the nation. Recently, we expanded our distribution network as far as Seattle, Washington. If you would like to be a part of the *Discussions* team, we are always looking for hardworking and motivated individuals. Feel free to email me at nathan.kong@case.edu or askdiscussions@case.edu for more information and to find out how to become more involved.

Finally, I would like to recognize Linda Relson for all her hard work and dedication to *Discussions*. She has played an integral part in making *Discussions* what it is today and her work culminated in a complete redesign of our website. In addition, I would like to thank Sheila Pedigo and the entire SOURCE office for their continued support. Please enjoy the articles as I am sure you will find a lot of interesting topics.

Sincerely,

Nathan Kong

South Korea's Sustainable Urban Planning and Environmental Technology

ABSTRACT

South Korea's rapid urbanization began in the 1950s and greatly increased the urban population as well as the country's economy. However, the development has been highly damaging to the environment surrounding high-density metropolitan areas such as Seoul. With cutting-edge technology and modern science, green methods of urban development are underway. The ubiquitous city concept, landscape character assessment, and eco-friendly waste management are all facets of an eco-friendly city model that are discussed in this research.

INTRODUCTION

In the process of rapid urbanization spurred on by an increasingly globalizing world, the inhabitants of mega-cities make an important trade-off between improved quality of life and the systematic destruction of the natural organization of land and the environment. In the developing nations of East Asia, rapid urbanization and economic growth are visibly apparent, but so are urban environmental problems in overcrowded cities. The complexity of the issue is ever-growing because slowing economic growth is not a favorable solution, but sustainable urban development is still a viable possibility. In the case of South Korea, several municipalities are partaking in an effort to move toward sustainability in different sectors through modern technology. For instance, Kwangmyung City is "at the cutting edge of environmental administration of local government" with its environmental infrastructure that is more advanced than other local governments (Kim, 2002). Seoul, the nation's capital, is in the process of implementing the U-city model, specifically in its transportation sector.

The five facets of environmental deterioration – "rapid economic growth," "high industrialization ratio," "rapid urbanization," "mass consumption," and "energy efficiency" – are the prime focus of this study. The paper will examine each factor and discuss how the process of industrial development causes serious environmental damage, and how modern urban planning and technology have great potential to reverse those damages (Bai and Imura, 2000). It will discuss the details of the forms of technology used in the two South Korean case studies, as well as the impact they are making in urban sustainability. This paper will discuss modern urban planning and environmental technology and their roles in eco-friendly urbanization.

The goal of this paper is to persuade members of the general public, especially those who live in metropolitan areas, to make their lifestyles more eco-friendly and to prompt more intensive research into green technology that would help curb the effects of urban pollution and environmental damage.

Lorna Kang

Lorna Kang is a third-year student at Case Western Reserve University studying Biology with minors in Chemistry and Medical Anthropology. She is involved with peer tutoring and helping international students through the SELP program. She is also a research assistant in immunology and is striving towards a dual MD/PhD degree. Lorna loves to teach, and has traveled to a rural community in Nicaragua to help local children and adults with English.

Acknowledgements

I would like to thank Dr. Peter Yang and Dr. Cameron Strathman in providing helpful feedback and primary sources during the research process. Their enthusiasm and willingness to give their time has been greatly appreciated.

KOREA'S URBANIZATION: AN OVERVIEW

The Republic of Korea experienced an unprecedented increase in the rate of urbanization over the past 40 years since the end of the Korean War. The level of urbanization rose drastically from 35.8 percent in 1960 to 85.0 percent in 1995 (Kwon, 2001). The national government played an important role in decisively modernizing South Korea through urban growth over the decades; for example, the city of Ulsan was constructed in 1963 through a series of ambitious government initiatives and grew into an important industrial town (Kwon, 2001). Population centralization in urban areas is strongly incited by the prospect and availability of jobs, especially in Seoul. The influx of rural residents to take up jobs as laborers within the city has proven to be problematic, even with the number of blue-collar workers decreasing. Also, the trend of globalization demands a more modern and urban infrastructure, and high-class and educated professionals are sensitive to the living and working environment (Kwon, 2001). These factors have contributed to the rise of densely packed blocks of offices and apartment complexes that lead to many of the consequences that entail heavy development.

A combination of socialist and capitalist economic policies has proven to be very effective in boosting the industrial productivity of South Korea, but this industrialization has taken a severe toll on the environment. Since the 1960s, the government has been ambitiously pushing for an export-oriented development strategy, and heavy industrial centers were formed in urban areas, leaving the rural parts of the country largely underdeveloped. The economic drive that produced such rapid growth also proved harmful to the lands surrounding major urban centers, with overcrowding, high consumerism, land encroachment, and heavy traffic causing most of the damage. It is particularly important to take into consideration the geography of South Korea and how cities were built in order to thrive in the surrounding ecosystem and adapt to the natural formation of the land, oftentimes causing damage to the environment (Kwon, 2001).

SUSTAINABLE URBAN PLANNING IN SOUTH KOREA'S METROPOLIS: SEOUL'S GREENBELT

Urban congestion and high-density cities with sprawling development are significant contributors to Korea's urban environmental problems. The largest share of Seoul's carbon emissions comes from the residential sector and continues to increase every year. The average annual growth rate of carbon emissions in Seoul is 1.63 percent each year (Dhakal *et al.*, 2003), and per capita carbon emission levels skyrocketed in the 1990s, which was when CO_2 levels were first recorded. Cities are "centers of high living standards, population density, pollutants of air and water, and producers of solid wastes" and also centers of massive consumerism and infrastructure development (Dhakal *et al.*, 2003). Highly urbanized areas are generally viewed as places of modernity, high class, and sophistication to most South Koreans, leading to high consumerism. As high demand for land as population drastically increased, green areas around cities decreased by 1480 km^2 in the past 10 years as natural land was paved to provide space for business buildings and apartment complexes (Yoon and Lee, 2003). Green areas include land used for agriculture and mountainous areas. In Seoul, along with several other rapidly urbanized mega-cities in East Asia, there is a serious situation of environmental degradation that can impact the health and well-being of urban dwellers. In fact, the South Korean government already has in place some measures to control urban sprawl; the greenbelt, built around the city of Seoul in the 1970s, is one such measure. Seoul's greenbelt now measures about 1,566.8

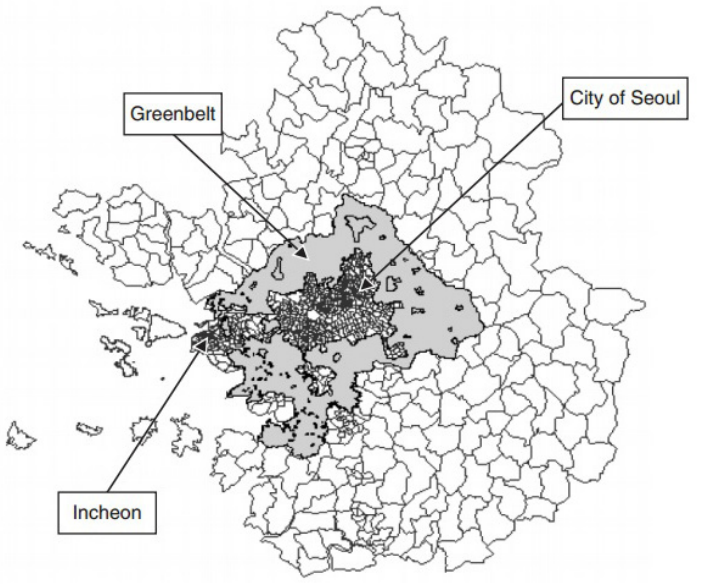

Figure 1. The Capital Region (Gyeonggi Province) and Seoul's greenbelt. Source: "*Seoul's Greenbelt: An Experiment in Urban Containment*" by Bengston and Yeo-Chang, 2005.

km^2, which accounts for about 13.3 percent of the Seoul metropolitan area (Bengston and Youn, 2005). Figure 1 illustrates the size of the greenbelt surrounding Seoul.

As is evident in Figure 1, the greenbelt is essentially a "belt" of greenery surrounding the city limits. The greenbelt was designed to corral urban sprawl and create a more compact infrastructure, thereby increasing efficiency in public service provisions (Bengston and Youn, 2005). Most importantly, however, it strived to provide a "wide range of ecosystem services such as air purification, habitat and biodiversity protection, flood control, and water supply and quality" and therefore has many important environmental implications (Bengston and Youn, 2005).

These benefits however, become less significant as the increasingly heavy congestion within the city outweighs the amenity values and the environmental value of the greenbelt. The greenbelt's initial goal, the containment of urban sprawl, did not take into account the influx of people moving into the city over the decades. Without the space to expand its diameters, the city has become more and more heavily congested (Bengston and Youn, 2005). Also, the residents that live in or near the greenbelt have experienced a large decrease in property values over the past few decades since the inception of the policy, which creates an unequal balance in the quality of life of those who live in the city and those who live in the urban fringe (Bengston and Youn, 2005). The severity of the pollution caused by confinement and congestion within the city is another ironic side effect of the greenbelt.

Urban planning is a complex issue that spans a wide range of concerns, intertwining with social, economic, and environmental sectors of the city. Although the greenbelt may have been an ideal solution to pollution before heavy development began, it is simplistic in practice – especially over the four decades after its inception. A more expansive policy, adapted to the modern socio-economic and environmental issues, is required for large cities such as Seoul. This paper will discuss methods of urban planning from the external view of the city and the thorough changes in internal infrastructure.

LANDSCAPE CHARACTER ASSESSMENT

The United Kingdom has developed a technique called landscape character assessment that takes into account the diversity of the land in a detailed survey to preserve biodiversity and sustainable land use. Landscape character is defined as "a distinct and recognizable pattern of elements that occur consistently in a particular type of landscape" and is the main component of planning land for development (Kim and Pauleit, 2005). This method can be applied to the landscape of South Korean cities because preserving biodiversity and sustainably developing land are two major concerns when facing rapid urbanization. Landscape character assessment consists of two main stages: 1) identifying the main distinguishing features of landscape character unites and creates a detailed map of the characteristics, and 2) providing quantitative data for biodiversity conservation (Kim and Pauleit, 2005). In the example of the Kwangju city region in Kim and Pauleit's study, it was discovered that the greatest and most rapid changes in landscape occur in the urban fringes and the greatest biodiversity exists in the wooded highlands (2005). Human developments, such as the creation of small commercial agricultural plots and the covering of high biodiversity-value lands with business complexes, contribute to a systematic destruction of ecosystems; therefore, the stakeholder community and policymakers should take into consideration the best ways to plan a city in accordance with the surrounding environment and its characteristics.

Efficient urban planning is possibly the most effective and cost-saving method of curbing the negative environmental effects of rapid urbanization. An efficiently organized metropolitan area will not encroach upon agricultural land, thereby preserving the ancient and traditional agrarian aspect of the Korean society. Also, the inefficiency of the greenbelt is met with opposition from landscape character assessment, as the latter does not seek to forcefully contain urban sprawl. Heavy urban development is inevitable in actively industrious countries such as South Korea; therefore, planners should seek ways to use the natural land that minimizes the loss of biodiversity and environmental health. However, efficient urban planning has proven to be highly inefficient despite its initial welcoming. Landscape character assessment, however, is a progressive and highly scientific effort that takes into account the way land changes and the pattern it follows (Kim and Pauleit, 2007). Preserving biodiversity is the highest priority, and this method has been successful in many parts of the United Kingdom and across the world (Kim and Pauleit, 2007). The process also calls for a close working connection between the stakeholders,

the community, and environmental scientists, which should strengthen the role of residents in influencing the environment they inhabit in a more positive way.

Landscape character assessment has proven to be a useful tool in curbing the human forces on the natural landscape in the U.K. (Kim and Pauleit, 2007). It is important to note, however, that the data gathered in this method are independent of the social impacts that also shape the land. Although this method addresses the problems immediately associated with urban sprawl, such as the deterioration of the surrounding land and the damage to biodiversity, it fails to take into account how people are affected by the changes; in this way, landscape character assessment can be viewed to be more ecocentric than anthropocentric. Therefore, landscape character assessment should not be the sole method of developing green infrastructure. South Korea is highly developed in technology and city planners of major metropolitan areas are seeking ways to apply technology to simultaneously improve the lives of the residents and the environment.

UBIQUITOUS CITY CONCEPT

Sustainable development is one of the facets of the Ubiquitous City, or U-city, concept. The main goal of the U-city is "to create a built environment where any citizen can get any services, anywhere, and anytime through any ICT (information and communication technology) devices" (Lee *et al.*, 2008). The complex networking of digital connections will provide easy, high-speed access to intelligent services and information from anywhere within the city, improving urban infrastructure and the quality of life of urban dwellers. The efficient use of technology can shape the lifestyles of urban residents and therefore promote eco-friendly and environmentally conscious mindsets of urban residents.

Before iterating the environmental impact of the U-city, it is important to discuss some of the technologies involved with it and the implications in the future of sustainable urban living and planning. The focal point of ubiquitous computing is the high-speed wireless networking capabilities between buildings and in the city. This establishes a giant virtual network in which information can be accessed freely, with services provided digitally to wireless devices, such as smartphones and laptops. The most encompassing of these technologies is possibly the broadband convergence network, or BcN, which is the "backbone of ubiquitous computing services" at speeds from 50 Mbps to 100 Mbps, or about 50 times faster than conventional internet services (Lee *et al.*, 2008). Other technologies stem from the extensive high-speed internet network, such as the ubiquitous sensor network (USN) and location based services (LBS). The USN allows for any devices, wired or wireless, the ability to access information from other devices or computing devices embedded within the environment.

One project that takes advantage of the high internet development rate of Seoul is the Personal Travel Assistant system. The PTA service delivers real-time information about public transportation, such as routes with the least amount of carbon emissions, green transportation arrival times, and other ecofriendly options while taking into account the traffic updates (Kim, 2009). This project aims to reduce urban congestion, one of the greatest problems that large cities in South Korea face. Urban congestion is a cause, and in some cases a result, of other urban problems such as the smog effect, asthma in younger children, high carbon emissions level, and a decline in the quality of life. Through the extensive PTA service which is a part of the ICT system, some of these problems will be alleviated in the long run by changing the behavior of urban dwellers and their perspective on carbon emissions. PTA is not one of the mechanisms to tackle urban sustainability directly, but other technologies are in development in order to reduce carbon emissions of tall buildings and to organize the city in a more efficient way that would benefit both the residents and nature.

Not only does the U-city concept address the issue of urban sustainability, it focuses on making the ecofriendly lifestyle more accessible to urban residents by providing high-speed services and amenities through digital means. It embodies the characteristic of the ideal futuristic city in which the lives of people, as well as the health of the environment, are improved simultaneously, whereas in the past the environment was exploited for profit. If the U-city project proves to be successful in Seoul, it should be relatively easy to implement it in other major cities, creating a nation-wide high-speed information highway. The efficiency with which people commute and the ease with which the scientists, engineers, and business leaders can access information to improve the environment and lives of people is possible through cutting-edge technology (Kim, 2009).

TECHNOLOGY AND WASTE MANAGEMENT

So far, various methods of sustainable urban

planning have been examined. Of the many pollutants that are produced in large cities, solid wastes require the most energy and time to sort and dispose of. High-income nations in East Asia, such as Japan, Hong Kong, and South Korea, with GDP per capita ranging from 23,331 to 37,385 USD, produce more wastes with smaller biodegradable composition than countries with lower GDP such as India and Vietnam (Shekdar, 2008). With the growing economy come bigger problems; higher income nations are now seeking ways to eliminate landfills and push for reduction in waste generation rather than trying to accommodate for the consequences of high consumption.

As a part of the green infrastructure, ecofriendly waste management is now possible using the highest technology. Municipal solid waste, or MSW, is a by-product of human daily life that is now being addressed by individual municipalities in South Korea. The composition of MSW varies greatly, but much of it is combustible into ash, while non-combustible materials such as glass and metals are shredded and recycled. The autonomy of each municipality in South Korea allows for local governments to seek waste management systems that meet their specific needs. Kwangmyung City exemplifies the autonomic municipality, which utilizes high-end technology to improve the lives of its citizens and reduces MSW in a way that benefits the environment as well as the local government. The construction of the waste-to-energy incinerator in Kwangmyung was initially met with opposition from the citizens and the neighboring cities due to "mutual distrust" by "alienated people who never received such proposals" (Kim, 2002). Despite the contentious beginning in 1999, the incinerator has been used as a model because Kwangmyung was the first municipality to incorporate it into its waste management system.

Waste-to-energy incinerators work by burning MSW in extremely high temperatures of up to 2000° F. The waste volume after incineration is reduced by 90 percent and CO emissions of 15 to 40 ppm ("Traditional 'Waste to Energy' Plants"). These incinerators generate about 2,816 megawatts per hour of electrical power, converting large volumes of trash into useable electricity. However, the burning process still produces some carbon emissions. In order to alleviate the amount of greenhouse gases emitted from the facilities, technologies are in place in modern incinerators to control the amount of pollutants being released into the atmosphere. Furthermore, the "flue gas" resulting from burning wastes is cleaned of dust, heavy metals, gaseous acids, NO_2, and dioxins through several steps before being released (Nilsson, 2006). Denmark has developed a very strong system of MSW treatment through waste-to-energy methods, and Kwangmyung is on its way to following a similar model. The incinerators are much more eco-friendly and sustainable alternatives to combustion by oil and fossil fuel as well as landfills.

Reducing the number of landfills is an expensive task that higher-income countries are currently undertaking. This approach requires investing in more modern waste management methods, as well as changing the behavior of the consumers. Coupled with U-city, other major cities in South Korea can follow Kwangmyung's example in using ecofriendly methods of disposing wastes in an environmentally responsible manner.

CONCLUSION

As South Korea's economic standing in the world rises, so does its environmental responsibility. High consumerism, lack of available land, and rapid urbanization, among others, are contributors to environmental problems in urban areas. Heavy development has enabled South Korea to catch up just in time with the global demands of the 21st century, at the cost of environmental health. However, the nation is progressively moving towards green development along with the rest of the globalized world.

Landscape character assessment is a useful approach in preserving the health of the environment surrounding the city, such as forests and biodiversity-rich lands. It is a highly scientific approach that focuses on preserving the health of fringes surrounding cities, but overlooks other human impacts. The U-city approach to sustainable urban development uses cutting edge technology to improve the lives of urban dwellers by reducing congestion and the stress associated with living in a densely populated area. Through high-speed internet available in every aspect of the city, urban residents can access information about green transportation and carbon footprints anywhere and at any time. The U-city concept therefore shapes the behavior of urban dwellers and enables ecofriendly urban lifestyle a more accessible possibility. Seoul is currently taking small steps to implement the U-city model and the city is projected to expand successfully in the near future. Finally, South Koreans have taken a step towards eco-friendly waste management with the exemplary implementation of a

modern waste-to-technology incinerator in a metropolitan area. The incinerator uses modern filtration systems to eliminate harmful acids and metals from the flue gas resulting from burning MSW. Further development of modern waste management technology in urban areas will greatly reduce carbon emissions and eliminate the need for landfills.

The three primary methods discussed in this research – landscape character assessment, U-city, and eco-friendly waste management – are ideas gathered from scientists and policymakers that are concerned with the future of environmental conservation as well as the well-being of not only urban dwellers, but also citizens of the entire world.

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Genome Profile of *Ambystoma mexicanum*

Patrick Wu

Patrick Wu is a third year undergraduate student majoring in biology and minoring in business management at Case Western Reserve University. He has been involved in various researches including epigenetic regulation through histone-modifying enzymes. Outside of research, he is actively involved in kendo and a member of the Phi Kappa Tau fraternity. As a pre-medical student, he plans to pursue medical school after graduation.

ABSTRACT

The *Ambystoma mexicanum*, commonly known as the axolotl, possesses extraordinary regenerative abilities and is capable of reconstituting limbs, retina, liver, and even minor regions of the brain (Muneoka *et al.*, 2008). At the most elementary level, regeneration is mediated by a cascade of epigenetic processes. With the aid of recent advances in Next Generation Sequencing (NGS), a study was conducted to identify and sequence the gene expression responsible for axolotl regeneration. Tissue samples from denervated limbs and regeneration blastema of 36 axolotls were sequenced by Illumina. Following *de novo* assembly of fragmented DNA, over 40 million reads were classified into 307,345 unigenes. Annotated sequences were analyzed against the *Xenopus laevis* database and sorted by gene oncology and clusters of orthologous groups (COGs) classification. In result, growth factors and pattern formation genes were detected in the blastemal tissue and analyzed for gene expression; these assembled transcripts will pave the foundation for future research relating to wound regeneration, genomic stability, and cell differentiation. In addition, the results of this experiment provided evidence for the applicability of Illumina sequencing to yield comprehensive data for species lacking a reference genome.

INTRODUCTION

The axolotl has long been the model for studies on regeneration in organisms. But perhaps the most intriguing aspect of salamander regeneration is their cells' ability to "know" where on the proximal-distal axis the amputation took place and regenerate in the proper order (Ferris *et al.*, 2010). Upon limb amputation, the epidermal cells migrate to cover the wound, which hardens into a layer of signaling cells called the apical epithelial cap (AEC), while truncated nerves innervating the limb release mitosis-stimulating factors, such as glial growth factor, to attract fibroblasts from nearby connective tissues to form the blastema (Mchedlishvili *et al.*, 2007). However, in the absence of an intact nerve supplxay at the site of amputation, these factors are not released and limb regeneration is terminated. At this stage, the regeneration blastema continues to grow as fibroblasts, bone, muscle, and other cells undergo dedifferentiation into their embryonic stages; these blastemal cells will eventually redifferentiate to form the mesodermal structures of a vertebrate limb.

The *Ambystoma mexicanum* has a large genome composed of repetitive DNA components and functional elements (Smith *et al.*, 2009). Recent studies have also shown the presence of Ambystoma-human non-redundant (nr) orthologous (Caron *et al.*, 2001). In comparison to humans, whose genomic library has been approximated to be around 3.2 giga base pairs, the axolotl's genomic library is estimated to have around 10 times the amount of base pairs; current data suggests the axolotl has around 21.9 to 48 giga base pairs (Habermann *et*

Acknowledgements

I would like to thank Professor Hsuan-Shu Lee, M.D. for the opportunity to intern in his laboratory at National Taiwanese University Hospital during my half-year stay in Taiwan. I would also like to acknowledge Charlie Wu and the rest of the lab members for the oversight of my experiments in Professor Lee's lab. This study was supported by the National Science Council, Taipei, Taiwan.

al., 2004). While the roles of these DNA components are not yet fully understood, it can be inferred that these DNA components harbor sequences that regulate the biological processes and gene expression profiles unique to axolotls (Tamura *et al.*, 2008). In the absence of a completed gene database, a comprehensive description of the spectrum of genes expressed during axolotl regeneration is unavailable. It is therefore inevitable that the sequencing of the axolotl genome is a foremost priority in understanding the cellular mechanisms by which this epimorphic process works.

NGS technology provides a viable resource for sequencing the axolotl genome. NGS has not only enabled researchers to produce accurate results, but also to sequence DNA in a much shorter time (Parchman *et al.*, 2010). In their work to recognize gene expression in regenerative tissues, Campbell and colleagues suggested the use of highly parallel 454 pyrosequencing to identify axolotl sequences (Campbell *et al.*, 2011). A separate study conducted verified that pyrosequencing of the axolotl genome produced over 1.7 million high-quality cDNA sequences without the use of a reference genome (Monaghan *et al.*, 2012). An alternative to pyrosequencing is another NGS technique, Illumina sequencing, which amplifies DNA molecules into clonal arrays that are then sequenced by reverse terminator bases (Bentley *et al.*, 2008). Whereas Illumina boasts a larger coverage, higher reads per run, and more paired-end read, it also suffers from a shorter read length when compared to pyrosequencing. But for the purpose of sequencing an entire genome, Illumina offers a broader coverage of genes at a lower cost per run.

Genetic data for salamanders is scarce, and the lack of a reference genome precludes the use of a reference-based assembly to acquire additional data. However, with the information obtained through NGS sequencing, *de novo* assembly can be utilized to generate a transcriptome composed of the mRNA sequence resources. Additional conclusions can be drawn through functional annotation to account for repeated sequences, while *in situ* hybridization can reveal the sites of gene expression. Through this method, a comparison between a regeneration blastema and a denervated limb should show significant differences in levels of differentiated expressed genes. In conjunction with the hypothesis, an assumption was made that most of the cellular processes to be identified during the experiment will be those relating to DNA regulation and synthesis. Therefore, the characterization of the axolotl transcriptome can clarify the functions in which these sequences are involved.

METHODS

Animal Experimental Procedures

The experimental sample size was comprised of 18 wild-types (WT) and 18 white mutants (d/d) reared from laboratory-farmed eggs. Each axolotl was kept separate in 14-20°C tap water with a pH level of 6.5-7.5. Anesthesia (0.1% MS-222) was used for all surgical procedures, and the experiment was done in accordance with the regulations of the Institutional Animal Care and Use Committee of the National Taiwan University College of Medicine. At a snout to vent length of 80 to 90 mm, the juvenile axolotls were denervated at the brachial plexus of the right supplies brachium. Amputation was performed on both forearms at the ulna one week later, and collection of tissue samples was conducted two weeks post-amputation (Figure 1) . One library was assembled from each of the acquired samples: blastemal cells from the left forearm and non-regenerating tissue from the right.

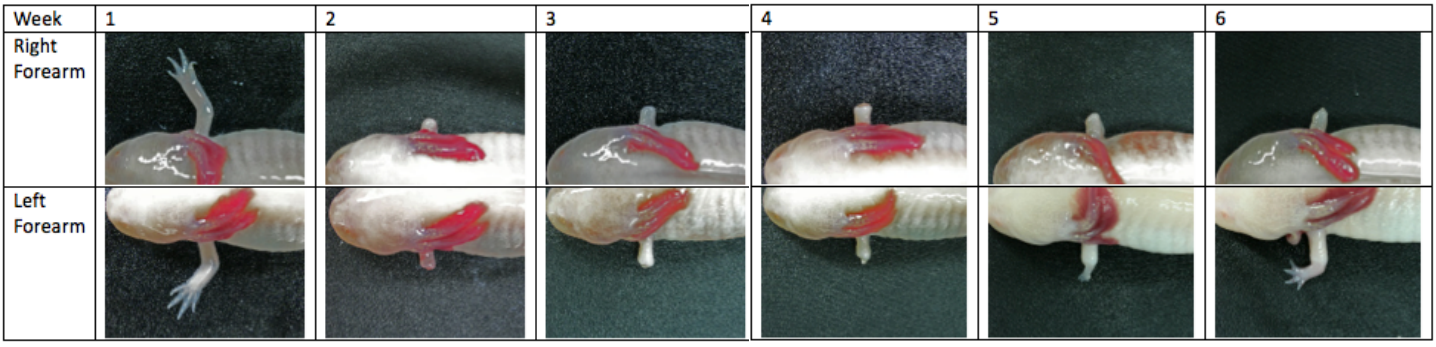


Figure 1. Stages of regeneration in a (d/d) *Amystoma mexicanum*. The right forearm was denervated in week 1 followed by amputation on both forearms in week 2. Collection of tissues was conducted in week 4. Complete regeneration of the left forearm is observed in week 6.

Library Preparation

RNA from both libraries was isolated and purified using Trizol Reagent and RNeasy Mini Kit, respectively. Once a sufficient concentration of high-quality RNA was confirmed by spectrophotography, RNA was fragmented by sonification into random pieces. Reverse transcription and polymerase chain reaction (PCR) yielded second-stranded cDNA, which was purified through gel electrophoresis. All visible bands were eluted out of the gel using QlAquick Gel Extraction Kit and then amplified again by PCR.

Illumina Sequencing

The cDNA was sequenced on the Illumina GA IIx platform after the low-quality sequences had been removed from the libraries. The remaining fragments were assembled by three *de novo* transcriptome techniques: Trinity, trans-ABySS, and SOAPdenovo (Robertson *et al.,* 2010). Trinity and SOAPdenovo were run at the default k-mer settings, while trans-ABySS was run at k-mer values of 45, 46, and 89, as suggested by Robertson and his colleagues (2010). The assembled contigs were then sequenced again by Illumina, and contigs of at least 100bp in length were collected for functional annotation.

Functional Annotation and Quantitative Analysis

Contigs were input into Basic Local Alignment Search Tool (BLASTx) software. The data was assessed against the protein database of *Xenopus laevis* as a reference because it has a close evolutionary relationship with the axolotl (Altschul *et al.*, 1997). The cut-off score for BLASTx analysis was set at an e-value of 1E-5. Contigs from each of the data sets were assigned a name and function to that of the matching protein in the *Xenopus laevis* genome based on the best BLASTx hit. If similar contigs were assigned to the same gene, the one with the lowest e-value was selected, and if these contigs shared the same e-value, the one with the longest base pairs was chosen. The non-redundant NCBI nucleotide database was also used for comparison. CLC Genomics Workbench 4.8 software was used for quantitative analysis with the parameter settings of 0.5 for the minimum length fraction, 0.95 for the minimum similarity fraction, and 10 for the maximum number of hits for a read.

In situ Hybridization

The two genomic libraries were amplified by PCR using primers that contained the T7 (anti-sense) and SP6 (sense) promoters. Anti-sense and sense probes for the genes *patched-2* and *pax7* were synthesized with the primers and tagged with digoxigenin, an antibody-based marker. Blastemal tissues were sectioned at increments of 10μm, and alkaline phosphatase activities on the anti-DIG-antibodies were detected using a mixture of the BCIP/NBT solution.

RESULTS AND DISCUSSION

Illumina NGS and Read Assembly

cDNA samples from Illumina sequencing were compared to the denervated limb stump as the control. Cumulatively, both libraries yielded over 40 million reads. Of the three *de novo* assemblies, SOAPdenovo produced the highest number of high-quality contigs at 2,920,951 contigs, whereas Trinity produced a smaller number of contigs but at a higher average read length. Due to its more prominent use by the scientific community, SOAPdenovo was chosen as the standard for the experiment (Li *et al.*, 2010). From the SOAPdenovo data, unigenes, scaffolds that do not match any other scaffolds in the *Xenopus levis* database, numbered at 116,787, with a mean length of 529bp (Table 1) . In comparison, Monaghan and his colleagues used pyrosequencing to generate over 1,700,000 reads with approximately 400,000 unigenes from cDNA samples across a broad range of regeneration stages (Monaghan *et al.*, 2009). The lower unigene count found in this experiment can be attributed to the small sample size used: tissue samples were harvested only once from each of the only 36 axolotls. Also, the average length of contigs synthesized by pyrosequencing is 215bp compared to 117bp by Illumina (Table 1), and because the longer the contigs, the more likely it is for the assembled scaffold to have no pre-existing matches and be classified as a unigene, this could also account for the lower unigene count (Tamura *et al.*, 2008). Nevertheless, the fact

Table 1. SOAPdenovo analysis of the *Ambystoma mexicanum* cDNA

Total number of reads	40,688,892
Total base pairs (bp)	4,862,000,340
Average read length (bp)	100
Total number of contigs	2,920,951
Mean length of contigs (bp)	117
Total number of scaffolds	307,345
Mean length of scaffolds (bp)	373
Total number of unigenes	116,787
Mean length of unigenes (bp)	529
Unigenes with e-value <1E-5	39,228

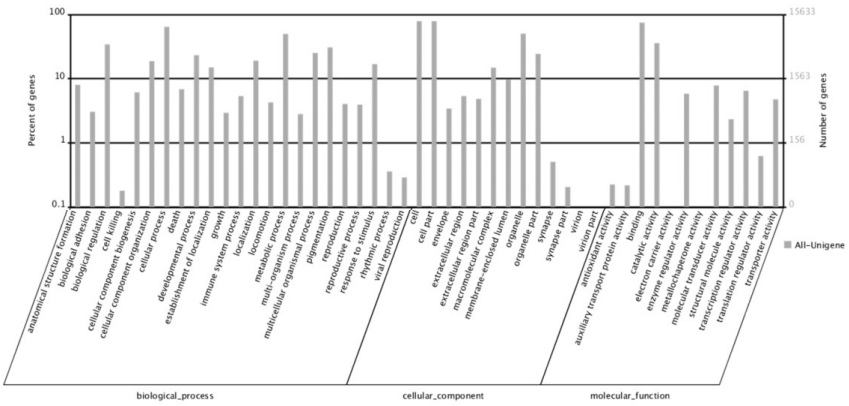


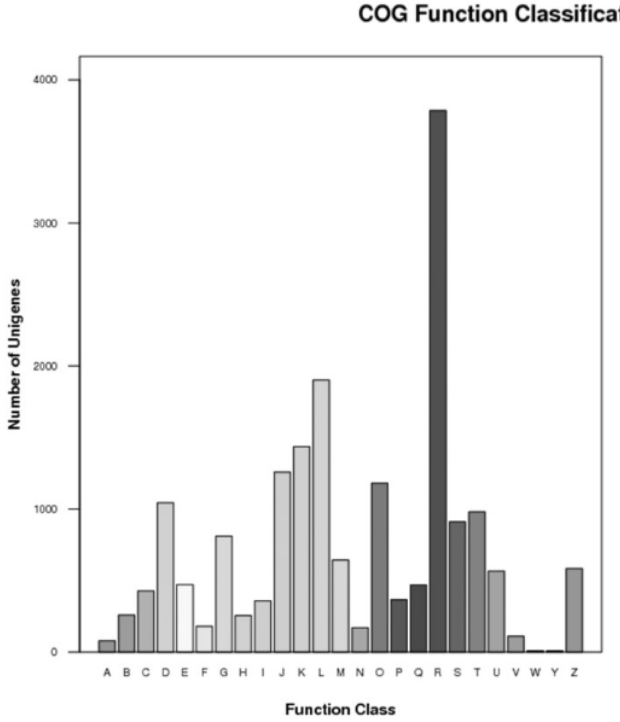
Figure 2. Histogram Presentation of Gene Ontology Classifications. Genes were summarized into three primary categories: biological process, cellular component, and molecular function. The right y-axis indicates the number of genes and the left y-axis indicates the percentage of genes from the respective primary category.

that significantly more DNA was sequenced by Illumina highlights its potential in analyzing genomic sequences.

Gene Oncology (GO) and Clusters of Orthologous Groups (COG) Classification

Identified genes were categorized by function into orthologous groups by gene ontology (GO) assignments. Based on sequence homology, 15,633 sequences were categorized into 48 functional processes (Figure 2). The most common genes within the "biological process," "cellular component," and "molecular function" classifications were "cellular process," "cell part," and "binding," respectively. Developmental process and response to stimulation are functions most pertinent to regeneration in axolotls; each consists of over 10% of biological processes (Figure 2). The remaining homology assignments concurred with experimental expectations that epigenetic and developmental functions are active during regeneration. Of the remaining functions noted, a minimal number of genes fell under the "virion," "virion parts," "electron carrier activity," and "metallochaperone activity" categories. While these functional processes were not expected, their roles should be studied further to discover whether they have prominent tasks in axolotl regeneration.

To test the accuracy of gene oncology assignments, clusters of orthologous genes (COG) classifications were assigned as well. The COG database provided a faster alternative for describing the functional characteristics of genes. Using COG classifications, 9,744 of the 39,228 non-redundant genes were categorized (Figure 3). Among the 25 COG categories, the clusters for "general function



A. RNA processing and modification
B. Chromatin structure and dynamics
C. Energy production and conversion
D. Cell cycle control, cell division, chromosome partitioning
E. Amino acid transport and metabolism
F. Nucleotide transport and metabolism
G. Carbohydrate transport and metabolism
H. Coenzyme transport and metabolism
I. Lipid transport and metabolism
J. Translation, ribosomal structure and biogenesis
K. Transcription
L. Replication, recombination and repair
M. Cell wall/membrane/envelope biogenesis
N. Cell motility
O. Posttranslational modification, protein turnover, chaperones
P. Inorganic ion transport and metabolism
Q. Secondary metabolites biosynthesis, transport and catabolism
R. General function prediction only
S. Function unknown
T. Signal transduction mechanisms
U. Intracellular traffiicking, secretion, and vesicular transport
V. Defense mechanisms
W. Extracelluar structures
Y. Nuclear structures
Z. Cytoskeleton

Figure 3. Histogram presentation of clusters of orthologous groups (COG) classification. Major function classes are listed.

Table 2. Comparison of Selected Gene against nr, NCBI nucleotide, and EST databases. Three genes: transforming growth factor-βs, fibroblast growth factors, and *hox* genes were chosen for the comparison.

Gene Name	Number of matches with nr database	Number of matches with NCBI	Number of matches with EST
Transforming growth factor-βs	6	1	1
Fibroblast growth factor	8	5	2
Hox genes	28	7	1

prediction only" represented the largest group (3785, 20.7%), followed by "replication, recombination and repair" (1901, 10.4%) and "transcription" (1436, 7.9%). In comparison to the COG analysis of the *Taxus mairei* genome, which showed "general function prediction only" as the largest group at 17.1%, it can be seen that the axolotl has a fairly similar genomic expression profile to that of *Taxus mairei* (Hao *et al*., 2011). However, as "general function prediction only" is a poorly characterized group, it was excluded in the comparison. Otherwise, a notable difference was found in the "replication, recombination, and repair" category, in which the axolotl had significantly more genes. All three processes – replication, recombination, and repair – are cellular processes that concern DNA regulation and synthesis, and an examination of cellular processes by gene

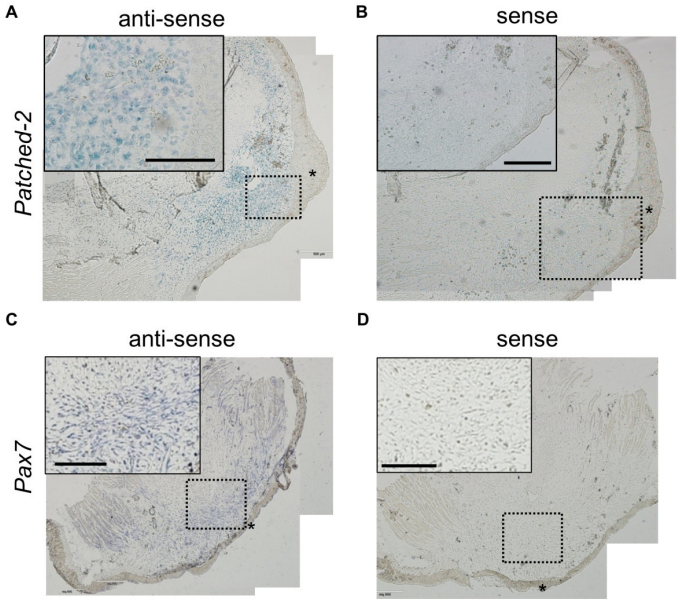


Figure 4. In situ hybridization analysis of *patched-2* and *pax7* expression in the regeneration blastemas. *Patched-2* (2) or *pax7* (C) signals (blue) using respective anti-sense probes are shown in the distal tips of the regenerating limbs. No signals were detected in the negative-control sections using respective sense probes of *patched-2* (B) and *pax7* (D) on serially sectioned slides. Scale bars indicate 200 μm.

oncology and COG classifications revealed a particular emphasis of DNA regulation and cellular growth during axolotl regeneration. These annotations provide a valuable resource for investigating specific processes, functions, and pathways during axolotl limb regeneration research.

Detection of Sequences Related to Limb Regeneration

Fibroblast growth factors have been shown to contribute to vertebrate limb regeneration in axolotls (Poulin *et al*., 1993). For example, *hoax-13*, an autopod marker in many vertebrates, is expressed in the distal regions of the blastema (Satoh et al., 2011). Comparisons with the NCBI, EST, and nr databases yielded a multitude of sequences homologous to limb regeneration: transforming growth factors, fibroblast growth factors, and homeobox genes (Table 2). As tgf-β sequences (tgf-β1, 2, 3, and 5) have been proven to be in the axolotl genome, the table captured a nearly complete portfolio of these genes (Koniski and Cohen, 1998). Both fibroblast growth factors and *hox* genes are linked to embryonic formation; their presence confirms the dedifferentiation of blastemal tissues followed by redifferentiation into new limbs. Moreover, the high yield of high-quality sequences shows the ability of Illumina to facilitate research in axolotl genetics, whether on the identification of new genes or the reconfirmation of previous genes.

Expression Patterns of Differentially-Expressed Genes in Limb Regeneration

Technical difficulties in the isolation of the regeneration blastema may produce inaccuracies, such as the accidental contamination of tissue samples by the underlying epidermis, which can lead to the higher expression of certain genes. Thus, *in situ* hybridization was done to reveal the specific cells that expressed the identified genes. *In situ* hybridization showed that *patched-2*, one of the genes differentially expressed in blastema, is expressed in the cells located in blastema (Figure 4A). Conversely, *in situ* hybridization with sense control probes gave no signals (Figure 4B). It can be concluded, then, that *patched-2* expression is limited to within the blastema, and not in the surrounding epidermis (Figure

4A). Similarly, *pax7* is also expressed only in the blastema (Figure 4C)*; pax7*-positive cells also appeared in tail blastema and midbud-stage limb blastemas (Altschul *et al.*, 1997). Therefore, the expression of regulatory genes involved in limb regeneration is confirmed to exist primarily in the blastema and not in surrounding non-blastemal tissues. These results demonstrate that the NGS libraries may identify potential markers for the blastemal progenitor cells that initiate limb regeneration.

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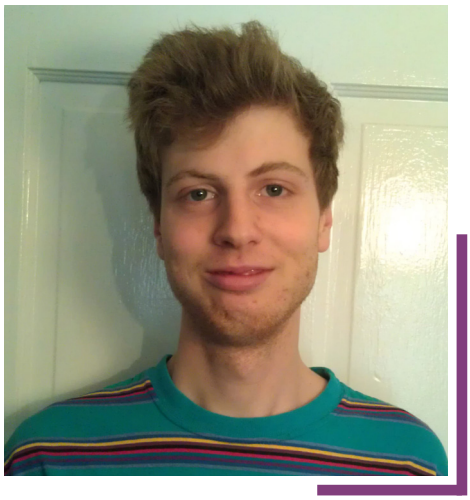
Race as a Material Ideology



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INTRODUCTION

The persistence of racism within the working class is a fundamental problem for any Marxist analysis of race, and there have been several attempts to solve this problem within the Marxist tradition. Most traditional understandings, however, turn out to be theoretically inconsistent and lacking in terms of explanatory power when confronted with the historical realities of Italian, Irish, and African-American labor relations in the early 20th century. I will argue that bringing Louis Althusser's theories of the state and ideology to bear on the problem of working-class racism can offer a better historical understanding than traditional explanations.

HISTORICAL ATTEMPTS

One traditional analysis, which can be placed within the orthodox school of Marxism, simply "subsumes racism under the general rubric of working-class exploitation" (West). This classical analysis emphasizes the economic above all other factors. The relations of production determine everything else, and the extraction of surplus value via wage labor is the primary form of exploitation. Racism is seen as nothing more than an effective divide-and-conquer tactic of the capitalist class, and any focus on anti-racist work simply distracts from the class struggle that is the 'true' nature of history.

This theory, however, has significant shortcomings. For one, if capitalism is understood only "according to the abstract economic logic described in *Capital*" it does not require any divisions in the working class (Moufawad-Paul). In fact, divisions could be detrimental to capital because a unified working class provides a larger reserve army of labor. Furthermore, divisions within the working class along race, gender, or other lines may lead to struggles (anti-racist, feminist, etc.) that can slow down or undermine the "day-to-day functioning of capital" (Moufawad-Paul). Historically, divisions within the working class have sometimes benefited capital by suppressing wages, but there is no requirement in the structure of capitalism that the working class be kept divided. Understanding racism as nothing more than a divide-and-conquer tactic ignores the fact that capital has no inherent need to divide the working class.

A more sophisticated Marxist analysis "claims that racist practices result not only from general and specific working-class exploitation but also from xenophobic attitudes that are not strictly reducible to class exploitation" (West). Seen this way, "racist attitudes have a life and logic of their own" (West). This, however, leaves a significant question unanswered: if racism is simply a continuation of xenophobic attitudes that are always present in human groups, then "What prevents all cases of the affinity-disaffinity dialectic from

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being translated into racism? What prevents all national formations, all caste formations, all ethnic formations, all class formations from becoming racial formations at the same time?" (Liem 39) There is something historically specific about racism unaddressed by the xenophobic explanation. Racism, nationalism, caste systems, and ethnicity all operate by logics of inclusion and exclusion, but none of these social formations are identical in formation or operation. The xenophobic explanation allows for an understanding of racism as more than a capitalist conspiracy while being overly reductionist by treating all exclusionary social formations as the same.

The most common Marxist answer for racism is the phenomenon of "false consciousness" (Willhelm 106). In this explanation, the working class suffers from an "illusory perception" and they "believe in both racism and the property rights of capitalists" (Willhelm 106). This contains elements of the previous two explanations considered. Like xenophobia, but unlike 'divide-and-conquer,' it does not present racism as a conspiratorial invention by capitalists. It allows for the historical development of racist attitudes independently from (or at least not directly invented by) the ruling class. Like both of the previous explanations, however, false consciousness still toes the orthodox Marxist line that proletarian identity is the 'truest' identity of members of the working class and that workers who act in racist ways simply do not understand their true nature as a member of the proletariat.

The false consciousness explanation of racism suffers from significant problems. First, false consciousness blames "the very victims of capitalist oppression and exploitation for their own fate" (Willhelm 106). False consciousness supposes that the working class does not understand their "real" conditions, and that they believe in the "false" conditions of racism. The second problem is an analytic error: in appealing to false consciousness, Marxists simply replace one noneconomic variable (racism) with another (false consciousness). In order to "incorporate racism in what is, supposedly, a materialistic analysis, they [analysts who employ false consciousness] ultimately place less reliance upon the economics of a class struggle" (Willhelm 107). False consciousness is reductionist in the same manner as the xenophobic analysis: "false consciousness" reduces racism, sexism, nationalist, etc to "false" ideologies which are not "real." False consciousness as a theory has no political solution for dealing with these ideologies other than telling workers to stop believing in them because they are "false."

Most importantly, all three of these explanations of racism have no compelling answer for the following question: "what is to be done with the noneconomic variable of race within the framework of an economic analysis conceding the presence of racism transcending class lines?" (Willhelm 105). Marxism is a materialist framework, but all of these analyses explain racism by putting more emphasis on ideological factors than on material conditions. As such, they offer no theoretically consistent answer for the question "If history is the story of class struggle, how can racism inhibit class conflict?" How can the proletariat engage in behavior that actively divides them against the bourgeoisie? This is the fundamental question that a Marxist theory of racism must address, and a question that "divide-and-conquer," xenophobia, and false consciousness fail to answer satisfactorily.

A DIFFERENT DIRECTION

Building upon the work of Louis Althusser offers a much more fruitful way to reconcile Marxism and working-class racism. Instead of interpreting racism as false consciousness, it should be viewed through the lens of Althusser's theory of ideology. To develop that theory, Althusser offers an interpretation of the State in which he distinguishes between state power and state apparatuses, and divides the state apparatuses into the Repressive State Apparatus and Ideological State Apparatuses. According to Althusser, the Repressive State Apparatus contains "the Government, the Administration, the Army, the Police, the Courts, the Prisons, etc." while the Ideological State Apparatuses include, but are not limited to, religious institutions, educational institutions, the conventional family structure, the political system, and popular culture (Althusser 96). While there is a single Repressive State Apparatus and a multitude of Ideological State Apparatuses, what unites them all is that "the ideology by which they function is always in fact unified, despite its diversity and its contradictions, *beneath the ruling ideology*" (Althusser 98). For Althusser, the state apparatuses (repressive and ideological) exist to facilitate "the reproduction of the relations of productions" (Althusser 101).

One more key point from Althusser is necessary before constructing a theory of working-class racism on his ideas: Althusser claims that ideology always exists in a "material ideological apparatus" which prescribes "material practices" (Althusser 114). Furthermore, "there is no practice except by and in an ideology" and therefore "ideology has a material existence" (Althusser 115). This is Althusser's attempt to reconcile the materialism of Marxism

with the supposed immateriality of ideology. If racism can be interpreted as an Althusserian ideology, it must have a material existence in the practices of the state apparatuses which will (1) show how racism serves to reproduce the relations of production; and (2) explain the persistence of working-class racism in a more compelling way than previous Marxist theories of racism.

It is easy to see that historically, racism has been present in the Repressive State Apparatus. Legally enforced chattel slavery was the expression of racism in 19th century legal and judicial structures. In her book *Manifest Destinies: The Making of the Mexican American Race*, Laura Gomez argues that legislation and judicial decisions about citizenship were instrumental in creating "Mexican American" as a racial category. The Johnson-Reed Act of 1924, which established immigration quotas based on race and nationality, was at least partially influenced by the steel industry's desire for control of its labor supply (Esch 180) and can be seen as a material expression of racism in the Repressive State Apparatus. The cyclical importation and deportation of Mexican immigrants by government agencies, often motivated by business's desires about the labor force ("20th Century Immigration"), is another example of material consequences of racial ideology in the government and courts. Race as an ideology, then, clearly has a material existence in the state apparatuses. But, can it deal with the problem of working-class racism? At this point, Althusser's perspective is no more revealing than false consciousness because no light has been shed on how racism actually functions as an ideology. It has not been shown how racism's material existence reproduces the relations of production.

First, it is clear that competition among the working class for jobs, whether it is along racial lines or not, reinforces one of the essential notions of capitalism, "the transformation of the worker into a thing through the purchase and sale of his labour power as a commodity" (Callinicos 21). Labor competition, whether racially motivated or not, facilitates the reproduction of the relations of production. However, while labor competition and racism are correlated, this is not a direct relationship and labor competition is not the entire story. David Roediger best problematizes the relationship, in the context of Irish immigrant labor, by asking "why did they [Irish immigrant workers] choose to stress competition with Black workers instead of with other whites?" (Roediger 147). In both skilled and unskilled labor markets, "the Irish had far more German-American competitors than Black ones" (Roediger 147) but Irish workers still chose to compete primarily with black workers. Historical evidence denies any suggestion that racism is solely the product of labor competition.

A possible solution lies in the relationship between blackness and whiteness and the correlation of upward social mobility with this relationship. Here, Althusser's idea of different "modalities of materiality" (Althusser 114) is necessary. As Thomas Guglielmo argues in *White On Arrival*, being considered white gave Italian immigrants greater privilege and more of a chance for upward social movement than African Americans, even if Italians were considered inferior to Anglo-Saxon whites (Guglielmo 10). While Italian immigrants may have been impoverished day laborers whose immediate material conditions were roughly equivalent to those of unskilled black laborers, the possibility of upward movement, which would come with very real economic consequences, can be seen as a material privilege of whiteness (or off-whiteness). If upward social mobility is recognized as a material privilege of whiteness, albeit in a different "modality of materiality" than higher wages, membership in unions, or access to skilled jobs, the idea that whiteness comes with material privileges is not refuted by unskilled white and black laborers living in similar material conditions in a given time and place.

Even if Germans were their more direct competitors at the time, Irish immigrants stood to gain materially by placing themselves on the opposite side of blackness. In the racial hierarchy of early 20th century America, with "black" clearly at the bottom and "white" clearly at the top, even if the definition of white was fluid and changing, placing themselves on the other side of "black" was the way towards some kind of upward social mobility. This is reflected in Gunnar Myrdal's argument that for most immigrants, the "development of prejudice against the Negroes is usually one of their first lessons in Americanization" (Guglielmo 35); in Ralph Ellison's claim that "one of the first epithets that many European immigrants learned when they got off the boat was the term 'nigger'" (Guglielmo 35); that in oral interviews many Italian Americans often contrasted "themselves explicitly with African Americans" (Guglielmo 12); that "dark skinned" people, whether dark skinned Italians, African Americans, or otherwise, were often the victims of the harshest racial prejudice (Guglielmo 28); that Chicago "neighborhood boundaries seem to have been a lot less permeable when it came to African Americans" (Guglielmo 51); that it was much easier "for the Irish to defend jobs and rights as 'white' entitlements instead of as Irish ones" (Roediger 148); and finally that "relations between 'colored' groups and European immigrants deteriorated over time"

(Guglielmo 56). Even if Italians, Irish, and other immigrants did not initially see themselves or were seen as white, they were certainly not black. In contrast to African Americans, "Europeans could find an alternative location for themselves on the racially keyed map of New World political identity" (Jacobson 255).

This is not to suggest that all European immigrants actively claimed whiteness and were racist towards African Americans as soon as they arrived. Guglielmo makes it clear that it was a long, slow process for Italian immigrants to develop any kind of white consciousness (Guglielmo 6). Nor is it to suggest that European immigrants in early 20th century America were never themselves victims of racial discrimination. Most importantly, it is not to suggest that when white consciousness *did* develop among these immigrants it was simply the triumph and continuation of past hatred and racism in America, which would now be perpetrated by immigrant white labor upon black labor. It *is* to suggest, however, that upward social mobility has real material results, that there is a relationship between upward social mobility and the racial categories of "black" and "white", and that this relationship is useful in explaining the eventual categorization of most European immigrants into the "white" category.

In a racial hierarchy with "white" at the top and "black" at the bottom, then, there is a strong correlation between upward social mobility and racial category. Upward social mobility has direct economic consequences in the type of jobs that are available, access to education, and more. Consequently, groups of people with different perceptions of their possibility of upward movement have divergent material interests. Racism is thus an ideology existing in both repressive (Immigration Acts, Jim Crow laws) and ideological (education discrimination, political disenfranchisement, negative cultural representations of immigrants and African Americans) state apparatuses which divides the working class by creating divergent material interests between those who see themselves as having upward social mobility and those who do not, a division which is closely tied to white and black racial lines. Furthermore, racism serves to reproduce the relations of production both by fostering job competition, which reinforces the notion of human labor as a commodity, and by dividing the working class against itself along real economic lines of upward social mobility.

CONCLUSION AND AREAS FOR FURTHER RESEARCH

A theory of racism as an Althusserian ideology removes the problem of appealing to false consciousness from an analysis of racism and explains the working class racism of early 20th century Irish and Italian immigrants as a product of divergent material interests within the working class. By elucidating the material consequences of racial categories along lines of social mobility, by acknowledging that historically there have been "economic advantages to racist practices by white unionists" (Willhelm 103), and by concluding that racism *is* a material force, this manner of theorizing racism places the emphasis squarely on the material conditions of racist practices rather than on ideological conditions.

This offers several avenues for further research. Historically and economically, one would expect to see stratification in income levels between black and white workers, and further stratification between Anglo and non-Anglo whites in the early 20th century before they had fully gained "white" status. In *Economics of Racism*, Victor Perlo uses census data to analyze income differentials and trends in income for black and white workers. He shows that, from 1945 – 1965, "the ratio of Black to white median family incomes fluctuated up and down within the 50-55 percent range" (Perlo 54). In other words, the median income for a black family was stagnant at roughly half of that for a white family. Looking at this ratio and its change over time, as well as its rate of change, offers one way to quantify economic equality and upward mobility. A similar method, targeted at Anglo and non-Anglo whites in the early 20th century, could be used to determine trends in income and analyze overall mobility. The idea of divergent material interests raises historical questions as well. If black, Anglo, and non-Anglo white workers all had different material interests, how did this manifest itself in practice? Did these groups consequently have different attitudes and approaches towards workplace organizing or broad working-class movements?

Theoretical questions remain as well. Althusser's understanding of the structure of ideologies has not been touched on in this paper. The doubly-mirroring interpellation of subject by Subject could possibly be productively deployed on the problem of the relationship between whiteness, blackness, and the gradient in between. What is the Subject of racial ideology? Can this shed any light on the importance of skin color, i.e. the fact that darker-skinned people, regardless of ethnicity or nationality, were generally subject to worse discrimination than lighter-skinned people?

By arguing that upward social mobility has material consequences and is closely correlated with "black" and "white" racial categories, we can see that racism is an ideology

which divides the working class between groups that do and do not have chances of upward movement. Racism is not a conspiracy foisted on workers by the capitalist class, it is not a hangover of natural human xenophobia, and it is not simply a case of false consciousness: it is a material force which divides the working class by creating divergent material interests along lines of upward social mobility.

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Toward A More Sustainable Food Supply Network: An Economic Analysis of Sustainability in the United States Food Industry

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Morgan Bulger is a recent graduate from Case Western Reserve University's Weatherhead School of Management with a Bachelors degree in Business Management with concentrations in Marketing and Sustainability. She is passionate about the food industry and finding truly sustainable solutions for a diverse set of externalities created by our industrial food system. After graduation the author plans to continue serving CWRU's Office of Sustainability as a Sustainability Consultant, while continuing her research in the field of sustainability.

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ABSTRACT

In order to determine the current state of the industrial food system, both a quantitative survey and a qualitative interview were conducted and administered to various food corporations in the United States. These surveys assessed the corporations' current awareness, attitudes, and actions in regards to specific unsustainable externalities in the food industry. By applying regression analysis to the data collected, it becomes clear that perceptions of risk and opportunity of specific externalities, or external problems, of the food system directly affect the degree of sustainable action that a given corporation takes. Additionally, the relationship between vertical integration and sustainable action suggests that the driving factor influencing the corporation's degree of sustainable action is the ability to recognize environmental and social externalities as opportunities to gain a competitive advantage.

INTRODUCTION

As the debate over the ethics of what we eat becomes more prominent and inclusive, it is important to look at the complex problem from a whole systems approach. Through holistic exploration, the human food system presents externalities in the areas of human health (Simon, 2006, p. xiii), social equality (Patel, 2007, p. 194), environmental degradation (Jackson, 2010, p. 154), and animal welfare (Singer & Mason, 2006, 45). Most notably, by exploring the chain of interactions that occur from farm to fork, it becomes apparent that the current industrial design of food processing and distribution pressures farmers to act unsustainably – both in regards to the environment and in regards to their own economic well-being – while simultaneously pressuring consumers to eat in a manner that is detrimental to their personal health (Patel, 2007, 183). The current human food chain creates a force working against both producers and consumers, benefitting only the most vertically and horizontally integrated and concentrated corporations in the supply chain (Patel, 2007, p. 12). While several consumer-driven alternatives have accelerated in prevalence, a discussion of the validity of these alternatives reveals that these movements alone may not be enough to change to the system as a whole; but with the action from key actors within the web of the current industrial system, true sustainability can be reached (Jackson, 2010, p. 169). Studying the current state of the industrial food system allows for an understanding of the mechanisms that encourage companies to act sustainably and how to further incentivize this type of action.

METHODOLOGY

In order to analyze the current state of the United States Food Industry, I created both a quantitative survey and a qualitative interview to be administered

to prominent food corporations. I created the sample for my survey by listing the most prominent food corporations in each sector of the industry and accounted for the following: production, processing, distribution, wholesale, retail (grocery), and industrial catering (restaurants). The corporations were selected based on a cross reference of public financial information (Bloomberg Food, 2013), public records of prominent distribution companies (Top 75, 2012; Top 50, 2013; Food Processing's, 2012), and public documents from the USDA (USDA Export, 2002). Once this list was created, I contacted each company for contact information of the Chief Executive Officer (CEO), Chief Operating Officer (COO), Vice President, or similarly high ranking individual who would have a holistic view of the company and its operations. I attained 109 email addresses and administered an online survey to these individuals via an online survey website, and then sent 100 print surveys via traditional mail to 100 corporations from my original list that I had not attained the contact information for. Collectively, my sample consisted of 209 individual corporations throughout the food supply chain. I received a response rate of 40% for the online sample (including incomplete surveys) and a 20.6% response rate over the entire sample. Regarding only completed surveys, I received a 14.7% response rate from the online sample and a 9% response rate over the entire sample. Interviews consisted of seven individuals, each from a different food corporation throughout the supply chain, and were conducted after the survey had closed.

The survey was comprised of 36 questions, split into sections of basic information (i.e. name, company name, title, etc.), awareness of unsustainable externalities of the food system, attitudes on such externalities (i.e.: perceptions of risks or opportunities), and specific sustainable actions taken by each corporation (Figure 1).

The six proven externalities presented were documented regarding the food system, and each action proposed was a solution towards attaining sustainability. Intensive farming procedures and increased use of nitrogen- and phosphorous- based fertilizers and other intensive farming procedures have led to an increase in soil degradation levels (Jackson, 2007, p. 130). This increased use has also led to ocean eutrophication, among other issues of local water contamination (Mackenzie, F. T., Ver, L. M., Lerman, A, 2002, p. 16). Additionally, the agriculture industry is a major emitter of greenhouse gases, including carbon dioxide and methane (Patel, 2007, p. 299). It is also documented that the industrial food system supports social injustice (Patel, 2007, p. 25), and has led to increased levels of nutrition-related diseases (Pollan, 2008, p. 10). Finally, consumers are facing unequal access to nutritious foods, also known as the "food gap" between those with financial means to eat nutritiously and those without (Winne, 2008, p. xi). These are thus the six externalities used: soil degradation, ocean acidification and eutrophication, greenhouse gas emissions, social injustice, nutrition-related diseases, and unequal access to nutritious food. Furthermore, it has been proposed that Life Cycle Analysis (Guinee & Heijungs, 2011, p. 657), Appreciative Inquiry (Venter, 2010, p. 43), USDA Organic certified food products (Halweil, 2010, p. 83), LEED certified building procedures (Orr, 2012, p. 43), Fair Trade certified products (Martin, 2009, 77), localized food production and distribution (Pollan, 2006, p. 249), employee ownership (Beyster, 2008, p. 29), consumer health education (Carmona, 2005, p. 9), and community development (Blandy & Fenn, 2012, 274) could all be potential solutions to the externalities created by our society and the food industry, and will thus be used as the sustainable actions in my analysis.

Each survey question was asked on a scale with five choices, typically from "Not at all" to "Extremely," in the context of each question. The interviews were sets of seven questions relating to the survey questions and inquiring into further detail about the awareness, attitudes, and actions of each company interviewed (Figure 2).

Having collected the data, I then ran 241 regressions using the statistical program, SPSS, in order to determine what, if any, relationships existed between the variables in my data set, and to define what those relationships were. Primarily, only statistically significant relationships will be discussed in this paper. Qualitative data from the interviews were then compared to the statistical regressions.

DATA

The data used in the statistical regressions included 27 numerical variables each recoded on a scale of one to five: one typically being "Not at all" and five being "Extremely" or "Exclusively." Figures 3 and 4 provide the full statistical summary and description of each of the variables used, respectively. Qualitative variables including the company name, respondent name, and respondent title were not used in statistical regression. In addition to the 27 numerical variables, a dummy variable indicating a binary response out of a categorical question was created from question five of the survey, which asked respondents to indicate any and all sectors of the food business their company is involved in. Specifically, corporations were able to select food production, food processing, food

distribution, food wholesale, food retail (grocery), industrial catering (restaurants), and an option for other. In order to use this variable as a measure of vertical integration, or how much of the supply chain an individual company contributes to, I first counted the number of answers each respondent selected. I recoded these numbers into either "vertically integrated" for respondents who were involved in three or more sectors of the supply chain or "not vertically integrated" for respondents who were involved in two or less sectors. Additionally, composite variables were created for each the composite question sections of awareness, risk attitude, opportunity attitude, and action. Each variable was created by taking the sum of each category's variable responses. Including the dummy variable and composite variables, 32 variables were used for regression analysis.

Empirical Model Results

For each relationship analyzed through regression, an empirical model or equation will be created that defines the relationship both in terms of correlation and in terms of how well that equation explains the relationship of the independent variable(s) on the dependent variable. The first set of relationships was between the attitudes of a corporation on specific externalities and their likelihood to take specific sustainable actions.

The first relationship was the correlation of the risk that corporations associate with consumer's unequal access to nutritious food and the likelihood that they will initiate the sustainable practice of life cycle analysis. The relationship will produce the following empirical model:

1a. LifeCycleAnalysis = $\beta_0 + \beta_1$ R_UnequalAccess + u_i

where LifeCycleAnalysis represents the predicted degree to which corporations will initiate and engage in life cycle analysis at their corporation. β_0 represents the intercept, or what Y (LifeCycleAnalysis) will equal when X (R_UnequalAccess) equals zero. β_1 is the coefficient of R_UnequalAccess. This number will be generated by the regression. R_UnequalAccess represents the degree to which a given corporation associates consumer's unequal access to nutritious foods as a risk to their corporation. u_i represents the error term, or how far off the actual value of life cycle analysis is from the predicted value of LifeCycleAnalysis. The results of all regressions are detailed in Figure 5.

The regression between consumer's unequal access to nutritious foods and the engagement in life cycle analysis produced the following equation, with the standard errors for each figure below each coefficient estimate:

1b. LifeCycleAnalysis = 3.232 (0.549) - 0.549 (0.269) R_UnequalAccess + u_i

The intercept is statistically significant at the 1% level and the coefficient of R_UnequalAccess is statistically significant at the 10% level. The adjusted R^2 value is 0.150, meaning that this equation shows a 15% explanation of the change in the degree of engagement in life cycle analysis. What this equation means is that the more a company views consumer's unequal access to nutritious foods as a risk, the less likely they are to engage in life cycle analysis. Figure 6 provides a graph of the relationship between the risk of consumer's unequal access to nutritious foods and corporations' engagement in life cycle analysis.

The second relationship I found between the attitudes of a corporation and their propensity to take sustainable action is between the risks corporations associate with unequal access to nutritious foods and the sustainable action of Appreciative Inquiry. The relationship fills the following empirical model:

2a. AppreciativeInquiry = $\beta_0 + \beta_1$ R_UnequalAccess + u_i

where AppreciativeInquiry represents the predicted degree to which a given company engages in Appreciative Inquiry practices in their corporation. All other variables represent the same coefficients and variables as the previous equation (1a). The regression produced the following equation, with the standard errors for each figure below each coefficient estimate:

2b. AppreciativeInquiry = 2.902 (0.461) - 0.593 (0.208) R_UnequalAccess + u_i

The intercept is statistically significant at the 1% level, and the coefficient of R_UnequalAccess is statistically significant at the 5% level. The adjusted R^2 value is .284, meaning that this equation shows a 28.4% explanation of the change in the degree of engagement regarding appreciative inquiry. Essentially, the more a company views consumer's unequal access to nutritious foods as a risk, the less likely they are to engage in appreciative inquiry. Figure 7 provides a graph of the relationship between the risk of consumer's unequal access to nutritious foods and corporations' engagement in appreciative inquiry. The relationship of the last two regressions indicates that as companies perceive a higher level of risk for the specific social externality of consumer's unequal access to nutritious foods, they become less likely to engage in specific sustainable activities.

The third relationship between corporate attitudes and sustainable action is the degree to which a corporation views social injustice as a risk, and the degree to which they include USDA Organic products in their business model. The relationship will produce the following empirical model:

3a. USDAOrganic = β_0 + β_1 R_SocialInjustice + u_i

where USDAOrganic represents the predicted degree to which corporations will include USDA-certified organic food products in their business model. β_0 represents the intercept and β_1 represents the coefficient of R_SocialInjustice, with both generated by the regression. R_SocialInjustice represents the degree to which a given corporation views social injustice as a risk. u_i represents the error term. Running the regression produced the following equation, with the standard errors for each figure below each coefficient estimate:

3b.USDAOrganic = 2.061(0.337) + 0.412 (0.162)R_SocialInjustice + u_i

The intercept is statistically significant at the 1% level and the coefficient of R_SocialInjustice is significant at the 5% level. The adjusted R^2 value is .232; this equation shows a 23.2% explanation in the change of the degree of incorporation of organic food products. The more a corporation views social injustice as a risk to their own company, the more likely they are to include USDA organic food products in their business model. A graph was produced of the relationship between the risk of social injustice and corporations' engagement in incorporating organic food products (Figure 8).

The fourth relationship between a corporation's perceived risks and their likelihood to take sustainable action is the correlation of both the perceived risks of consumer's unequal access to nutritious foods and soil degradation to the degree to which a corporation has integrated LEED certification into their buildings and structures. The relationship will produce the following empirical model:

4a. LEEDCert = β_0 + β_1 R_SoilDegradation + β_2R_UnequalAccess + u_i

where LEEDCert represents the degree of company integration of LEED-certified building procedures and materials into their structures. β_0 represents the intercept, β_1 represents the coefficient of R_SoilDegradation, and β_2 represents the coefficient of R_UnequalAccess, all of which are generated by the regression. R_SoilDegradation represents the degree to which a given corporation views soil degradation as a risk to their corporation, and R_UnequalAccess represents the same perception of risk for consumer's unequal access to nutritious food. u_i represents the error term. Running the regression produced the following equation, with the standard errors for each figure below each coefficient estimate:

4b. LEEDCert = 1.29 (0.565) + 0.471 (0.221) R_SoilDegradation + 0.286R_UnequalAccess + u_i(0.565)(0.221)(0.157)

Both the intercept and the coefficients of R_SoilDegradation are statistically significant at the 5% level, and the coefficient of R_UnequalAccess is statistically significant at the 10% level. The adjusted R^2 value is .270, so this equation shows a 27% explanation in the change of the degree of engagement in LEED certification. The more a corporation views soil degradation and unequal access to nutritious foods as risks to their own company, the more likely they are to pursue LEED certification. In this regression as well as the previous regression, we can see a relationship between how perceptions of both environmental and social risks can improve a company's sustainable actions, whereas only considering perceptions of social injustice as a risk decreases the likelihood of specific sustainable actions.

In addition to the impact that perceptions of risks can have on the actions a corporation takes, recognition of opportunity can also have an effect. The first relationship of this variety that I discovered was between the perception of ocean acidification and eutrophication as an opportunity to improve and gain competitive advantage, with the sustainable action of local food production and distribution. This relationship produced the following empirical model:

5a. Local = β_0 + β_1 O_Ocean + u_i

where Local represents the predicted degree to which corporations will engage in local food production and distribution. β_0 represents the intercept and β_1 represents the coefficient on O_Ocean. These variables will again be generated by the regression. O_Ocean represents the degree to which a given corporation associates ocean acidification and eutrophication as an opportunity for their corporation to improve and gain competitive advantage. u_i represents the error term. The regression produced the following results, with the standard errors for each figure below each coefficient estimate:

5b. Local = 2.114 (0.338) + 0.510 (0.172) O_Ocean + u_i

Both the intercept and coefficient of O_Ocean are statistically significant at the 1% level, and the adjusted R^2 value is .301, meaning that this equation shows a 30.1% explanation of the change in local production, which is very economically significant. Essentially, the more a corporation perceives ocean acidification and eutrophication as an opportunity to improve and gain competitive advantage, the more likely they are to engage in local food production and distribution. A graph of the relationship between the perception of opportunity of ocean acidification and local

food production is provided (Figure 9).

Similarly, there is also a relationship between the perception of opportunity surrounding ocean acidification and the engagement of corporations in consumer health initiatives. The regression will produce the following empirical model:

6a. HealthEd = β_0 + β_1 O_Ocean + u_i

where HealthEd represents the predicted degree to which corporations will engage in consumer health education initiatives. All other variables represent the same coefficients and variables as in the previous regression (5a). Running the regression produced the following equation:

6b. HealthEd = 2.138 (0.545) + 0.527 (0.278) O_Ocean + u_i

The intercept is statistically significant at the 1% level, and the coefficient of O_Ocean is statistically significant at the 10% level, with the adjusted R^2 value of .126, meaning that this equation shows a 12.6% explanation of the change in consumer health education. Similarly, the more a corporation perceives ocean acidification and eutrophication as an opportunity to improve and gain competitive advantage, the more likely they are to engage in consumer health education initiatives. Figure 10 contains a graph of the relationship between the perception of opportunity of ocean acidification and health education. Interestingly, while companies perceiving social injustice as a risk were less likely to engage in specific sustainable actions, companies perceiving ocean acidification and eutrophication as an opportunity to improve and gain competitive advantage were more likely to engage in specific sustainable activities.

There were an additional two regressions that correlated and showed relationships between attitudes on closely linked externalities and sustainable actions. The first of these correlations is the relationship between the likelihood of a company to perceive social injustice as a risk to their own company and the likelihood that they would engage in Fair Trade certified products. This relationship produced the following empirical model:

7a. FairTrade = β_0 + β_1 R_SocialInjustice + u_i

where FairTrade represents the degree to which a company integrates Fair Trade certified products into their business model. β_0 represents the intercept and β_1 represents the coefficient of R_SocialInjustice. These numbers will again be generated by the regression. R_SocialInjustice represents the degree to which a given corporation perceives social injustice as a risk. u_i represents the error term. The regression produced the following results, with the standard errors for each figure below each coefficient estimate:

7b. FairTrade = 1.695 (0.472) + 0.439 (0.227) R_SocialInjustice + u_i

The intercept is statistically significant at the 1% level, and the coefficient on R_SocialInjustice is statistically significant at the 10% level. There is an adjusted R^2 value of .132, meaning that 13.2% of the change in Fair Trade certification is explained by this equation. This equation states that companies that feel that social injustice is a great risk to their corporation are more likely to integrate Fair Trade certified products into their business model. Fair Trade is essentially a sustainable solution to the social injustice in our global food system. The corporations that view social injustice as a risky externality are more likely to take precautions to manage this risk by incorporating Fair Trade products into their business procedures. A graph of the correlation between attitudes of risk about social injustice and the sustainable action of fair trade is displayed in Figure 11.

Another logical relationship between attitudes and action is seen between the opportunity corporations perceive in regards to nutrition-related diseases and the degree of community development a corporation engages in. The empirical model that that relationship creates is as follows:

8a. CommunityDevelopment= β_0 + β_1 O_NutritionDiseases + u_i

where CommunityDevelopment represents the degree to which a company is engaged in community development. β_0 represents the intercept and β_1 represents the coefficient of O_NutritionDiseases. These numbers are generated by the regression. O_NutritionDiseases represents the degree to which a given corporation perceives nutrition-related diseases as an opportunity to improve and gain competitive advantage. u_i represents the error term. The regression produced the following results, with the standard errors for each figure below each coefficient estimate:

8b. CommunityDevelopment = 2.719 (0.514) + .313 (0.178) O_NutritionDiseases + u_i

The intercept is statistically significant at the 1% level, and the coefficient on O_NutritionDiseases is significant at the 10% level. The adjusted R^2 level is 0.104, which means that 10.4% of the change in community development can be explained by this equation. The equation demonstrates that the corporations that perceive nutrition-related diseases as an opportunity to gain a competitive advantage are more likely to engage in community development. This is relatively logical: Corporations that see nutrition-related diseases as an opportunity to gain a competitive advantage use community

nutrition-related diseases and the sustainable action of consumer health education is not statistically significant. A graph of this relationship was created (Figure 12).

Another set of relationships I discovered was between vertical integration and various aspects of awareness, attitudes, and action. The first vertical integration relationship I discovered was between vertical integration and corporations' awareness of soil degradation. The empirical model for this relationship is as follows:

9a. A_SoilDegradation = β_0 + β_1 VerticalIntegration + u_i

A_SoilDegradation represents the predicted level of awareness a corporation will have of soil degradation. β_0 represents the intercept, or what Y (A_SoilDegradation) will equal when X (VerticalIntegration) equals zero. β_1 represents the coefficient of VerticalIntegration, and VerticalIntegration represents whether or not the respondent's corporation is vertically integrated. u_i represents the error term, or how far off the actual value of awareness is from the predicted value of A_SoilDegradation. The regression between vertical integration and corporations' awareness of soil degradation produced the following equation:

9b. A_SoilDegradation = 2.20 (0.374) + 1.00 (0.529) VerticalIntegration + u_i

The intercept is statistically significant at the 1% level and the coefficient of VerticalIntegration is significant at the 10% level. The adjusted R^2 value is 0.119, meaning that this equation shows an 11.9% explanation in the change in awareness for soil degradation. Essentially, the more vertically integrated a company is, the more likely it is that they are aware of soil degradation as an externality of the food supply system. The relationship between Vertical Integration and corporations' awareness of soil degradation is seen in Figure 13.

The second relationship found was between vertical integration and the likelihood that corporations will view consumer's unequal access to nutritious food as an opportunity to improve their practices and gain competitive advantage. The empirical model for this relationship is as follows:

10a. O_UnequalAccess = β_0 + β_1 VerticalIntegration + u_i

O_UnequalAccess represents the predicted level of opportunity a corporation will associate with consumer's unequal access to nutritious food. All other variables represent the same variables and coefficients as in the first regression (9a). The regression produced the following equation:

10b. O_UnequalAccess = 2.70 (0.357) - .922 (0.519) VerticalIntegration + u_i

The intercept is significant at the 1% level and the coefficient of VerticalIntegration is statistically significant at the 10% level. The adjusted R^2 value is 0.107, meaning that this equation shows a 10.7% explanation in the change in opportunity perceived in improving consumer's unequal access to nutritious foods. Essentially, the more vertically integrated a company is, the less they will see consumer's unequal access to nutritious foods as an opportunity to gain competitive advantage. A graphical representation of the relationship between Vertical Integration and corporations' perception of opportunity in consumer's unequal access to nutritious foods was created (Figure 14).

The third relationship correlated vertical integration's effect on the composite variable for action. This tested the relationship between how vertically integrated a corporation is and the level of sustainable actions they currently have initiated. The empirical model for this relationship is as follows:

11a. Action = β_0 + β_1 VerticalIntegration + u_i

where all variables represent the same coefficients and variables as the first two equations (9a and 10a), and Action represents the predicted level of sustainable actions a corporation will initiate and engage in. The regression produced the following equation, with the standard errors for each figure below each coefficient estimate:

11b. Action = 25.80 (2.231) - 5.50 (3.155) VerticalIntegration + u_i

The intercept is significant at the 1% level and the coefficient on VerticalIntegration is statistically significant at the 10% level. The adjusted R^2 value is 0.097, meaning that this equation shows a 9.7% explanation in the change in sustainable action taken by a given corporation. The more vertically integrated a company is, the less they will take sustainable action. A graphical representation of the relationship between Vertical Integration and Action was produced (Figure 15). Taking this in accordance with the first two equations, we see that although vertical integration may make companies more aware of the externality of soil degradation, they are less likely to perceive consumer's unequal access to nutritious foods as an opportunity, making them less likely to take any sustainable action.

Finally, there are two relationships between composite variables that contribute to the depth of understanding between the variables in this set of data. The first is the relationship between the composite variable for awareness and the composite attitude variable for risk. The

following is the empirical model for this relationship:

12a. Risk = $\beta_0 + \beta_1$ Awareness + u_i

where Risk represents the predicted level of composite risk a corporation will perceive for all externalities. β_0 represents the intercept and β_1 represents the coefficient of Awareness. Awareness represents the composite awareness of a given corporation of all externalities of the food system. u_i represents the error term. The regression between awareness and corporations' perception of risk produced the following equation:

12b. Risk = 9.434 (2.147) + 0.264 (0.134) Awareness + u_i

The intercept is statistically significant at the 1% level and the coefficient of Awareness is significant at the 10% level. There is an adjusted R^2 value of 0.131, meaning that 13.1% of the change in Risk is explained by this equation. From this equation, we learn that as companies become more aware of externalities, they become more likely to perceive those externalities as risks. As we viewed earlier, an increase in the perception of risk does not necessarily lead to an increase in action. Figure 16 contains the graphical representation of the relationship between Risk and Awareness.

The final relationship between composite variables is between the composite variable for perceived opportunities for externalities and the composite variable for taking sustainable action. This relationship created the following empirical model:

13a. Action = $\beta_0 + \beta_1$ Opportunity + u_i

where Action represents the predicted level of composite sustainable action a given corporation will take. β_0 represents the intercept and β_1 represents the coefficient of Opportunity. Opportunity represents the composite opportunity a given company will associate with all externalities of the food system. u_i represents the error term. This regression created following equation, with the standard errors for each figure below each coefficient estimate:

13b. Action = 14.146 (3.606) +
0.751 (0.279) Opportunity + u_i

The intercept is significant at the 1% level, the coefficient of Opportunity is statistically significant at the 5% level, and the adjusted R^2 value of 0.248 means that 24.8% of the change in Action is explained by the equation. This equation means that as corporations perceive externalities as more of an opportunity, they are more likely to take sustainable action. This, in accordance with the previous regression, is pivotal to understanding what motivates action from corporations. While awareness drives the perception of risk, only opportunity has been statistically proven to drive sustainable action. There appears to be a missing link between awareness and action that occurs in the transition of perception of externalities as opportunities to gain competitive advantage, rather than as risks to be managed. The graph of this relationship is displayed in Figure 17.

LIMITATIONS

The various limitations to these results revolve primarily around the general low response rate received from the sample. This low response rate could have originated from a perceived bias that respondents sensed in the questions. Of the 40 individuals that started the survey, 23 of the 24 respondents that did not finish stopped the survey upon seeing the first question about externalities of the food industry. As leaders of some of the largest corporations within the industry, it is possible that corporations thought that by stating they were aware of the externalities, they would implicate themselves as accepting blame. A possible way to gain more responses and remove the perceived bias could be by rephrasing the questions from "To what extent are you aware of soil degradation as a consequence of the industrial food production process?" to "To what extent do you feel that soil degradation is a consequence of the industrial food production process?"

This data set could also be limited by omitted variables bias, as many variables go into determining whether or not a company takes sustainable action or if they view externalities as risks or opportunities. Similarly, as many of the corporations surveyed were privately held, it was not possible to cross reference these variables with existing data from external sources.

CONCLUSIONS AND DISCUSSION

After analyzing the results from the above statistical regression of data, a few takeaway conclusions have become clear. The first being although some corporations may view the externalities of the food system as risks, they may not take actions on those risks, and thus are less likely to act sustainably through some specific actions. Notably, all of the risks that had a negative impact on the likelihood of taking sustainable action were social risks, specifically the risk of social injustice, rather than environmental ones. Perhaps there is an industry bias that solving social externalities would add costs to production – for example, increasing wage costs and inspection standards on child labor – while environmental externalities present an opportunity to become more efficient, cutting costs. In an interview with the CEO of a major food processing corporation, who

would prefer to remain anonymous, he states that:

> [Attaining] competitive advantage is pretty hard. Just because you use less water or less energy, that's great to say in my opinion, but in the end in the grocery store, consumers are looking at price. …The reality is that most folks are only concerned with their pocket books. …If I can use less water, if I can use less energy, it is not only good for the environment; it's good for my business. So the projects that are associated with savings that have environmental opportunities, we will go after more aggressively than opportunities that don't have dollars associated with them. It is a strategic business decision (Anonymous, personal communication, March 6, 2013).

Similarly, in an interview with Vice President Keith Slater of Ruby Tuesday, a national restaurant chain, Slater explained how social externalities are "more of a risk. While we can take advantage of social programs as part of our food integrity program, it is very hard to leverage to the point of being an advantage, so the risk side … is much greater." (personal communication, March 4, 2013). From a public policy stand point, it seems that a beneficial way to drive sustainable action would be to communicate to corporate leaders how improving the social implications of their business, such as social injustice and consumer's unequal access to nutritious foods, could benefit them financially. This understanding of financial benefit could potentially be the missing link between perceptions of risk and opportunity.

A second major conclusion is the close relationship between perceptions of social injustice as a risk, and taking the sustainable action of incorporating fair trade products. It is logical that externalities that are so closely linked to specific actions would be correlated, and it is likely that when companies can clearly see the connection between either avoiding risk or attaining opportunity with a specific action, they are likely to take that action. Bon Appetite Management Company, also known as BAMCo, a nationwide industrial catering and distributioncompany, has dedicated itself to numerous social and environmental sustainable actions, including their Fair Trade chocolate sourcing. As a Fair Trade advocate, Vice President of BAMCo, Maisie Greenawalt, states that "the way that farm workers lack protection and rights in this country is astounding, and that's a major social problem" (personal communication March 15). In this case, it may be beneficial to educate corporations of the risks of social injustice, in that it may encourage Fair Trade procedures throughout the supply chain. Not all companies, however, even perceive that social injustice is an externality of the U.S. food system. For instance, an anonymous CEO stated that

> In the food industry in the U.S., I have a hard time believing that there is any social injustice. Most food in the U.S. is based here, and … I quite candidly don't believe there is any social injustice (Anonymous, personal communication, March 6, 2013).

In this case, perhaps driving sustainable action first starts with communicating the various social externalities of the food system to the members of that system, and then communicating how those externalities affect an individual's corporation. This communication can come from Non-Governmental Organizations (NGOs) or other corporations from within the supply chain.

A third major takeaway is the impact that perceiving ocean acidification and eutrophication as an opportunity to improve can have on the production and distribution of local food as well as on consumer health education initiatives. While it is hard to connect why the opportunity of ocean acidification might correlate with consumer health education, the connection between local food production and improving the situation of ocean acidification is clearer. Local food production has increased in popularity among consumers partly because of the less frequent use of fertilizers and pesticides that have led to ocean acidification and eutrophication, among other environmental and health-related concerns. Corporations that consider the decrease in ocean acidification as an opportunity are decreasing chemical growth products through localized production. However, further research would be required into this connection, as well as the connection between the opportunity of ocean acidification and consumer health education.

The fourth major conclusion from these regressions is the impact that vertical integration has on awareness, attitudes, and actions. While vertical integration led to an increase in corporations' awareness of soil degradation, it was also correlated with a decrease in the level of opportunity that corporations associated with consumer's unequal access to nutritious foods as well as lower levels of sustainable action. If a corporation is extremely vertically integrated, they have more information about the supply chain as a whole, and supply chain transparency is not an issue for them. This would lead to increased awareness of the problems created by the supply chain as a whole, such as soil degradation in this instance. In an interview with Mike Fernandez, vice president of Cargill, he explained how he did not feel that supply chain transparency was a concern in the industrial

supply chain due to the "USDA inspectors, [and] tests where the products are examined as a result of that consolidation that doesn't take place in a less consolidated environment" (personal communication, March, 14, 2013). Cargill, a food processing and distribution company, is the largest private company in the world and incredibly vertically integrated. Therefore, it is not likely to see supply chain transparency as an issue of the supply chain. As Maisie Greenawalt states:

> "We're operating in at least a national and in many cases, a global food system. As we get farther and farther away from our food source, and there are more middle men in the process, we lose transparency, and I think that a fair amount of that has been intentional on the part of our producers. They don't want you to know who they are. They don't want you to ask questions" (M. Greenawalt, personal communication, March 15).

Maisie goes on to discuss the challenges of transparency when negotiating with large corporations for sustainable products:

> "We need more transparency in the supply chain [to] allow food purchasers on all levels to make decisions based on their values. When I say all levels, I mean everything from a large purchaser like Bon Appetite, all the way to an individual consumer. We can't make ethical purchasing decisions all the time, because we don't have the information either. We need more transparency for everyone" (personal communication, March 15).

Differing perspectives are represented in the statistical regression analysis above. The more vertically integrated a company is, the more aware they are of externalities; logically because there are fewer issues of supply chain transparency within the corporation. In terms of public policy, it is difficult to encourage awareness through supply chain transparency, allowing corporations and the transaction channels between each corporation to operate as a vertically integrated corporation without the negative externalities of a consolidated non-competitive market. This problem deserves further research in the field.

Although vertically integrated corporations are more aware of externalities such as soil degradation, they are less likely to take sustainable action. This is most logically explained by the fact that these corporations feel less pressure from the external market because so much of the supply chain is contained within their own corporation. If the incentives for action are not present, a corporation is not going to take action even if they are aware of an externality. As executive vice president of food distribution company Labatt Food Service explains, "there's this tension between doing the right thing and doing the least expensive" (T. Canty, personal communication, March, 18, 2013). Ultimately, if a corporation does not see the financial value of an action, there is no incentive for them to act sustainably.

The final conclusion from the above regressions is that although a higher level of awareness will lead to a higher level of risk perception, this does not imply that a higher level of opportunity perception will lead to more sustainable action. This slight disconnect in the thought process of corporations is pivotal to understanding how to encourage sustainable action. Many corporations interviewed reported not taking specific actions because there was no consumer demand for it, and therefore no incentives to take action, even if they were aware of the externalities and the risk they posed their company. As Michael Neuwirth, the senior director of public relations for the Dannon company states:

> "I don't believe that consumer awareness of the realities of environmental and social impacts of food companies is high. I believe that the awareness is quite low…among mainstream consumers. … The number one reason why people buy a particular food is the taste, price is the second. Environmental and social impact are very low" (M. Neuwirth, personal communication, March 1, 2013).

However, representatives of corporations who had taken significant action such as M. Greenawalt of BAMCo, reported having "gained competitive advantage by having taking initiative and leadership on these issues" (M. Greenawalt, personal communication, March 15) before there was a consumer demand for solutions to externalities of the food system.

Based on the above regression analysis and the interviews conducted, it is clear that food companies currently in the food supply chain system can take sustainable action if properly incentivized, just as a company in any other industry. Acknowledging that this is a business opportunity, some corporations are currently leading the way towards a sustainable food supply system, typically by choosing projects that best fit their own business model and core competencies. However, many companies are still unaware that these environmental and social externalities exist along the food supply system, and even fewer recognize these externalities as opportunities to better our planet while improving their financial performance.

While several relationships and conclusions have become clear from this survey and interview, further

research is required to determine what exactly incentivizes corporations to view environmental and social externalities as opportunities to create sustainable solutions and gain competitive advantage. Endless opportunities exist within the food industry to create truly innovative solutions to global problems such as hunger, social injustice, and nutrition-related diseases, as well as land, oceanic, and atmospheric degradation and pollution. It is important that the intricacies of incentives and corporate motivations for sustainable actions are further researched to get one step closer towards a more sustainable food supply network.

APPENDIX

1.Company Name:_____
2.Your Name:_____
3.Title:_____
4.Email:_____

5. Please check any of the following that is an established branch or function of your company. If other, please define in the space provided.

[ ] Food Production
[ ] Food Processing
[ ] Food Distribution
[ ] Food Wholesale
[ ] Food Retail (Grocery)
[ ] Industrial Catering (Restaurants)
[ ] Other: _____

6. Please check which of the following is the primary or predominant branch or function of your company. If other please define in the space provided.

[ ] Food Production
[ ] Food Processing
[ ] Food Distribution
[ ] Food Wholesale
[ ] Food Retail (Grocery)
[ ] Industrial Catering (Restaurants)
[ ] Other: _____

7. Is your company a subsidiary of, or owned by, any larger conglomerate or corporation? If "Yes", please define in the space provided.

[ ] Yes _____
[ ] No

8. To what extent are you aware of soil degradation as a consequence of the industrial food production process?

[ ] Not Aware At All
[ ] Somewhat Aware
[ ] Moderately Aware
[ ] Very Aware
[ ] Extremely Aware

9. To what extent are you aware of ocean eutrophication and acidification as consequences of the industrial food production process?

[ ] Not Aware At All
[ ] Somewhat Aware
[ ] Moderately Aware
[ ] Very Aware
[ ] Extremely Aware

10. To what extent are you aware of greenhouse gas emissions including Carbon Dioxide and Methane as consequence of the industrial food production process?

[ ] Not Aware At All
[ ] Somewhat Aware
[ ] Moderately Aware
[ ] Very Aware
[ ] Extremely Aware

11. To what extent are you aware of social injustice as a consequence of the industrial food production process?

[ ] Not Aware At All
[ ] Somewhat Aware
[ ] Moderately Aware
[ ] Very Aware
[ ] Extremely Aware

12. To what extent are you aware of an increase in nutrition related diseases as a consequence of the industrial food production process?

[ ] Not Aware At All
[ ] Somewhat Aware
[ ] Moderately Aware
[ ] Very Aware
[ ] Extremely Aware

13. To what extent are you aware of consumers' unequal access to nutritious foods as a consequence of the industrial food production process?

[ ] Not Aware At All
[ ] Somewhat Aware
[ ] Moderately Aware
[ ] Very Aware
[ ] Extremely Aware

14. To what extent do you feel that soil degradation is a risk your own business?

[ ] No Risk
[ ] Low Risk
[ ] Moderate Risk
[ ] High Risk
[ ] Very High Risk

15. To what extent do you feel that ocean eutrophication and acidification is a risk your own business?

[ ] No Risk
[ ] Low Risk
[ ] Moderate Risk
[ ] High Risk
[ ] Very High Risk

16. To what extent do you feel that greenhouse gas emissions including Carbon Dioxide and Methane are a risk your own business?

[ ] No Risk
[ ] Low Risk
[ ] Moderate Risk
[ ] High Risk
[ ] Very High Risk

17. To what extent do you feel that social injustice is a risk your own business?

[ ] No Risk
[ ] Low Risk
[ ] Moderate Risk
[ ] High Risk
[ ] Very High Risk

18. To what extent do you feel that nutrition related diseases are a risk your own business?

[ ] No Risk
[ ] Low Risk
[ ] Moderate Risk
[ ] High Risk
[ ] Very High Risk

19. To what extent do you feel that consumers' unequal access to nutritious foods is a risk your own business?

[ ] No Risk
[ ] Low Risk
[ ] Moderate Risk
[ ] High Risk
[ ] Very High Risk

20. To what extent do you feel that soil degradation is an opportunity for your company to improve so as to gain competitive advantage in the market?

[ ] Not an Opportunity
[ ] A Minimal Opportunity
[ ] A Possible Opportunity
[ ] A Probable Opportunity
[ ] A Definite Opportunity

21. To what extent do you feel that ocean eutrophication and acidification is an opportunity for your company to improve in order to gain competitive advantage in the market?

[ ] Not an Opportunity
[ ] A Minimal Opportunity
[ ] A Possible Opportunity
[ ] A Probable Opportunity
[ ] A Definite Opportunity

22. To what extent do you feel that greenhouse gas emissions including Carbon Dioxide and Methane are an opportunity for your company to improve in order to gain competitive advantage in the market?

[ ] Not an Opportunity
[ ] A Minimal Opportunity
[ ] A Possible Opportunity
[ ] A Probable Opportunity
[ ] A Definite Opportunity

23. To what extent do you feel that social injustice is an opportunity for your company to improve in order to gain competitive advantage in the market?

[ ] Not an Opportunity
[ ] A Minimal Opportunity
[ ] A Possible Opportunity
[ ] A Probable Opportunity
[ ] A Definite Opportunity

24. To what extent do you feel that the increase in nutrition related diseases is an opportunity for your company to improve in order to gain competitive advantage in the market?

[ ] Not an Opportunity
[ ] A Minimal Opportunity
[ ] A Possible Opportunity
[ ] A Probable Opportunity
[ ] A Definite Opportunity

25. To what extent do you feel that consumers' unequal access to nutritious food is an opportunity for your company to improve in order to gain competitive advantage in the market?

[ ] Not an Opportunity
[ ] A Minimal Opportunity
[ ] A Possible Opportunity
[ ] A Probable Opportunity
[ ] A Definite Opportunity

26. To what extent does your company integrate Life Cycle Analysis into your business procedures?

[ ] Not At All
[ ] Minimally
[ ] Somewhat
[ ] Mostly
[ ] Extremely

27. To what extent does your company integrate Appreciative Inquiry into your business procedures?

[ ] Not At All
[ ] Minimally
[ ] Somewhat
[ ] Mostly
[ ] Extremely

28. To what extent does your company include USDA Organic Certified products into your business model?

[ ] Not At All
[ ] Minimally
[ ] Somewhat
[ ] Mostly
[ ] Exclusively

29. To what extent does your company integrate LEED Certification in your property design (e.g. buildings, factories)?

[ ] Not At All
[ ] Minimally
[ ] Somewhat
[ ] Mostly
[ ] Extremely

30. To what extent does your company integrate Fair Trade Certified products into your business model?

[ ] Not At All
[ ] Minimally
[ ] Somewhat
[ ] Mostly
[ ] Exclusively

31. To what extent does your company integrate Localized Food Production and Distribution into your business procedures?

[ ] Not At All
[ ] Minimally
[ ] Somewhat
[ ] Mostly
[ ] Exclusively

32. To what extent does your company integrate Employee Ownership into your business model?

[ ] Not At All
[ ] Minimally
[ ] Somewhat
[ ] Mostly
[ ] Extremely

33. To what extent does your company integrate Consumer Health Education initiatives into your business procedures?

[ ] Not At All
[ ] Minimally
[ ] Somewhat
[ ] Mostly
[ ] Extremely

34. To what extent does your company engage in community development in your business procedures?

[ ] Not At All Engaged
[ ] Minimally Engaged
[ ] Somewhat Engaged
[ ] Quite Engaged
[ ] Very Engaged

35. Please define any other initiatives that are designed to benefit the environment or society that your business has integrated. _____
_____
_____
_____

36. May I contact you for additional information or an interview?

[ ] Yes
[ ] No

Figure 1. Above copy of the print survey sent to participating food corporations

Awareness

1. How do you feel that environmental and social problems are affecting the food industry?
2. Which do you feel has a greater impact on your company? Environmental and social problems themselves, or consumer's awareness of those problems?

Attitudes

3. Do you feel that these problems pose more of a risk to your company, or an opportunity to gain competitive advantage?
4. What do you think needs to be done to lessen environmental degradation and social injustice in the food industry?
5. To what extent do you feel that supply chains in the food industry need to be more transparent in order to become more sustainable?

Actions

6. What is your company currently doing to improve environmental and social implications of your business?
7. What are three initiatives that your company could initiate to become an industry leader in solving environmental and social problems?

Figure 2. A copy of the interview questions asked of interview participants.

	N	Minimum	Maximum	Mean	Std. Deviation
VerticelIntegration	20	0.00	0.00	0.5000	0.51299
Awareness_Comp	20	7.00	30.00	14.8500	6.17529
A_SoilDegradation	20	1.00	5.00	2.7000	1.26074
A_Ocean	20	1.00	5.00	2.0000	1.21395
A_GHG	20	1.00	5.00	2.9000	1.11921
A_SocialInjustice	20	1.00	5.00	2.2000	1.39925
A_NutritionDiseases	20	1.00	5.00	2.6500	1.22582
A_Unequ	20	1.00	5.00	2.4000	1.09545
Risk_Comp	20	7.00	21.00	13.3500	3.86992
R_SoilDegradation	20	1.00	4.00	2.2500	0.71635
R_Ocean	20	1.00	5.00	2.2000	1.05631
R_GHG	20	1.00	4.00	2.5500	0.75915
R_SocialInjustice	20	1.00	4.00	1.9500	0.88704
R_NutritionDiseases	20	1.00	4.00	2.3000	0.80131
R_UnequalAccess	20	1.00	4.00	2.1000	0.85224
Opportunity_Comp	19	0.00	21.00	11.8500	5.29424
O_SoilDegradation	19	1.00	4.00	1.7895	0.91766
O_Ocean	19	1.00	4.00	1.7368	0.93346
O_GHG	19	1.00	4.00	2.1579	0.95819
O_SocialInjustice	19	1.00	4.00	1.9474	1.02598
O_NutritionalDiseases	19	1.00	5.00	2.5789	1.34643
O_UnequalAccess	19	1.00	5.00	2.2632	1.19453
Action_Comp	19	0.00	32.00	23.0500	7.42311
LifeCycle	19	1.00	4.00	2.1053	1.04853
AppreciativeInquiry	19	1.00	3.00	1.6842	0.88523
USDAOrganic	19	2.00	4.00	2.8421	0.68825
LEEDCert	19	2.00	4.00	2.8947	0.65784
Fair-Trade	19	1.00	4.00	2.5263	0.90483
Local	19	1.00	4.00	3.0000	0.81650
EmpOwn	19	1.00	5.00	2.6316	1.46099
HealthEd	19	1.00	5.00	3.0526	1.17727
CommunityDevelop	19	1.00	5.00	3.5263	1.07333
Valid N (listwise)	19				

Figure 3. Summary statistics for all variables.

Variable Name	Description
VerticalIntegration	Also known as Num_Type this variable represents how vertically integrated a corporation is, or how many portions of the supply chain they operate in
Awareness	Also known as Awareness_Comp this variable is the composite of all awareness variables, and represents the total awareness of any given corporation of the externalities of the food system
A_SoilDegradation	This represents a company's awareness of soil degradation as an externality of the food industry
Risk	Also known as Risk_Comp this variable is the composite of all risk variables, and represents the total risk that any given corporation will associate with externalities
R_SoilDegradation	This represents the perceived risk associated with the externality of soil degradation
R_SocialInjustice	This represents the perceived risk associated with the externality of social injustice
R_UnequalAccess	This represents the perceived risk associated with the externality of consumer's unequal access to nutritious foods
Opportunity	Also known as Opportunity_Comp this variable is the composite of all opportunity variables, and represents the total opportunity that any given company will associate with making improvements to externalities and gaining competitive advantage
O_Ocean	This represents the perceived opportunity to gain competitive advantage by making improvements to the externality of ocean acidification and eutrophication
O_NutritionDiseases	This represents the perceived opportunity to gain competitive advantage by making improvements to the externality of nutrition related diseases
O_UnequalAccess	This represents the perceived opportunity to gain competitive advantage by making improvements to the externality of consumers' unequal access to nutritious foods
Action	Also known as Action_Comp this is the composite of all action variables, and represents the total sustainable actions currently taken by a given corporation
LifeCycle	This represents the degree to which a corporation has integrated the sustainable action of life cycle analysis into their business processes
AppreciativeInquiry	Also known as AppreciativeInq, this represents the degree to which a corporation has integrated the sustainable action of appreciative inquiry into their business processes
USDAOrganic	This represents the degree to which a corporation has taken the sustainable action of integrating USDA certified organic foods products into their business model
LEEDCert	This represents the degree to which a corporation has taken the sustainable action of integrating LEED certified building practices and materials into their structures
FairTrade	This represents the degree to which a corporation has taken the sustainable action of integrating certified Fair Trade food products into their business model
Local	This represents the degree to which a corporation has taken the sustainable action of producing and distributing food locally
HealthEd	This represents the degree to which a corporation has taken the sustainable action of encouraging and facilitating consumer health education
CommunityDevelopment	Also known as CommunityDevelop, this represents the degree to which a corporation has taken the sustainable action of engaging and facilitating community development initiatives.

Figure 4. Descriptions for any variable used in the regressions presented in this paper.

	Independent Variables	1b	2b	3b	4b	5b	6b	7b	8b
Dependent Variables	⟶	Life Cycle Analysis	Apreciative Inquiry	USDA Organic	LEEDCert	Local	HealthEd	FairTrade	Community Development
	R_Soil Degradation				0.471** (0.221)				
	R_Social Injustice			0.412** (0.162)				0.439* (0.227)	
	R_Unequal Access	-0.549* (0.269)	-0.593** (0.208)		0.286* (0.157)				
	O_Ocean					0.510*** (0.172)	0.5270* (0.278)		
	O_Nutrition Diseases								0.313* (0.178)
	Intercept	3.232*** (0.549)	2.902*** (0.461)	2.061*** (0,337)	1.29** (0.565)	2.114*** (0.338)	2.138*** (0.545)	1.696*** (0.472)	2.719*** (0.514)
	Adjusted R^2	0.150	0.284	0.232	0.284	0.301	0.126	0.132	0.104
	n	19	19	19	19	19	19	19	19

*Statistically significant at the 10% level. ** Statistically significant at the 5% level, *** Statistically significant at the 1% level.

	Independent Variables	9b	10b	11b
Dependent Variables	⟶	A_SoilDegradation	O_UnequalAccess	Action
	Vertical Integration	1.00* (0.529)	-.922* (0.519)	-5.50* (3.155)
	Intercept	2.20*** (0.374)	2.70*** (0.357)	25.80*** (2.231)
	Adjusted R^2	0.119	0.107	0.097
	n	19	19	19

*Statistically significant at the 10% level. ** Statistically significant at the 5% level, *** Statistically significant at the 1% level.

	Independent Variables	12b	13b
Dependent Variables	⟶	Risk	Action
	Awareness	0.264* (0.134)	
	Opportunity		0.751** (0.297)
	Intercept	9.434*** (2.147)	14.146*** (3.606)
	Adjusted R^2	0.131	.248
	n	19	19

*Statistically significant at the 10% level. ** Statistically significant at the 5% level, *** Statistically significant at the 1% level.

Figure 5. A summary of all statistically significant regressions.

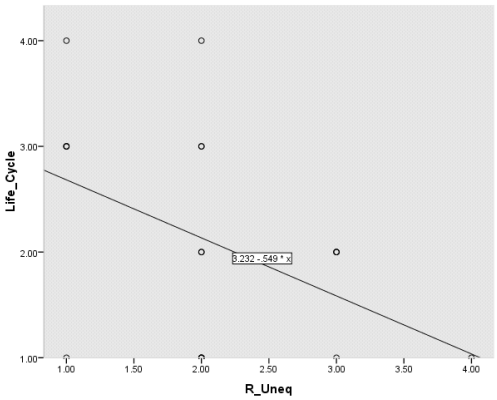

Figure 6. The effect of corporations' perceived risk of Consumer's Unequal Access to Nutritious Food and the likelihood that they will participate in Life Cycle Analysis. As shown in this graph, perceiving this externality as a risk decreases the likelihood that a corporation will engage in Life Cycle Analysis.

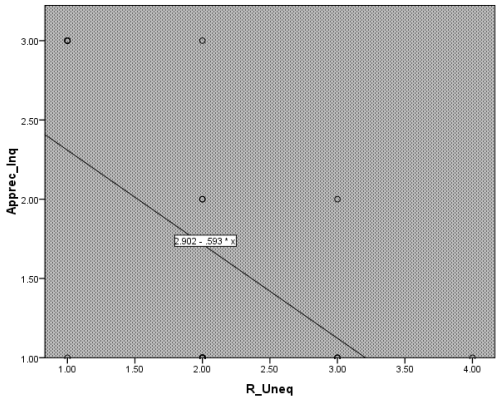

Figure 7. The relationship between corporations' perceived level of risk associated with consumers' unequal access to nutritious foods and their likelihood to participate in the sustainable practice of Appreciative Inquiry. As corporations perceive a higher level of risk for this externality, they are less likely to engage in Appreciative Inquiry.

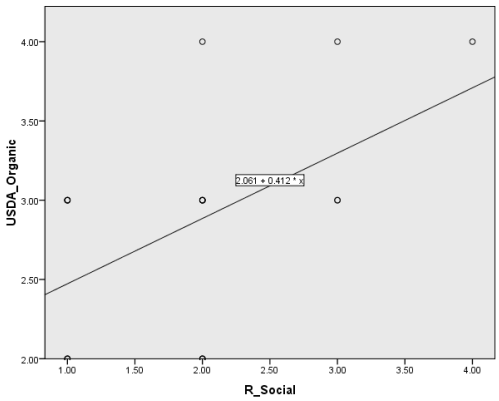

Figure 8. As the perceived risk of social injustice increases, so too does the likelihood that a corporation will incorporate USDA certified Organic food products into their business model also increases.

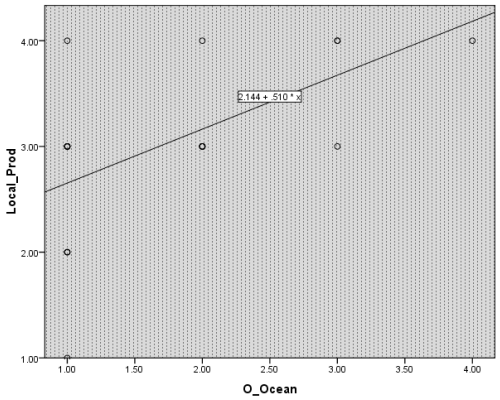

Figure 9. The relationship between the degree of opportunity a corporation perceives for the externality of ocean acidification and eutrophication, and the degree of Local Production and distribution the company engages in. The greater the opportunity perceived for ocean acidification, the greater the chance that that company will engage in local food production.

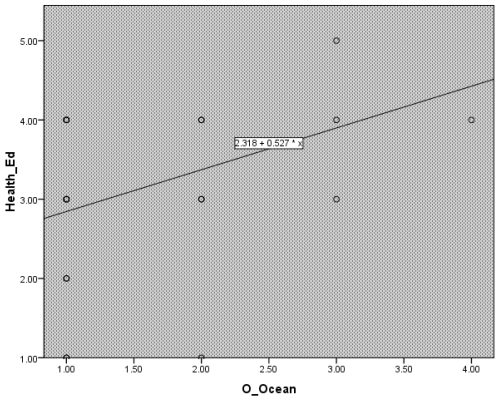

Figure 10. The relationship between the opportunity perceived in Ocean Acidification and engagement in consumer health education initiatives is shown below. As the level of opportunity perceived rises, the engagement in consumer health education also increases.

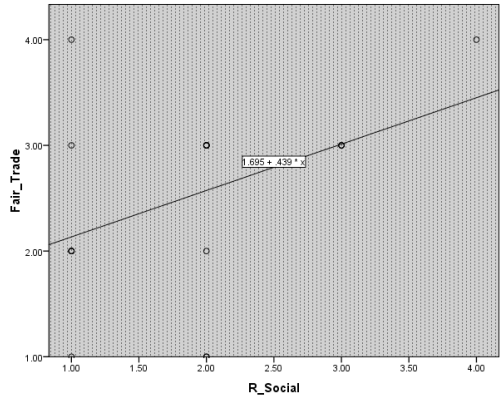

Figure 11. As the level of risk perceived for the externality of social injustice increases, and the level of incorporation of Fair Trade certifies products a company has integrated also increases.

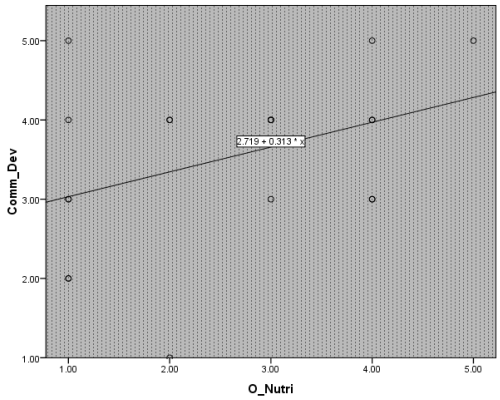

Figure 12. The relationship between the opportunity that corporations associate with nutrition-related diseases and the degree to which they engage in community development. As the degree of opportunity increases, so does the level of education engagement.

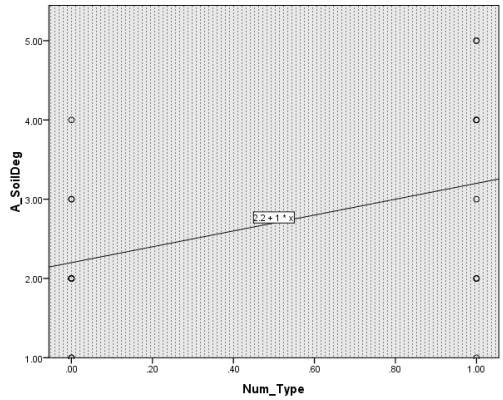

Figure 13. The relationship between vertical integration (Num_ Type) and the awareness of corporations of soil degradation. As demonstrated, more vertically integrated companies are more aware of soil degradation as an externality of the food system.

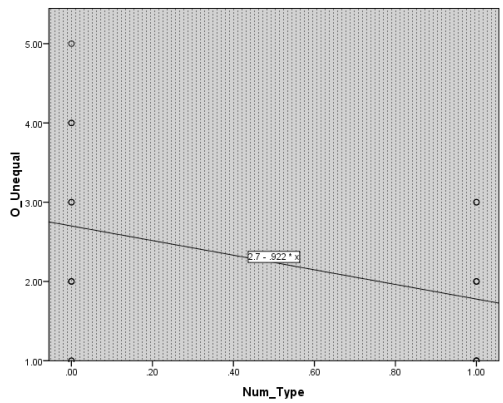

Figure 14. The relationship between vertical integration and the opportunity perceived by corporations in regards to consumers' unequal access to nutritious foods. As companies become more vertically integrated, they are less likely to view consumers' unequal access to nutritious foods as an opportunity to improve and gain competitive advantage.

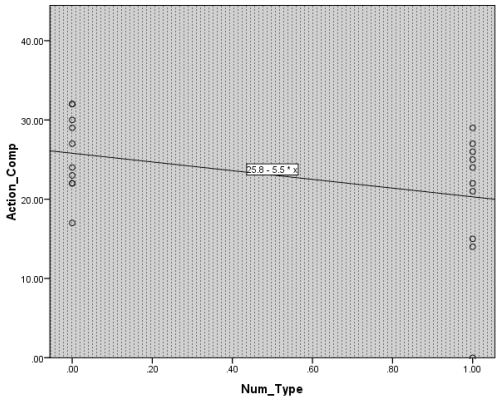

Figure 15. The relationship between vertical integration and the composite sustainable actions that a given company is currently taking. As companies become more vertically integrated, they become less likely to take sustainable actions.

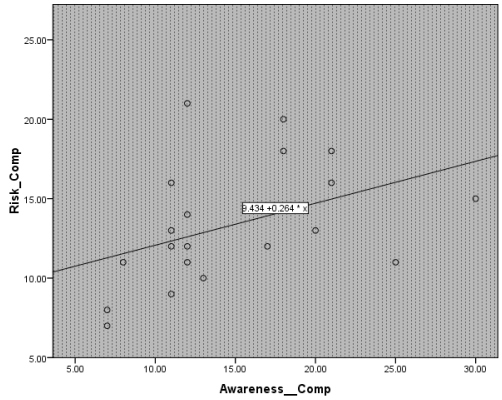

Figure 16. As companies become more aware of externalities (as a composite variable), they also are more likely to perceive externalities as risks, again a composite variable.

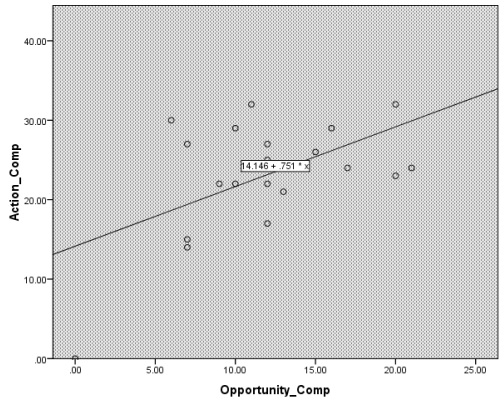

Figure 17. As the composite variable for opportunity increases, the composite variable for action also increases.

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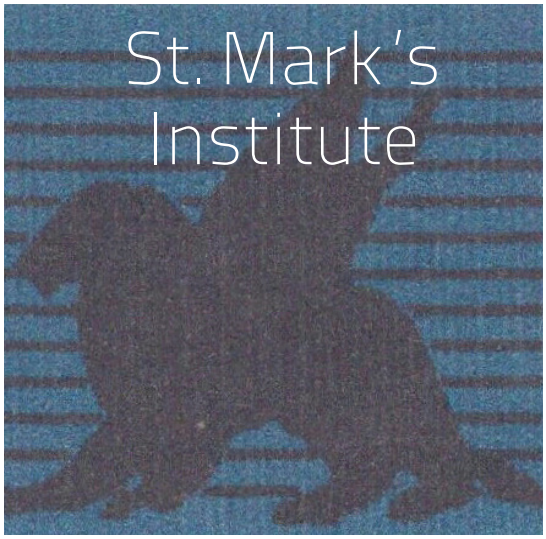

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