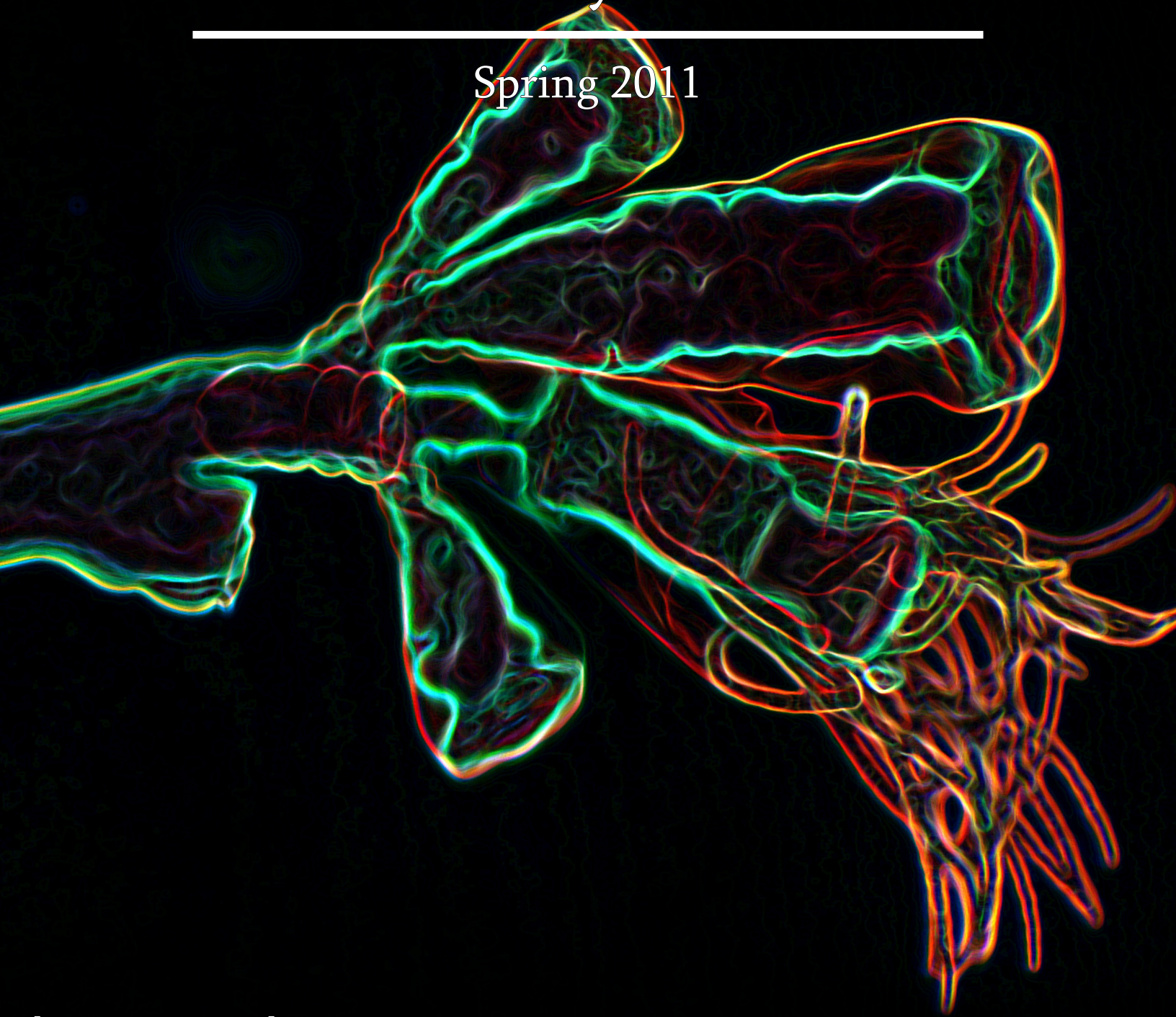

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A false color light microscopy image of a member of the class Hydrozoa, genus Obelia. Hydrazoans include some jellyfish, and typically go through two life stages, a free swimming medusoid stage and the hydroid stage (pictured) where the organisms form anchored colonies.

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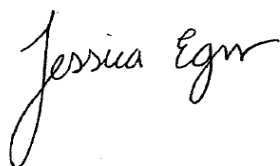
Corrections: The article "Antibiotic resistance profiles for the opportunistic pathogens *Burkholderia oklahomensis*, *Burkholderia ubonensis* and *Burkholderia vietnamensis*" by Erin Breland has been reprinted with the table that was missing from the Fall 2010 edition.

A letter from the editor:

The world is quickly changing. In the past few months we have seen revolutions spread across the Middle East and Africa, debate over the fate of unions in the United States, crises in Japan, and continued economic hardship in many countries. We have witnessed the deaths of the last known American World War I veteran, an iconic movie star, and the first female VP candidate running on a national ticket in the US. But there is promise. All over the globe, young people are leading campaigns for change and equality; their nerve in the face of challenge has inspired the world. Generation Y will both inherit and change the course of a future that is dependent on our adaptability, resourcefulness, and appreciation of diversity.

In this issue, undergraduate scholars share their insight into current events, demonstrate scientific curiosity and know-how, and display their creative abilities. Today's undergraduates are tomorrow's scientists, politicians, artists, and journalists. We at JUR want to give each and every one of them a chance to share their passions with the public. This goal is made possible by the staff of JUR, all of our wonderful referees, and you, our kind readers.

Thank you,

A handwritten signature in black ink that reads "Jessica Egner". The signature is written in a cursive, flowing style.

Jessica Egner
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Antibiotic resistance profiles for the opportunistic pathogens *Burkholderia oklahomensis*, *Burkholderia ubonensis* and *Burkholderia vietnamensis*

BY ERIN BRELAND WITH HERBERT P. SCHWEIZER AND
ROXANN KARKHOFF-SCHWEIZER

COLORADO STATE UNIVERSITY

Abstract

Various bacteria belonging to the genus *Burkholderia* are recognized as emerging pathogens. Some of these have not yet been well studied. Here we determined the antibiotic susceptibility profiles of the three opportunistic pathogens *Burkholderia oklahomensis*, *B. ubonensis* and *B. vietnamensis*. All three bacterial species show resistance to carbenicillin, erythromycin and gentamicin and, with the exception of *B. ubonensis*, are most susceptible to tetracycline, trimethoprim and the carbapenems imipenem and meropenem. *B. ubonensis* was consistently the most resistant of the three bacteria and also exhibits increased resistance to tetracycline and carbapenems. Availability of antibiotic resistance profiles for these bacteria will facilitate future clinical, environmental and genetic studies with these opportunistic pathogens.

Introduction

There are over 40 different species of *Burkholderia* commonly found in surface soils and groundwater worldwide.¹ Although many of these species exhibit intrinsic antibiotic resistance, few have been studied for their antibiotic resistance profile. Understanding bacterial antibiotic resistance is a key factor in understanding the resistance mechanisms innate to bacteria. Developing antibiotic resistance profiles is also crucial for clinical, environmental and genetic studies.

Like many Gram-negative bacteria, mounting evidence indicates that multidrug efflux pumps of the resistance nodulation cell division (RND) superfamily play an important role in the multidrug resistance of *Burkholderia* species. *Burkholderia cenocepacia* expresses several RND pumps that contribute to drug resistance.^{2,3} Likewise, most *B. pseudomallei* strains are intrinsically antibiotic resistant due to AmrAB-OprA^{4,5} and BpeAB-OprB^{6,7} efflux pump expression. *Burkholderia pseudomallei* is classified by the Centers for Disease Control and Prevention (CDC) as a bio-safety

level (BSL) 3 organism and category B bio-threat agent. *Burkholderia pseudomallei* is endemic to Southeast Asia, Northern Australia and other tropical and subtropical regions of the world.⁸ In endemic regions it is of clinical importance as the etiologic agent of human melioidosis, a progressive disease with high mortality rates.^{9,10} Other *Burkholderia* species that have been studied include the BSL-2 *B. gladioli* and the *B. cepacia* complex (BCC). As opportunistic pathogens, these soil and water pathogens typically only affect immunocompromised or cystic fibrosis patients.^{11,12} The BCC contains at least ten closely related strains of *Burkholderia* species that are phylogenetically distinguishable, but are phenotypically indistinguishable. Other species of *Burkholderia* are also intrinsically antibiotic resistant but there is little known or published for these organisms. The CDC lists the three *Burkholderia* species, *B. oklahomensis*, *B. ubonensis*, and *B. vietnamensis* as BSL-2 opportunistic pathogens. *B. oklahomensis* C6786 was isolated in 1973 from a wound infection after a farming accident in Oklahoma and initially named as the "Oklahoma" strain of *B. pseudomallei*. It was later determined, through gene sequencing, to be a novel species, *B. oklahomensis*.¹³ Three more identical isolates were identified as sharing the same typical *Burkholderia* phenotypical features.¹³ Four isolates have been obtained for an environmentally important species *B. ubonensis* that has been speculated to be the tenth genomovar of the BCC. Little is known about this bacterium other than it is found in surface soils and has not to date been associated with human infections.¹⁴ The fifth genomovar of the BCC is known to be *B. vietnamensis*. *Burkholderia vietnamensis* is commonly isolated from surface soils and ground water and has been studied as a plant growth promoting bacterium and bioremediation agent for aromatic hydrocarbons.¹⁵ It is a Gram-negative rod, motile and aerobic. *Burkholderia vietnamensis* is an opportunistic pathogen in humans often affecting cystic fibrosis patients.¹⁶ As a prelude to future studies, we determined the antibiotic susceptibility profiles of *B. oklahomensis*, *B. ubonensis* and *B. vietnamensis*.

Materials and Methods

Bacterial strains and growth.

The strains used in this study were the clinical *B. oklahomensis* isolate C6786 (laboratory stock number B94),¹³ the environmental *B. ubonensis* isolate A1301 (laboratory stock number B180),¹⁴ and *B. vietnamensis* H4102 (laboratory stock number B122) (obtained from Dr. Alex Hoffmaster, CDC Atlanta). All strains were grown at 37°C. Before use, these strains were struck for single-colonies on Lennox Luria-Bertani (LB)¹⁷ agar (MO BIO Laboratories, Carlsbad, CA) plates. Single colony isolates were inoculated into Lennox LB broth in preparation for minimum inhibitory concentration (MIC) tests. For MIC tests, bacteria were then inoculated into 4 ml of Mueller-Hinton broth (MHB; Becton Dickinson, Sparks, MD) and grown overnight. The next day, the overnight culture was diluted into MHB and grown to log phase ($A_{600nm} \sim 0.7$). This culture was then diluted in sterile saline and adjusted to the density of a 0.5 McFarland equivalence turbidity standard (Remel, Lenexa, KS).

Antibiotics.

Table 1 lists the antibiotics used in the study by function, class and common name. Stock concentrations of antibiotics were made following standard protocol at concentrations of either 4,096 µg/ml or 32,768 µg/ml depending on the strain being tested and antibiotic. Antibiotics were either purchased as powders from Sigma, St. Louis, MO (carbenicillin, gentamicin, erythromycin, and tetracycline) or immobilized on Etest® strips from AB BIODISK, Solna, Sweden (trimethoprim, imipenem, meropenem).

MIC determinations.

A set of standard conditions set by the Clinical and Laboratory Standards Institute (CLSI)¹⁸ must be followed when defining antibiotic resistance profiles. All procedures were performed in a biosafety cabinet (BSL-2+ conditions). The two methods used for MIC determinations were two-fold serial dilution in microtiter plates and Etest®.

The two-fold serial dilution method utilizes

Bactericidal		Bacteriostatic	
Class	Representative tested	Class	Representative tested
Aminoglycosides	Gentamicin	Tetracyclines	Tetracycline
Penicillins	Carbenicillin	Sulfonamides	Trimethoprim
Carbapenems	Meropenem Imipenem	Macrolides:	Erythromycin ¹

Table 1. Antibiotics tested in this study. Antibiotics are listed by function, class, and common name.

¹Bacterial or bacteriostatic depending on concentration

96-well plates and two-fold serial dilutions of antibiotic concentrations. Each test was performed in triplicate with positive and negative controls. An antibiotic stock was made at twice the highest desired initial concentration of antibiotic to be tested in the dilutions. The antibiotic stock solution was distributed in 100 µl aliquots into the first column of the first four rows of a 96-well plate. Rows one through three constituted one triplicate experiment for one MIC test of a specific antibiotic. Rows four and five were controls to test the antibiotic stock and bacterial growth respectively to verify negative and positive growth controls. These controls allow visualization of any random growth that may occur in the wells and characteristics of the antibiotics (precipitate, color change, etc.).¹⁸

Mueller-Hinton broth was distributed (50 µl per well) to columns 2-12 of rows 1-5 and column 1 row 5. The antibiotic was then diluted two-fold throughout the plate. This was achieved by taking 50 µl from the first well in column 1, rows 1- 4, into the second column and mixing. This was then followed by taking 50 µl from this well into the next well, mixing and so on. Lastly, 50 µl aliquots were removed from the last wells in rows 1- 4. Next, prepared bacterial inoculant (50 µl; 0.5 McFarland turbidity standard) was added to each well in rows 1-3 and row 5. The plates were incubated for 24 h. 37°C and wells visually examined for growth. Growth in any well is considered a button of growth. The first concentration of antibiotic where no button of growth is visible is regarded the MIC in µg/ml.

Etest® strips are pre-loaded with a gradient of decreasing antibiotic concentrations. Each test was done in triplicate with three plates per test. Bacterial inoculant was pre-

pared the same way as in the two-fold serial dilution method but once adjusted to a 0.5 McFarland standard, a sterile cotton swab was used to transfer the saline inoculant to MHA plates. The plates were struck for confluency (inoculant fully covers the plate), which produces a lawn of growth covering the agar. Etest® strips were placed carefully on the plate with sterile forceps avoiding bubbles and displacement. The plates were then incubated at 37°C for 24 hours. Etest® strips depict a different form of susceptibility showing an area of inhibition on a confluent lawn of growth around the strip labeled with antibiotic concentrations. Etest® MIC results are read by determining the end point of growth adjacent

to the strip as seen by the naked eye for bactericidal antibiotics. Trimethoprim is bacteriostatic and thus Etest® protocols require that the results be read at 80% inhibition or the first point of significant inhibition as judged by the naked eye and not where the lawn is completely cleared.¹⁸

Results and Discussion

The results of multiple trials done in triplicate for accuracy have been condensed to arrive at the estimated minimum inhibitory concentration (MIC) values shown in Table 2. Carbenicillin was the only antibiotic for which MIC tests gave moderately varied results. However, the results were always greater or equal to the value listed in Table 2. For Etest® values that were between two markings on the strip, the upper value was used in accordance to the Etest® reading guide.

The CLSI determines breakpoints based on organism and antibiotic. Bacteria can be susceptible, intermediate, or resistant to antibiotics at different concentrations. After multiple trials (three to four) of each test performed in triplicate, we were able to confidently assign MIC values to each strain for all seven antibiotics used. Similar patterns of resistance and susceptibility can be seen between the three strains with respect to the different antibiotics tested. According to the CLSI breakpoint values for *Burkholderia* species, it can be concluded that *B. oklahomensis* exhibits resistance to carbenicillin, gentamicin and erythromycin, but susceptibility to tetracycline, trimethoprim,

Drug	MIC (µg/mL) ¹		
	<i>B. oklahomensis</i> C6786	<i>B. ubonensis</i> H4102	<i>B. vietnamensis</i> A1301
Carbenicillin	256	1,024	>512
Gentamicin	32	256	4
Erythromycin	128	64	32
Tetracycline	2	64	2
Trimethoprim	0.5	0.19	0.38
Imipenem	0.094	8	0.19
Meropenem	0.19	3	0.38

Table 2. Antibiotic Resistance Profiles for *B. oklahomensis*, *B. ubonensis* and *B.vietnamensis*. From the results of multiple trials, the following MIC values were determined. The protocols for MIC determination were performed as listed in the Materials and Methods section.

¹MICs for trimethoprim, imipenem, meropenem and trimethoprim were determined using Etest®; all others established using the two-fold serial dilution method.

imipenem and meropenem. *Burkholderia ubonensis* exhibits resistance to carbenicillin, gentamicin, erythromycin, tetracycline, imipenem and meropenem, and is only susceptible to trimethoprim. *Burkholderia vietnamensis* exhibits resistance to carbenicillin and erythromycin, and is susceptible to tetracycline, trimethoprim, imipenem and meropenem, with possible resistance to gentamicin.

The values obtained were compared to previously determined values in our laboratory for *B. gladioli* pathovar *cocovenenans* and *B. pseudomallei*, where *B. gladioli* pathovar *cocovenenans* was found to be resistant to carbenicillin, erythromycin, tetracycline and imipenem and susceptible to gentamicin, trimethoprim and meropenem (unpublished observations). *Burkholderia pseudomallei* was determined to be resistant to carbenicillin, gentamicin and erythromycin and susceptible to tetracycline, trimethoprim, imipenem and meropenem.⁷ Generally, each species tested was resistant to older forms of penicillin drugs (carbenicillin) and appears to be susceptible to newer β -lactam antibiotics (imipenem and meropenem). However, *B. ubonensis* also shows resistance to imipenem and meropenem. In *B. pseudomallei*, resistance to older β -lactams is due to expression of the chromosomally encoded PenA β -lactamase, which shows little activity against imipenem and meropenem^{19, 20} (D.A. Rholl and H.P. Schweizer, unpublished observations). *Burkholderia ubonensis* either encodes a similar enzyme with an extended substrate spectrum or the observed increased imipenem and meropenem resistance is due to another mechanism.

Of the three species examined in this study, *B. ubonensis* was consistently more resistant. All three bacterial species show resistance to carbenicillin, erythromycin and gentamicin and this resistance pattern is also observed with *B. pseudomallei* and *B. gladioli* pathovar *cocovenenans*. It has been well established that intrinsic aminoglycoside and macrolide resistance in *B. pseudomallei* is due to expression of the AmrAB-OprA efflux pump.^{4, 5} While tempting to speculate that the same pump also operates in the *Burkholderia* species examined in this study, this remains to be experimentally confirmed.

Availability of the antibiotic resistance profiles determined in this study will facilitate future clinical, environmental and genetic studies with these opportunistic pathogens.

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Confirmation of radiation-induced RET/PTC chromosome rearrangements in human thyroid cells

BY HILLARY W. BEDELL AND CHRISTINE L. R. BATTAGLIA, F. ANDREW RAY, AND SUSAN M. BAILEY
ALLEGHENY COLLEGE AND COLORADO STATE UNIVERSITY

Abstract

Environmental exposure to ionizing radiation has been linked to incidence of thyroid cancer. Genetic modifications have been shown to play a role in thyroid cancer occurrence, specifically chromosome arrangements involving the *RET* (Rearranged During Transfection) /*PTC* (papillary thyroid carcinoma) gene. The most common *RET/PTC* variants are *RET/PTC1* and *RET/PTC3*—both which are thought to involve intrachromosomal inversions. The goal of this study was to determine if ionizing radiation-induced *RET/PTC* rearrangements in human thyroid cells, which have been associated with thyroid cancer, could be identified molecularly by RT-PCR and confirmed cytogenetically with chromatid painting. After confirming that HTori-3 cells possessed specialized functions of human thyroid cells (*NIS* and *Tg* expression), cells were irradiated with 0, 1.25, 2.5, and 5 Gy gamma rays, and RT-PCR was run to detect *RET/PTC1* and *RET/PTC3*. *NIS* was used as a control for PCR with HTori-3 cells irradiated at 5 Gy and a strong band seen repeatedly around 200 bp, confirming that the cells retained the specialized functions after irradiation. Faint potential *RET/PTC1* products were noted after gel electrophoresis; however, these products were not confirmed and additional products were unaccounted for. Further studies will include a cell-by-cell cytogenetic analysis, by single-stranded chromatid painting.

Introduction

Numerous reports document an increased risk of thyroid cancer linked to environmental radiation exposure. The survivors of the Chernobyl nuclear accident exemplify this association between irradiation and thyroid cancer.¹ In 1986, the Chernobyl nuclear power plant accident in the Ukraine released a great amount of iodine isotope which resulted in extensive radiation exposure - including exposure to the human thyroid.² Incidence of thyroid gland tumor development increased following the accident.³⁻⁵

One of the genetic alterations confirmed to be involved in these radiation-induced

thyroid cancers involves chromosomal arrangements of the *RET* gene.¹ *RET* is a proto-oncogene located on chromosome 10q11.2 that spans 21 exons and encodes a single pass transmembrane tyrosine kinase that functions as a receptor.^{2,6} When the *RET* gene recombines with one of its 11 fusion partners, it becomes known as *RET/PTC*.⁷ *In vitro* studies have indicated that this chromosomal rearrangement is frequently associated with exposure to ionizing radiation.³ Various mechanisms including unscheduled expression of *RET*, ligand-independent kinase activation, subcellular relocalization and functional alteration of *RET*-fused genes, contribute to *RET/PTC*'s oncogene characterization.² The *RET/PTC* rearrangement has been found in both sporadic and radiation-induced tumors and has been detected in post-Chernobyl tumors. The prevalence of *RET/PTC* rearrangement is approximately 20-30% in sporadic thyroid papillary carcinomas and significantly higher in tumors from patients exposed to radiation.¹ The most common *RET* variants are *RET/PTC1* and *RET/PTC3*—both of which are suggested to be intrachromosomal inversions.^{1,8} These variants of *RET/PTC* account for more than 90% of all rearrangements in sporadic and radiation-induced thyroid tumors. *RET/PTC1* results from recombination between *RET* and *CCDC6*, and *RET/PTC3* results from recombination between *RET* and *NcoA41*.⁹⁻¹² Because these are known rearrangements induced by ionizing radiation and are suggested to be inversions, I aimed to create these rearrangements to use for tests for chromatid painting - a new method of detecting tumor specific chromosomal inversions.^{13,14} In this study, I sought to discover if ionizing radiation-induced *RET/PTC* rearrangements in human thyroid cells, which have been associated with thyroid cancer, can be identified molecularly by PCR and confirmed cytogenetically with chromatid painting.

Materials and Methods

Cell Line

HTori-3 cells, human thyroid epithelial cells which have been transfected with an origin-defective SV40 genome, were used in this experiment. These cells are immortalized and retain specialized functions of differentiated

cells.¹ The cells were a kind gift from the Niki-forov lab, University of Cincinnati. Cells were grown in RPMI 1640 medium supplemented with 10% fetal bovine serum and 1% penicillin streptomycin.

Detection of thyroglobulin (*Tg*) and sodium-iodide symporter (*NIS*)

Total RNA was isolated from HTori-3 cells using a RNeasy kit (QIAGEN, Valencia, CA). Then, mRNA was extracted using the Oligotex mRNA mini-kit (QIAGEN). RT-PCR was performed using the Superscript II Reverse Transcriptase kit and random hexamer priming (Invitrogen, Carlsbad, CA). PCR was performed to detect *NIS* and *Tg* in separate tubes using the following primers: 5'-CCTC-GCAGTTCAATCAGTCA-3' (*Tg* forward), 5'-TGGCTGAAGTAGCCTGAGGT-3' (*Tg* reverse), 5'-CTCCCTGCTAACGACTCCAG-3' (*NIS* forward), and 5'-GAGGTCCCACCA-CAACAATC-3' (*NIS* reverse). For each PCR, 2 uL RT mixture and 2 mM MgCl₂ was amplified in a final volume of 50 uL using 40 cycles of denaturation (94°C for 40 sec), annealing (59°C, 1 min for *NIS*; 57°C, 1 min for *Tg*), and extension (72°C for 1 min). PCR products were electrophoresed in a 1.5% agarose gel and visualized by ethidium bromide staining. The expected size of *NIS* was 207 bp and 303 bp for *Tg*.

Cell Irradiation

Sixteen hours after passage into 75-cm² flasks, actively growing cells were exposed to γ-irradiation from a ¹³⁷Cs Sealed Source, with the turntable in, at a dose rate of 3.9 Gy/min. The 75-cm² flasks that were exposed to higher doses of irradiation were more confluent to account for more cell killing due to irradiation. Cells were exposed to 0, 1.25, 2.5, and 5 Gy γ-irradiation. Cells were passaged once in the 9 days after irradiation. Cells were cultured in an incubator at 37° in 95% air/ 5% CO₂.

Detection of *RET/PTC* rearrangements

Total RNA was then extracted 10 days after irradiation from each flask using a RNeasy kit (QIAGEN). Then, mRNA was isolated using the Oligotex mRNA mini-kit (QIAGEN). RT-PCR was performed using the Superscript II Reverse Transcriptase kit and random hexamer priming (Invitrogen). PCR was performed to detect *RET/PTC1* and *RET/PTC3* concurrently in one tube using the following primers:

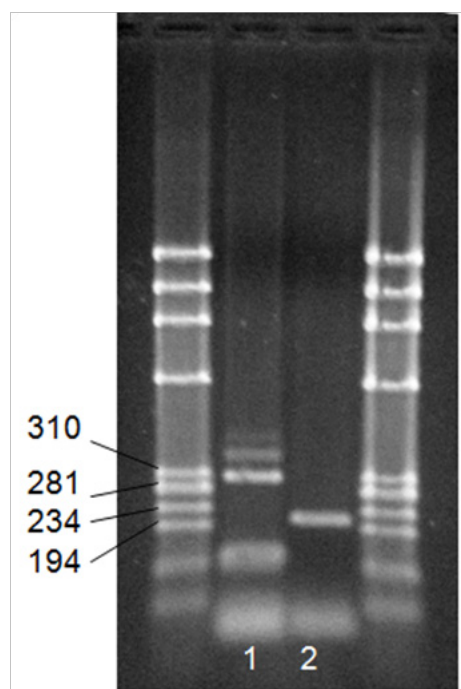


Figure 1. Characterization of HTori-3 cells. RT-PCR analysis demonstrating expression of *NIS* and *Tg*—differentiated thyroid genes. Expected size of *NIS*: 207 bp; *Tg*: 303 bp (*). Lane 1: *Tg*; Lane 2: *NIS*. L, 147-bp Ladder.

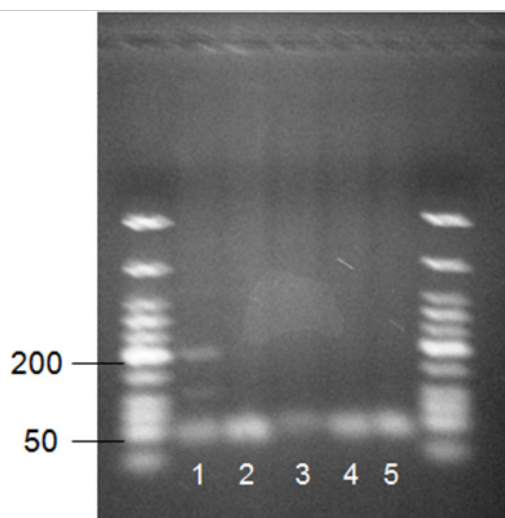


Figure 2. Detection of *RET/PTC1* and *RET/PTC3* rearrangements in HTori-3 cells; 5 Gy. RT-PCR analysis with temperature gradient using specific primers to detect specific *RET/PTC* products. Lane 1: control *NIS* (202 bp) at 59°; Lane 2: 60°; Lane 3: 59°; Lane 4: 58°; Lane 5: 57°. L, Low MW Ladder.

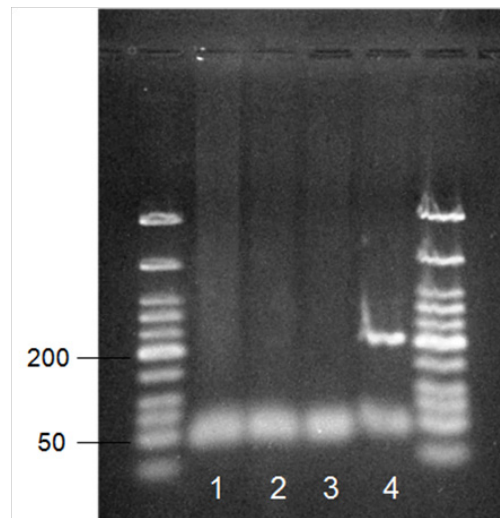


Figure 3. Confirmation of primer dimers around 60 bp. RT-PCR analysis comparing cells irradiated at 5 Gy with cells irradiated at 0 Gy using specific primers to detect *RET/PTC* products. Lane 1: 5 Gy; Lane 2: 5 Gy; Lane 3: 0 Gy; Lane 4: 5 Gy with control, *NIS* (202 bp). L, Low MW Ladder.

5'CAAGAGAACAA-GGTGCTGAAG-3' (*RET/PTC1* forward), 5'-CGGTATTG-TAGCTGTCCCTTTC-3' (*RET/PTC3* forward), and 5'-GCAGGTCTCGAAGCT-CACTC-3' (common reverse). For each PCR, 2 μ L RT mixture and 2 mM $MgCl_2$ was amplified in a final volume of 50 μ L using 40 cycles of denaturation (94°C for 40 sec), annealing (58°C for 1 min), and extension (72°C for 1 min). PCR products were electrophoresed in a 1.8% agarose gel and visualized by ethidium bromide staining. A BLAST search confirmed that the expected size of *RET/PTC1* was 137 bp and *RET/PTC3* was 66 bp.

Results

Detection of thyroglobulin (*Tg*) and sodium-iodide symporter (*NIS*)

Bright bands around 202 bp and 303 bp confirmed that the HTori-3 cells retained expression of *NIS* and *Tg*, respectively (Fig. 1).

RT-PCR with Temperature Gradient to Detect *RET/PTC* Rearrangements

Figure 2 demonstrates the products of RT-PCR performed on HTori-3 cells irradiated

at 5 Gy at different temperatures. A band in lane 1 at about 200 bp confirms *NIS* expression as a control. Products are also evident at about 60 bp in all five lanes (Fig. 2). In Figure 2, a temperature gradient for PCR was run because the annealing temperature for the primers was not known; however, it was estimated from the melting temperature to be 58-59°. The bands at about 60 bp in lanes 2-5 have the possibility to be the *RET/PTC3* product because *RET/PTC3* has an estimated size of 66 bp; however, it is believed that they are primer dimers for two reasons: the band at about 60 bp is also detected in lane 1 using the specific primers to detect *NIS*; also, *RET/PTC1* is more common than *RET/PTC3* so one would expect to visualize the *RET/PTC1* band (137 bp) before visualizing the *RET/PTC3* product (Fig. 2).

RT/PCR to Confirm Primer Dimers

The products of HTori-3 cells irradiated at 5 Gy and 0 Gy are depicted in Figure 3. There is a bright band at about 60 bp in all 4 lanes including lane 4, which *NIS* was run as a control. A band at about 200 bp in lane 4 confirms *NIS* expression (Fig. 3).

RT/PCR Detection of *RET/PTC* at 5 Gy

A faint band is present in Figure 4 between

the 118 bp and 194 bp ladder bands as well as the regular bright band at about 60 bp. Figure 5 depicts the results of RT-PCR using *Isis* DNA Polymerase (MP Biomedicals, Santa Ana, CA). Lane 1 demonstrates a couple bands from ~270-140 bp and the primer dimer around 60 bp. The *NIS* run in lane 2 reveals several bands at ~600, 320, 230, 180, 120, 60 (primer dimer) bp (Fig. 5).

RT/PCR Detection of *RET/PTC* at 0, 1.25, 2.5, and 5 Gy

HTori-3 cells irradiated at 0, 1.25, 2.5, and 5 Gy produced RT-PCR products at about 50-60 bp. Bands around the expected sizes of *RET/PTC1* (137 bp) are absent (Fig. 6).

Discussion

The HTori-3 cell line has preserved the most specialized functions of differentiated human thyroid cells, even after irradiation (Fig. 1; Fig. 2). To confirm it is product dimers, RT-PCR was performed on cells irradiated at 5 Gy and 0 Gy using specific primers to yield *RET/PTC* rearrangement products. Because the bands at about 60 bp are present in all the lanes, these bands are confirmed to be primer dimers (Fig. 3). If the band at about 60 bp was the *RET/PTC3* rearrangement, then the band would

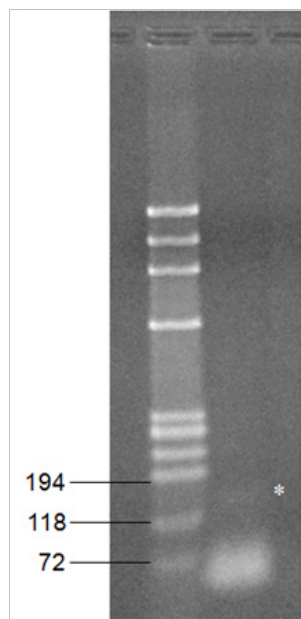


Figure 4. Detection of *RET/PTC1* rearrangements in HTori-3 cells; 5 Gy. RT-PCR analysis using specific primers to detect specific *RET/PTC* products. Expected size of *RET/PTC1*: 137 bp (*). Lane 1: *RET/PTC*. L, 147-bp Ladder.

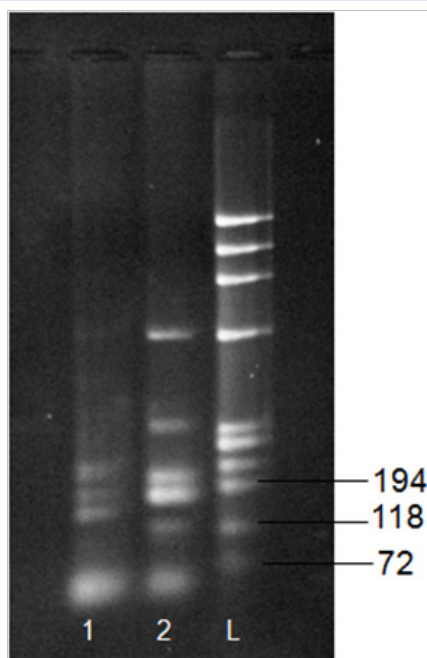


Figure 5. Detection of *RET/PTC1* rearrangements in HTori-3 cells with Isis DNA Polymerase; 5 Gy. RT-PCR analysis using specific primers to detect *RET/PTC* products. Expected size of *RET/PTC1*: 137 bp (*). Lane 1: *RET/PTC*; Lane 2: NIS (202 bp). L, 147-bp Ladder.

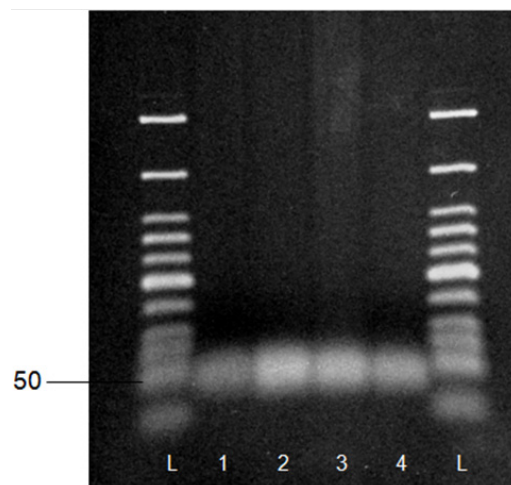


Figure 6. Detection of *RET/PTC1* rearrangements in HTori-3 cells. RT-PCR analysis using specific primers to detect *RET/PTC* products. Lane 1: 5 Gy; Lane 2: 2.5 Gy; Lane 3: 1.25 Gy; Lane 4: 0 Gy; L, 147-bp Ladder.

not be in lane 3 because the rearrangement would not be present in cells that have not been irradiated.

RT-PCR was performed again with HTori-3 cells irradiated at 5 Gy at 58° and a dim band between 119 bp and 194 bp could suggest a *RET/PTC1* product (137 bp) (Fig. 4). Assuming the band is the desired product, it was decided that greater amplification was needed. Thus, Isis DNA Polymerase, a highly thermostable DNA polymerase, was incorporated into the next PCR mixture and the number of cycles was increased to 60 cycles. The bottom band of lane 1 lies between 119 bp and 194 bp, thus it has the potential to be a *RET/PTC1* product (137 bp). However, there are other bands present which are not accounted for. This PCR also resulted in NIS to not yield the correct product. Instead of NIS resulting in a single band at 207 bp, it resulted in many additional products, most likely because of the increased number of cycles. Also, NIS did not depict a band right at 200 bp which could hinder the validity of the potential *RET/PTC1* product (Fig. 5). Even though faint bands around 137 bp were not confirmed to be *RET/PTC1* products for HTori-3 cells irradiated at 5 Gy, RT-PCR was run on cells irradiated at 0, 1.25, 2.5, and

5 Gy; bands at 137 bp were absent. Thus, the *RET/PTC* rearrangements were not identified with RT-PCR at this time.

One reason for limited or absent *RET/PTC* products detected by PCR is that they are reported to be low in frequency (3.0 per 106 irradiated cells).¹ Thus, future studies will include a cytogenetic cell by cell analysis for *RET/PTC* detection. A developing technology for high resolution inversion detection involves strand-specific chromatid painting. Strand-specific chromatid paints hybridize to one chromatid of a metaphase chromosome, so if an inversion is present, a switch in labeling from one side to the other occurs within the inverted region.^{13,14} Thus, if a *RET/PTC* rearrangement is present, a switch in labeling will confirm the inversion.

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To my parents for their endless love and support in all I do.

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The construction of plasmids for expressing an siRNA resistant human cofilin

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Abstract

Human cofilin is an essential 19 kDa actin assembly regulatory protein that enhances actin dynamics through depolymerization and severing of filamentous actin.¹ In the cell, it plays a major role in processes such as cytokinesis and cell migration.² When cofilin expression is silenced in HeLa cells using siRNA, cellular defects occur. Rescuing normal cell function by expressing cofilin from a mRNA that is resistant to the silencing RNA provides supporting evidence that the cellular defects are the result of cofilin silencing and not off-target effects of the siRNA. To this end we constructed a plasmid for expressing siRNA resistant human cofilin mRNA. To construct the plasmid we inserted four mis-matched nucleotides into the part of the cofilin cDNA sequence targeted by siRNA. The base substitutions selected were silent mutations, meaning that the cofilin sequence became siRNA resistant without changing the amino acid sequence of the encoded cofilin. Oligonucleotides containing the modified cDNA sequence were synthesized and used as primers in a polymerase chain reaction (PCR)-based site-directed mutagenesis. After sequencing confirmed the desired silent mutations were inserted into the human cofilin cDNA, the cDNA was inserted into a mammalian expression plasmid and tested for expression. After expression of the mutant cofilin was verified, the siRNA resistance of the expressed cofilin mRNA was also confirmed, making it a useful reagent for cofilin silence and rescue experiments.

Introduction

Human cofilin is an essential actin binding protein that is responsible for directly severing actin filaments and enhancing turnover of actin.¹ Cofilin is required for many of the normal cellular functions which re-

quire dynamic actin assembly/disassembly such as maintaining cell shape and driving cytokinesis and cell migration.² Cofilin is activated by Serine 3 dephosphorylation.³ Endogenous cofilin expression in HeLa cells can be silenced by small interfering RNA (siRNA). siRNAs are 21-23 nucleotide long double stranded RNA sequences that act as mediators in the process known as RNA interference.⁴ siRNAs bind to target mRNA through complimentary sequence alignment and signal the formation of the RISC complex, which leads to the degradation of the mRNA and silencing of the gene.⁵ siRNAs can be delivered directly through transfection or expressed as hairpin RNAs from an expression vector.⁵ In order to demonstrate that the cellular defects arising from cofilin mRNA silencing were caused by the absence of cofilin protein and not off-target effects of the siRNA, it is necessary to rescue the defects by re-expressing cofilin. Previous studies have shown rescuing of a cofilin silencing phenotype in rat cells by expression of a cofilin isoform from a different species (*Xenopus*) but the ideal silence and rescue experiment would involve re-expressing the same isoform and species of cofilin that was silenced.⁶ This requires having an siRNA resistant human cofilin expression plasmid available. To construct this plasmid, a human cofilin cDNA was mutated in the siRNA targeted region by inserting base mutations in the nucleotide sequence while maintaining the amino acid sequence (silent mutations). This mutant was tested for expression and siRNA resistance of its transcribed mRNA.

Methods and Results

Construction of Plasmid: Two versions of human cofilin cDNA were used. One version, called "tagged" had its translation stop codon mutated to encode a translatable linker region for later addition of red

fluorescent protein (RFP). The other version called "untagged" has the normal stop codon. An siRNA resistant human cofilin oligonucleotide was designed to contain four silent mutations in which the bases were changed but the amino acids that they encode remained the same (Figure 1).

The oligonucleotides were obtained from Integrated DNA Technologies (IDT) and used as primers in a PCR-based site-directed mutagenesis using methods of the Stratagene QuikChange site-directed mutagenesis kit (catalog #200518). A portion of the PCR reaction was electrophoresed on a 1% agarose gel, stained with ethidium bromide, and the PCR reaction products with the brightest band from both the tagged and untagged vectors were selected for subsequent steps (Figure 2).

Another portion of the selected PCR reactions was transformed into DH5α competent *E. coli* that had been made competent for heat shock-induced transformation by

The siRNA target sequence of human cofilin:

A T F V K M L
CC ACC TTT GTC AAG ATG CT

The siRNA resistant sequence in human cofilin:

A T F V K M L
CG ACG TTT GTG AAA ATG CT

Figure 1. Wild type human cofilin cDNA and the altered bases creating an siRNA resistant cofilin cDNA. This diagram shows the four silent mutations introduced into the human cofilin cDNA sequence that is targeted by siRNA. The underlined nucleotides replaced the corresponding nucleotides in the siRNA target sequence of human cofilin. The amino acid sequence remained the same.

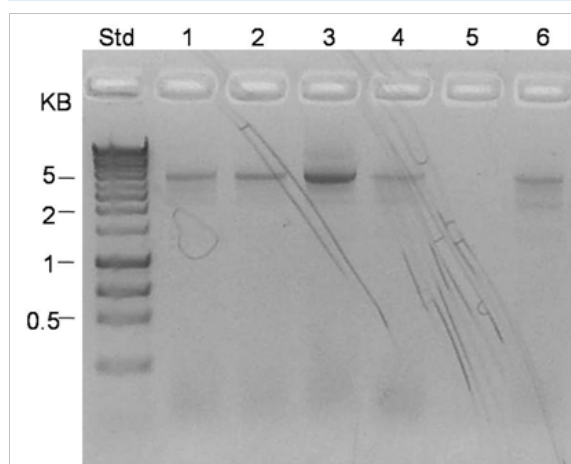


Figure 2. The PCR product from the site directed mutagenesis electrophoretically separated. Ethidium bromide stained agarose gel (1%) electrophoresis of the site directed mutagenesis PCR product. Lanes are as follows: 1) 40 ng untagged template, 2) 16 ng untagged template, 3) 40 ng untagged template with 1 mM $MgSO_4$, 4) 40 ng tagged template, 5) 16 ng tagged template, 6) 40 ng tagged template with 1 mM $MgSO_4$. Untagged cofilin cDNA in lane 3 and the tagged cofilin cDNA in lane 6 were used for the rest of the construction process.

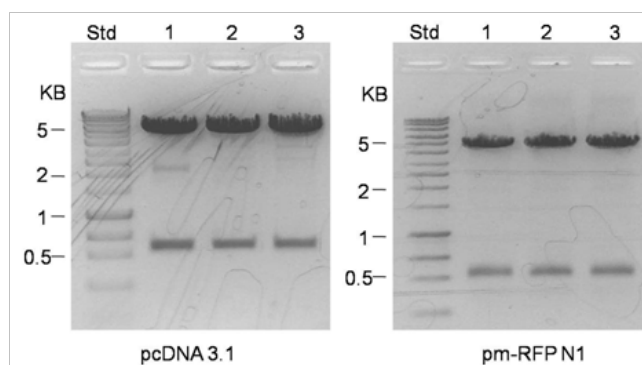


Figure 3. Confirmation of cofilin siRNA resistant mammalian plasmids by restriction enzyme digest. To determine if the ligation worked, a test digest using restriction enzymes that release the siRNA resistant human cofilin cDNAs from their respective mammalian expression plasmids was performed. The pcDNA3.1 test digest shows the release of untagged siRNA resistant human cofilin cDNA from clones 1-3. Human cofilin runs around 0.5 kb on the gel while the plasmid runs ~6 kb. The pmRFP-N1 test digest shows the released of the tagged siRNA resistant human cofilin cDNA from clones 1-3. The pmRFP-N1 plasmid runs at ~5 kb.

treatment with 0.1 M $CaCl_2$.⁷ Four colonies from the plates of bacteria transformed with each type of cofilin were individually inoculated into solutions of Luria broth containing 0.05 $\mu\text{g}/\mu\text{L}$ ampicillin, grown up overnight and the DNA plasmids isolated using GenElute® Mini Prep Kit (Sigma-Aldrich). Sequencing of each plasmid confirmed the siRNA resistant mutations had been inserted into the human cofilin cDNAs and that no other mutations occurred in the cofilin open reading frame. A single clone for each (tagged and untagged) was selected for use in subsequent steps.

Subcloning: The siRNA resistant human cofilin cDNAs were subcloned into mammalian expression plasmids with CMV promoters, which will drive strong, constitutive expression in HeLa cells. The tagged siRNA resistant human cofilin cDNA and pmRFP-N1 plasmid8 were digested with *Bam*HI and *Eco*RI whereas the untagged siRNA resistant human cofilin cDNA and pcDNA 3.1 plasmid (Invitrogen) were digested with *Hind*III and *Xba*I. The DNA was electrophoretically separated and purified from the agarose gel using GeneCleanIII® kit (MP Biomedical). The concentration of each sample of DNA was estimated from the ethidium bromide staining intensity.

The cofilin cDNAs were ligated into their respective mammalian expression plasmids with T4 ligase (New England Biolabs). Plasmids were transformed into DH5 α bacteria, colonies were selected and plasmid preparations were performed as previously described. Test digests were performed on each of the plasmids using the restriction endonucleases described above for their subcloning. The test digest confirmed the siRNA resistant human cofilin cDNA were inserted into the mammalian expression plasmids (Figure 3).

Test for Expression: HeLa cells were grown to 70% confluence in high glucose Dulbecco's Minimal Eagle's Medium (HG-DMEM) containing 10% fetal bovine serum (FBS) and transfected with Lipofectamine (Invitrogen) in Opti-MEM (Invitrogen) medium for 4 hours at 37°C according to the manufacturer's directions. One culture was transfected without DNA (control), and two others were transfected with plasmids for expressing siRNA resistant cofilin either RFP-tagged or untagged. After the incubation, the medium was changed to HG-DMEM-10% FBS. Expression was checked 48 h after transfection using microscopy (for RFP expression) and western blots (for increased cofilin expression or RFP-cofilin expression). Fluorescence microscopy showed red fluorescence of cells transfected with RFP-tagged cofilin and no fluorescence of cells transfected with no DNA or cells transfected with untagged cofilin (Figure 4).

Cultures of the mock transfected and transfected HeLa cells were washed free of medium and lysed using SDS-lysis buffer made of 2% SDS, 10mM Tris pH 7.5, 10 mM NaF, 5 mM DTT, 2 mM EGTA. Cell extracts were heated in a boiling water bath for 3 minutes and the concentration of total protein in each sample was determined using a filter paper protein assay with ovalbumin as a standard.⁹ Once concentrations were determined, volume of each sample that contained 6 μg of protein was loaded onto a 12.5% polyacrylamide gel for SDS-PAGE. The proteins were transferred to nitrocellulose and the western blot was probed by immunostaining for total cofilin (rabbit antibody 1439)¹⁰ and GAPDH as a loading control (mouse anti-GAPDH antibody (Millipore)). Secondary antibodies were conjugated to 700 and 800 nm fluorescent dyes (Dylight, Thermo Scientific). The Odyssey Li-COR scanner was used to visualize cofilin and GAPDH, respectively (Figure 5).

The GAPDH blot showed that there was an equal amount of protein loaded on each well. Both the mock transfected and the untagged cofilin transfected cells contain cofilin immunoreactivity that appeared as a band slightly

below the 20 kDa marker. Quantification of the band intensity by densitometry of the digital scans normalized to the GAPDH loading control showed about a 25% increase in expression of cofilin in cells transfected with untagged cofilin over the mock transfected cells. It is expected to have an increase in cofilin expression in these cells because they are expressing both endogenous cofilin and the siRNA resistant human cofilin. The moderate 25% overexpression is most likely due to the low transfection efficiency. HeLa cells transfected with the RFP-tagged cofilin showed a cofilin immunoreactive band at about 48 kDa.

Test for siRNA-resistance: HeLa cells were transfected at the time of plating with double-stranded human cofilin siRNA oligonucleotides (target sequence CCACCTTTGT-CAAGATGCT, Qiagen) using RNAiMAX (Invitrogen) following the manufacturer's directions. The day after this transfection, the cells were re-transfected again, this time using Lipofectamine 2000 (Invitrogen), with the human cofilin siRNA as well as the plasmid expressing siRNA resistant human cofilin mRNA. Two days after the second transfection, the cells were lysed and extracts were used for SDS-PAGE and western blotting as described in the previous section (Figure 6).

Mock transfected cells contained endogenous cofilin (band at ~19 kDa), which disappears when the cells are transfected with only cofilin siRNA. In cells treated with the cofilin siRNA and the plasmid for expressing untagged siRNA-resistant human cofilin, there is a ~19 kDa band present, indicating the siRNA resistant plasmid was expressing in the presence of the cofilin siRNA. In cells transfected with the cofilin siRNA and the RFP-tagged siRNA resistant human cofilin, there is a ~48 kDa band present that represents the chimeric cofilin-RFP protein. These results indicate that the four silent mutations in the siRNA targeted region of the human cofilin cDNAs are sufficient to allow expression of cofilin in the presence of cofilin siRNA.

Discussion

The ability to silence specific genes using siRNA has led to major advances in understanding the specific roles of proteins in cell function. Cofilin, the major actin dynamizing protein in cells, has been implicated in many essential aspects of cell function, including cytokinesis and polarized cell migration.² However, cofilin has also been implicated in various neurodegenerative diseases. In Alzheimer's disease, over-activation of cofilin in cells leads to formation

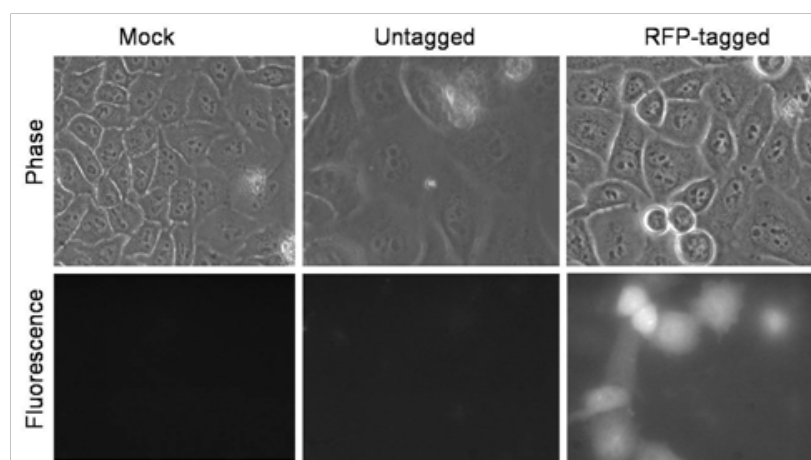


Figure 4. Fluorescent microscope images confirming RFP-tagged siRNA resistant human cofilin cDNA expression. HeLa cells transfected with different cofilin cDNA plasmids. Mock transfected cells were treated with reagents but no plasmid DNA. Untagged cells were transfected with siRNA resistant human cofilin in pcDNA3.1. RFP-tagged cells were transfected with siRNA resistant RFP-tagged human cofilin in pmRFP-N1. Both phase and fluorescent images were taken with a Nikon Diaphot microscope. As expected, fluorescence was only present in cells transfected with the RFP-tagged plasmid. Based upon the percentage of RFP positive cells, transfection efficiency was about 30%.

of cofilin-saturated actin filaments that bundle into rod shaped structures that can form in axons and dendrites to block transport.¹¹ In Huntington's disease, stress-induced nuclear rods of cofilin-actin are not cleared rapidly and may have an impact on gene expression or other events requiring proper nuclear-cytoplasmic transport.¹² To study the role of cofilin in cellular models of these diseases, it would be advantageous to be able to silence endogenous cofilin expression and then rescue with either wild type cofilin or mutant forms of cofilin that will not bundle actin filaments into rods or will not enter the nucleus.

Previously, cofilin silencing in rodent cells has been achieved using either siRNAs introduced by transfection or by using a plasmid or adenovirus from which is obtained expression of a hairpin RNA capable of forming a double stranded siRNA when processed in the cell. To demonstrate the specificity of the cofilin silencing to the phenotype obtained, rescue experiments have utilized plasmids encoding cofilin from a different species⁶, which are resistant to the siRNAs because of their altered nucleotide sequence. However, often minor changes in the amino acid sequence of protein are sufficient to alter its affinity for other binding partners. Thus, to achieve the maximum rescue it would be beneficial to have a reagent that will allow us to express the same cofilin amino acid sequence from an mRNA sequence that uses alternative codons.

Two types of siRNA resistant human cofilin cDNA plasmids were constructed, one type expressed only cofilin while the other ex-

pressed RFP-tagged cofilin. It was important to construct both types in case the presence of RFP interferes with the activity of tagged cofilin. Untagged cofilin could then be used instead, but the RFP tagged cofilin has the advantage of being able to directly visualize cofilin expression so analysis of rescue is confined to only RFP positive cells. Both plasmids expressed cofilin, which was confirmed by using microscopy and western blots. Both plasmids were also able to express cofilin in cofilin siRNA-treated cells that were transfected with these siRNA resistant plasmids.

Using the same methodology described here, we also made siRNA-resistant expression plasmids encoding two RFP-tagged forms of mutated cofilins. The mutations were made to encode either alanine (S3A) or glutamate (S3E) in place of serine at position 3. The S3A mutant behaves as a constitutively active form of cofilin because it is not subjected to phosphoregulation. The S3E version behaves as an inactive phosphomimetic form. Both forms have been useful in past studies of cofilin behavior and function through their overexpression^{13,14} but now, coupled with our ability to silence endogenous cofilin, these plasmids will be important tools to further investigate the functional roles of cofilin in the many cellular activities in which it is involved.

Acknowledgments

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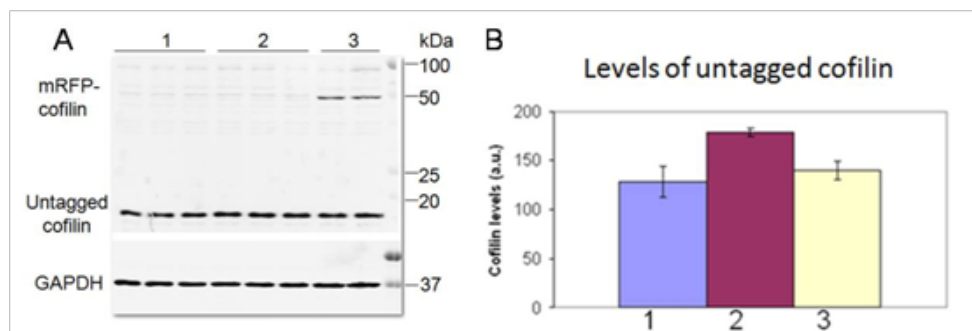


Figure 5. Western blot results confirm expression of both RFP-tagged and untagged siRNA resistant human cofilin. Protein was extracted from HeLa cells with SDS for electrophoresis onto 12.5% polyacrylamide gels and immunoblotting with antibodies to cofilin or GAPDH. The HeLa mock treated cells (1) express endogenous human cofilin. The cells transfected with siRNA resistant untagged cofilin (2) express both endogenous and siRNA resistant human cofilin and thus are expected to have brighter bands. It is easy to see the expressed RFP-cofilin protein (48 kDa band) in the cells transfected with RFP-tagged cofilin (3). The bands were quantified using TotalLab (Non-Linear Dynamics, Newcastle, UK). The bar graph shows that there is more cofilin expressed in cells transfected with the siRNA resistant plasmid relative to mock transfected HeLa cells.

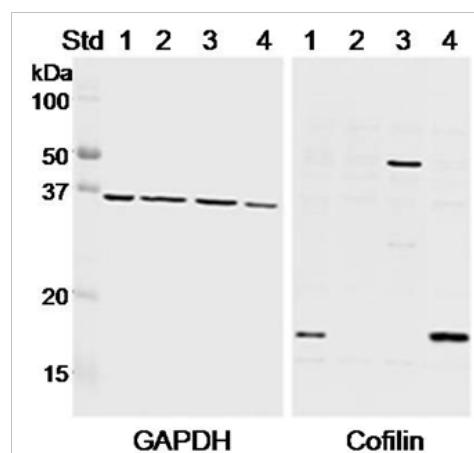


Figure 6. Expression of human cofilin siRNA resistant plasmids in the presence of cofilin siRNA. Protein was extracted from transfected HeLa cells with SDS for SDS-PAGE electrophoresis and immunoblotting with antibodies to cofilin or GAPDH. GAPDH was used as a loading control to demonstrate that approximately equivalent amount of cellular protein was loaded in each lane. HeLa mock cells (1) express endogenous cofilin. Cofilin siRNA transfection (2) results in a loss of cofilin expression. HeLa cells transfected with both the cofilin siRNA and either RFP-tagged (3) or untagged (4) siRNA resistant human cofilin show cofilin expression in the presence of the cofilin siRNA. Cofilin expressed at the expected molecular weight for RFP-tagged and for untagged cofilin.

sible but also enjoyable to finish. Thank you to Aaron Sholders, Yvonne Bridgeman, Marti Stokes and Paul Laybourn for organizing the summer REU program. Also for funding from the National Science Foundation REU Grant DBI-0852017 and NIH grants K01NS064217 (OW) and R01NS40371 (JRB).

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Arsenic - now part of a complete breakfast (for bacteria, that is)

BY RYAN KNODLE
JUR STAFF

If there is one thing we can say for certain in science, it is that very rarely can anything be said for certain. It has long been held that all of life requires six essential elements known as bio-elements: carbon, oxygen, hydrogen, nitrogen, sulfur, and phosphorus. These elements compose all proteins, lipids, and nucleic acids, and their function is aided by select trace elements, typically metals or metalloids. With such a delicate and crucial formation of the building blocks of life, it would seem unlikely for there to be any room for deviation. Or so we thought. Scientists have found, however, that substitution of similar trace elements occurs in a variety of cellular components. Examples include interchanging copper for iron as a carrier of oxygen in some invertebrates and cadmium for zinc in certain enzymatic pathways.¹ A significant consideration of these substitutions is the analogous nature of the elements themselves. Each of the new molecules is similar to the molecule it is replacing in regard to chemical characteristics. Most of the eligible trace elements are in the same periodic group as the elements they exchange with, emphasizing their similarities in electronegativity, orbital configuration, and numbers of valence electrons

Understanding that substitution can occur with trace elements is paramount in hypothesizing about a synonymous switch in the major bio-elements. Substitution of bio-elements has never been observed—nor thought to be possible—but a knowledge of the intricacies that make possible the exchanges in trace elements paired with a fascinating discovery in California has forced scientists to reevaluate this notion. Dr. Felisa Wolfe-Simon's discovery of a bacterial strain in Mono Lake, California, may present the first known case of a living organism to exchange an analog for one of the six bio-elements; in this case, arsenic for phosphorus.¹

Collections of detective novels and the alleged deaths of historical figures have sealed arsenic's fate as being known colloquially as a poison. Arsenic, sitting just below phosphorus on the periodic table, is a chemical analog of this crucial bio-element. The analogous nature of the parent element also transfers to other forms of the molecule; in this case, the relationship between phosphate (PO_4^{3-}) and arsenate (AsO_4^{3-}). Arsenate and phosphate are related closely enough that metabolic pathways in the body cannot distinguish between the two molecules. If arsenate is present in the body, it can be used in place of phosphate, creating major complications in the downstream steps of these pathways. These pathways involve the creation of nucleic acids and energy molecules like adenosine triphosphate (ATP), and thus require extremely stable molecules for their formation. Phosphate is chemically stable throughout these metabolic pathways and can therefore make up the backbone of nucleic acids. Arsenate is more easily hydrolyzed and has too short of a lifetime to form the molecules directed by the aforementioned cellular events. As a result, the analogous nature of arsenate and phosphate leads to the toxicity of arsenic, as metabolic pathways that mistakenly substitute arsenate for phosphate cannot produce a viable product. Since these pathways are absolutely crucial to cellular function, the results are fatal.¹

The presence of phosphate in the bacterium, or lack thereof, became the focal point of the study done by Dr. Wolfe-Simon and her co-researchers. The bacterium GFAJ-1, a member of the family *Halomonadaceae*, was isolated from Mono Lake, a hypersaline lake with alkaline conditions and a relatively high concentration of dissolved arsenic. In order to perform tests in a laboratory setting that simulated the natural environment of this bacterium, the scientists used lake sediments as inocula into an artificial medium at pH 9.8 containing glucose, trace minerals, and vitamins. The medium contained increasing arsenate concentrations in a range of 100 μM -5mM, but had no added phosphate or phosphorus-containing compounds. Trace amounts of phosphate were present in the medium as a result of impurities in the other nutrients added, but these concentrations were exceedingly low. Upon transferring a colony into a liquid form of the medium from the agar, the team progressively increased the arsenate concentration to detect the optimal level for growth. They found the optimal concentration of arsenate to be 40 mM with no added phosphate. When phosphate was added, the bacteria grew considerably faster, indicating that the use of phosphate is still preferred over the relatively unstable arsenate. To verify that arsenate-dependent growth was indeed occurring in the samples without additional phosphate, a negative control was set up with no added arsenate. After incubation, Wolfe-Simon and her team did not observe any growth, signifying that the trace phosphate present in the media was not sufficient to support growth. Due to the fact that GFAJ-1 grew more extensively in the presence of added phosphate, the bacterium is not considered an obligate arsenophile, but showed arsenic-dependent growth. In short, GFAJ-1 can grow solely on arsenic without the use of phosphate, but also can incorporate phosphate into its metabolic processes when available.¹

With evidence that GFAJ-1 actively uses arsenate for growth, the researchers extracted and gel-purified genomic DNA and positively identified arsenate in the sample. Experiments with radiolabeled arsenate confirmed the incorporation of arsenate into key biomolecules, and X-ray and other spectroscopic studies provided evidence that arsenate served a similar function as phosphate in DNA, composing the backbone. Although the study sheds significant light on the subject of major bio-elemental substitution, scientists are unclear about the mechanism by which arsenic is incorporated into the structure of biomolecules.¹

Dr. Wolfe-Simon and her team have come under intense criticism since the publication of the paper in December of last year, including scathing blog posts by scientists in the field and harsh criticism by peers in other media outlets. Issues with the study stem from a wide spectrum of scientists, including microbiologists and astrobiologists. The competence of the team's methodologies remains a focal point of the scientific debate. Some researchers do not think that arsenic is incorporated into the structure of nucleic acids, citing shortcomings of analyzing gel-purified DNA or other sources of the observed arsenic. Dr. Rosie Redfield, a microbiologist at the University of British Columbia who issued an abrasive attack in her blog just days after the article was published, argues that an analysis of DNA embedded in a gel could potentially pick up arsenic present in the gel which is not structurally associated with DNA.² Dr. Barry Rosen of Florida International University is also hesitant to jump on the arsenic bandwagon, saying his primary concern is that arsenic is being packaged into the bacterium's vacuoles and not expressed in the nucleic acids.³

Another principle criticism of the study which has been cited by a number of individuals is the pace at which the results were published. A resounding concern from many in science is that the experiments and investigative procedure lacked thoroughness. Experts in the field have identified a number of tests they believe should have been performed before publication. In an interview with *Science*, Dr. Wolfe-Simon addresses these criticisms, explaining that the suggested tests were not performed due to a lack of available resources. When asked about the rapid nature of publishing, she clarifies that her team decided to publish as soon as possible because they lacked the proper tools to take the study to the next level, and that publishing would likely pique the interest of other labs with more resources who would be interested in collaborating on the project. By publishing the article when they did, the information was given to the scientific community with the hope of inspiring others to become involved with researching the topic further.⁴

Upon first glance, the criticisms at the forefront of this scientific debate seem harsh and, in some cases rather scathing; there has certainly been more criticism than praise. With closer examination, however, we realize that these discussions work to promulgate the focal points of science: discovery and debate. To this day, some of the most influential discoveries in science were presented to an audience whose reactions spanned the spectrum from delving further into the topic, to issuing biting criticisms of the methodologies, to blatantly calling the scientist a liar. In many of these cases, such findings were published in times when people feared changes in the norms that they had held for centuries, or where shaking the foundation of religion was considered unacceptable. Although Copernicus died before he became embroiled in controversy over his theory of heliocentrism, Galileo spent the remainder of his life under house arrest for defending his predecessor's work. Charles Darwin faced scrutiny for the rest of his life after publishing *On the Origin of Species*, and his theories have been continuously attacked through the present day. If anything, this goes to show the importance of scientific discovery and its ensuing debate, which can have vast consequences on science.

It is no mystery that additional research needs to be done on the topic, and with the buzz in the media and the scientific community, I would be surprised if researchers do not jump at the opportunity. Additional research using materials and methods unavailable to Dr. Wolfe-Simon and her team has the potential of making all the difference. Dr. Erica Suchman, professor of microbiology at Colorado State University, says she is excited to see additional research done to either confirm or dispel the notion that arsenic can be incorporated into nucleic acids. "It would be a huge paradigm shift for science. It would prove once again that bacteria perform some of the most extreme functions of all organisms."⁵

If there is anything else that can be said for certain in science, it is that scientific debate will forever be an essential constant. This is how science was designed to work, this is how science has worked for thousands of years, and this is how science will continue to work. The length and nature of the debate are intrinsically related to the magnitude of the discovery: major scientific discoveries have been accompanied by years—if not decades—of scientific debate. This should not deter scientists from publishing. Instead, we must realize that this is necessary for maintaining the credibility and upholding the integrity of science. Dr. Wolfe-Simon's discovery of a bacterium with the potential to substitute one of the major bio-elements should be afforded no pass on this criterion. Both Copernicus and Darwin recognized that their theories would draw largely negative reactions and they both delayed publishing for some time, fearful of the scientific community's response. They both understood, though, that their work could not be withheld from science and that scrutiny of their work would ultimately lead to a better scientific understanding, whether that entailed acceptance or rejection of their theories.

Scientists, intrinsically, do not respond well to changes in the foundation they have built their careers on. Even today, critics attempt to dismantle Darwin's ideas of evolution. His work, however, has withstood one hundred fifty years of such criticism and persists to this day. This is a result of thorough science and constructive debate. Now, the results of the GFAJ-1 experiment are subjected to the same test, the test of time. If further research confirms this microbial action and her findings are upheld, it may be regarded as one of the major discoveries in science.

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Evaluation of lithium based concrete curing compound effectiveness

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Abstract

The purpose of this research was to conduct an evaluation of lithium concrete curing compounds for their relative effectiveness to decrease water evaporation and to meet other noted measures of effectiveness as well as to investigate the optimal time of application. In this regard, curing compound effectiveness was evaluated for four different curing compounds for comparative purposes as a function of differing performance indicators including moisture loss, dielectric constant, relative humidity, and compressive strength.

Based on the preliminary findings, even though the lithium curing compound seemed ineffective in limiting moisture loss from the concrete surface early in the curing cycle, the resulting compressive strengths were acceptable. A clear trend in the time of application of lithium compound places the optimal application time at 2.5 – 3 hours after casting using controlled environmental testing conditions. Differential hardening of the lithium treated concrete specimens was observed and suggests that the lithium compound should not be added to concrete prior to one hour after casting. Based on Environmental Scanning Electron Microscope (ESEM) images, the lithium compound is found to be reactive with the silicate in the mortar to form a gel-like membrane on the treated surface and later yields improved strength levels.

Introduction

Excessive early-age water evaporation from the surface of concrete pavement may induce detrimental impacts, high porosity, delamination (leading to joint spalling in concrete pavements and other similar distresses), and loss of strength on long-term performance of the pavement. Spalling involves a breakdown or dislodging of concrete segments along a crack or joint in a concrete slab within 0.6 m (2 ft) of a crack or joint, and it affects the quality of concrete pavement smoothness and riding quality.¹

The Texas Department of Transportation (TxDOT) has recently experienced cases of

spalling and delamination failures, which may be related to excessive early age evaporation worsened under the influence of certain field conditions such as high temperature, low relative humidity, high solar radiation, and high wind speed. To mitigate early-age unexpected water loss, application of curing compounds in concrete paving has been widely used to minimize evaporation. However, the TxDOT standard specifications for pavement construction (Item 360) is limited to the definition of membrane style curing compounds in terms of key characteristics such as percent solids, density, viscosity, color, and the application rate and does not specify curing performance in terms of field conditions. The current laboratory curing membrane effectiveness evaluation method ASTM C 156 has some intrinsic deficiencies: irrelevance of the test conditions to field performance, mortar's hardening effect, and questionable basis for assigning moisture loss limits. Previous research introduced a new laboratory test protocol based on changes in the surface relative humidity, moisture loss, and mortar compressive strength to evaluate the curing membrane effectiveness in controlling evaporation.²

The previous test protocol was used to evaluate resin and wax based curing compounds. The instrumentation (especially for surface humidity chamber) in the previous method was subsequently modified and found to be very effective in measuring curing effectiveness parameters. Lithium based compounds, which stop water loss by a different mechanism, was examined in this research by the updated test method in order to validate the applicability of the test protocol in evaluating lithium-based compounds.

Objective

The purpose of the current research is four-fold, which is listed below:

- To test lithium-based compounds using an updated test protocol in order to classify lithium compounds in terms of curing effectiveness using similar performance parameters as was previously used.
- To determine the optimal time of application of Li-compounds - to study if the time of application of lithium compound

after casting play any role on changing the performance indicators.

- Use a ranking system to compare different compounds.
- To investigate the mechanism by which lithium compounds aid in the retardation of evaporation from concrete during the curing process.

Experimental Program

Materials used and test procedure employed are described below.

Materials

Four curing compounds, i.e., (i) one Lithium-based compound (LiC), (ii) one Lithium and resin based compound (LiRC), (iii) one conventional resin based compound (RC) and (iv) one high reflective resin based compound (HRRC) were used in this research. Mortar specimens of different dimensions (described next) were used for measuring relative humidity, moisture loss, dielectric constant and compressive strength. The mix design of mortar specimens used is given in Table 1. A Type I/II cement and conventional concrete sand were used.

Table 1. Mixture Proportion

Mixture	W/C	Unit Weight (lb/ft ³)		
		Water	Cement	Sand
	0.40	13.94	34.84	95.81

The sequence of mortar mixing (in accordance with ASTM C 305) is described below:

1. The total amount of water was first placed in the mixing bowl.
2. The cement is introduced and mixed at a slow speed for 30 s.
3. The required amount of aggregate is added to the mixer over a period of 30 s while the mixer continues to operate.
4. The resulting mortar is allowed to mix for an additional 30 s at a medium speed.
5. After a minute rest period, the mixing is continued for an additional minute until a homogeneous mortar with no lumps is obtained.

Test Procedure

Mortar disc specimens of 12" diameter x 4" tall are used for relative humidity, moisture loss and dielectric constant measurements whereas 2 x 2 inch mortar-cube specimens are used for compressive strength measurement.

Moisture-Loss Specimens

A square chamber assembly with two chambers was attached to the mortar disc specimen (Figure 1), using commercial silicon adhesive, to measure relative humidity (RH). The left chamber in Figure 1 represents the configuration to measure surface RH (i.e. humidity just below the curing compound) and the right chamber record RH under sealed condition. The arrangement of placing a filter paper over a perforated support in the left chamber (called a filtered chamber) creates an environment that closely mimics the situation immediately below the curing compound. Curing compound was added to the surface of the disc immediately after casting in amounts corresponding to an application rate of 180 ft² / gallon. The mortar discs with the humidity chamber were then placed on a scale (Figure 1) to measure moisture loss inside an environmental chamber maintained at 104±5°F, 30% relative humidity, and 10 mph wind speed.

The lithium compound (LiC – non-resin based) was applied directly to the surface of the concrete in the filtered chamber rather than on the filter since the lithium needs to be in direct contact with the concrete. Relative humidity was then recorded in the filtered chamber but the difference between it and 100% was determined to represent the relative humidity immediately below the concrete surface; a similar difference between the sealed chamber (one with no treatment) and the filtered chamber could also be considered in characterizing the effects attributable to the lithium curing compound. This method, however, returns results that may not be directly compared or consistent with the relative humidity levels of the resin-based compounds particularly in using 80% as the key indicator in compound effectiveness.

Readings were taken every 30 minutes for the first five hours, every hour for the next five hours, and then at consistent intervals up to 48 hours for the following parameters:

1. Weight reading - taken by reading digital scale
2. Filtered chamber RH and temperature



Figure 1. Disc Specimen Testing Setup.

- taken by inserting handheld sensor into filtered chamber assembly.
3. Sealed chamber RH and temperature - taken by inserting handheld sensor into sealed chamber assembly.
4. Ambient RH and temperature - taken by placing handheld sensor in ambient position in the environmental chamber.
5. Dielectric Constant - taken by collecting three readings with a Percometer and averaging the three readings.

Cube Specimens for Compressive Strength

2" x 2" mortar cubes were cast by the following procedure:

Mortar was placed into each 2" x 2" opening to fill the cube mold. With a rubber

tapping device the mortar was compacted 16 times, four times in four differing directions to an approximate volume equaling ½ the mold height (1"). The entire brass mold (3 - 2" x 2" cubes) was tapped approximately 10 times. Mortar was placed into each 2" x 2" mold to fill the mold to the top (2"). With a rubber tapping device the mortar was compacted 16 times, four times in four differing directions. The entire brass mold (3 - 2" x 2" cubes) was tapped approximately 10 times. The tops of the 2" x 2" molds were smoothed (finished) with a metal trowel to the top of the brass mold assembly.

Curing compounds were applied three hours after casting with the same application rate of 180 ft²/gallon. The cube specimens were cured under the same environmental chamber and strength data were obtained at the age of 1, 3, 7, or 28 days. Average strength of 2-3 cubes are reported as representative strength at each age.

Additional cube specimens were tested to determine the best application time for only Li compound. Lithium compound was applied until it created a uniform thick layer on cube specimen surfaces at 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 and 5.0 hours after casting. These cubes were cured for three days inside the same environmental conditions and compressive strength corresponding to each application time was determined. Average of three compressive strength values are reported as representative strength for each application time.

Environmental Scanning Electron Microscope (ESEM)

The appearance of Li curing compounds as well as conventional resin based compound was studied using an environmental scanning electron microscope (ESEM).

Moisture loss, RH, dielectric constant data

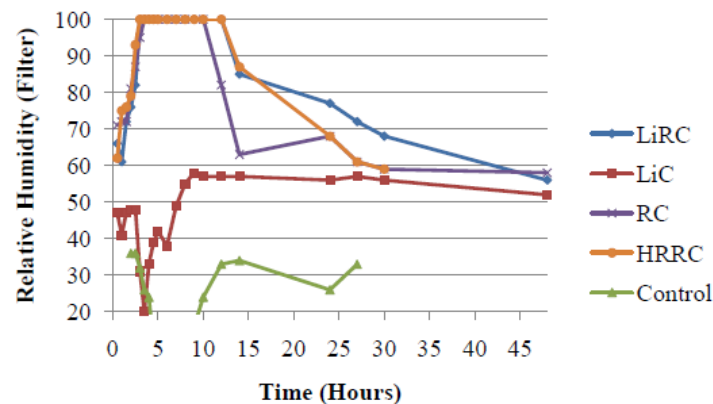


Figure 2. Relative Humidity Inside Filtered Chamber vs. Time for the Studied Curing Compounds.

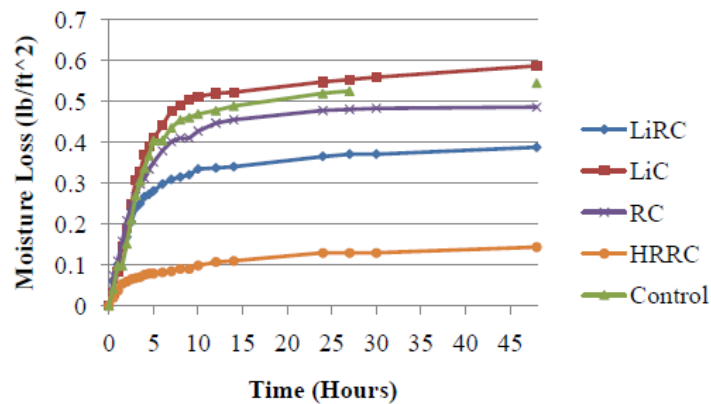


Figure 3. Moisture Loss vs. Time for the Studied Curing Compounds.

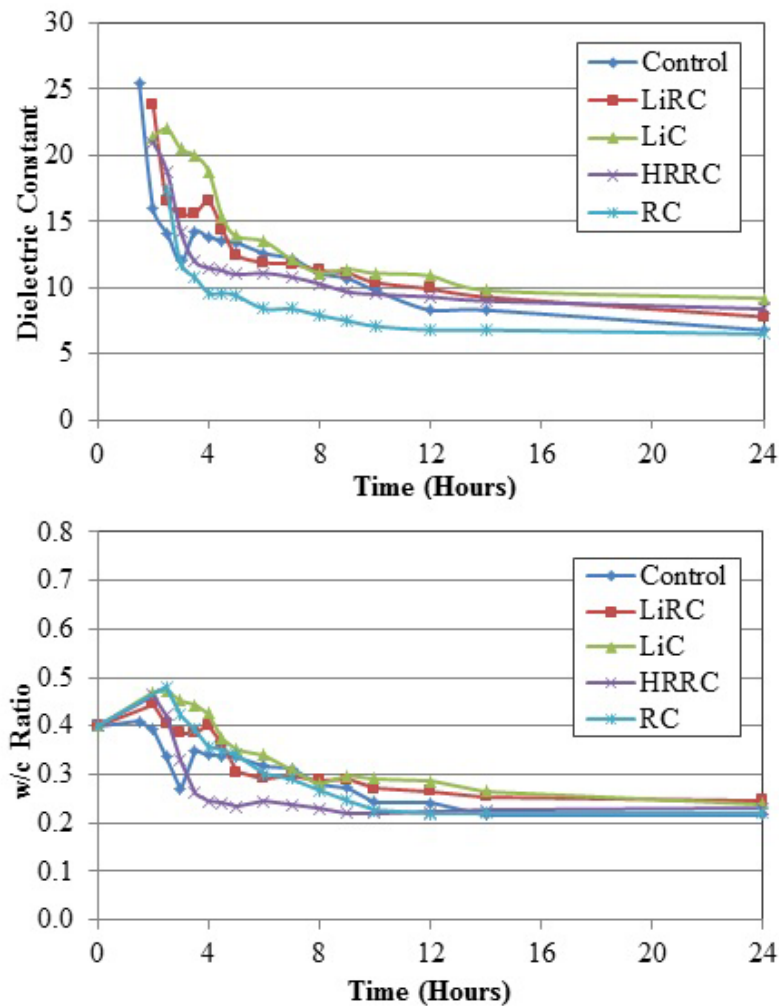


Figure 4. Dielectric Constant vs. Time for the Studied Curing Compounds.

from disc specimens, strength data using cube specimens, and selective ESEM testing were collected for each test run in Table 2. The test runs using different compounds is presented in Table 2.

Table 2. Test Combinations.

Test #	Curing Compound
1	LiRC
3	LiC
7	RC
9	HRRC

Relative humidity (i.e. cured conditions), moisture loss, and dielectric constant data was collected over a 24 hour period and summarized in Figures 2-4 for the four curing compounded listed in Table 2. In some instances, special measures were taken in order to account for the difference in how resin-based curing compounds functioned relative to non-resin-based or non surface membrane forming (i.e. reactive type) compounds. The word 'reactive' is used as a way of noting that these agents appear to react with the paste in the concrete to form a protective layer in the concrete in which to inhibit moisture loss. The reactive compounds tend to build up a protective layer gradually over time as an accelerated hydration process takes place through the depth that the curing agent penetrates the concrete surface, thus forming a hardened layer in which to inhibit the movement of moisture and facilitate strength gain in the concrete.

Relative Humidity

Relative humidity data for resin-based compounds was collected from inside a filtered chamber by placing the compound on a filtered covering which served to create a cured environment above the exposed concrete surface for sampling purposes. This test setup can be seen in Figure 1. The non-resin or reactive compounds were placed directly on the concrete surface where the difference between a RH of 100% and the measured RH immediately above the forming protective layer was observed. This observed data is presented in Figure 2. This difference is shown as a means of equivalency to the other RH data shown in the figure. The following observations were made:

- It takes around 2.0-2.5 hours for the RH inside the chamber to reach 80% for the

LiRC, RC, and HRRC compounds.

- The RH value reaches around 100% after 4-5 hours for these compounds and stays at 100% for 12-15 hours. The attainment of 100% RH is believed to be due to in part condensation inside the chamber. Nonetheless, the longer the condensation period the better the curing effectiveness. It is believed that quick decay of the condensation period is an indication of poor curing. The LiRC and HRRC both show longer duration of maintaining 100% RH followed by a slow decay till reaching 80% RH. However, RC shows a relatively shorter duration of 100% RH and a faster decay till it reaches 80% RH.
- The RH trend for the LiC compound, which is strictly a reactive type product, shows that little protection against moisture loss is not achieved until nearly 10 hours after placement. This compound, however, reaches the equilibrium RH much sooner than the resin-based or containing compounds do.

The time needed to maintain RH above 80% was found to be a useful parameter for determining curing effectiveness. The time for RC above 80% RH is around 12 hours whereas it is 18 hours for HRRC and 20 hours for LiRC. The ranking with increasing order of quality based on time above 80% RH is RC < HRRC < LiRC.

Moisture Loss

Moisture loss data was collected and is presented above in Figure 3. Moisture loss data was calculated by observing weight readings at pre-determined intervals of the disc samples to establish moisture loss curves. HRRC shows the lowest moisture loss whereas LiC shows the highest loss until 48 hours time period; the higher the moisture loss the lower the curing effectiveness. The ranking with increasing order of quality based on moisture loss is LiC < RC < LiRC < HRRC.

Dielectric Constant

Dielectric constant data of the surface concrete is presented in Figure 4. The dielectric of a material is a measure of the polarization or the electrical density that can develop within a material compared to air under an applied current. Dielectric constant readings were measured in this study using a Percometer, which produces a low frequency signal that only penetrates the

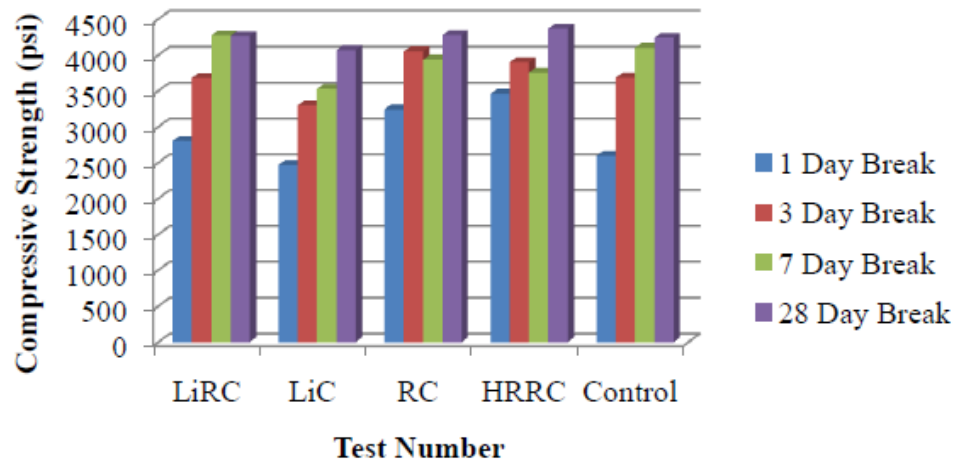


Figure 5. Strength vs. Test Number of Compressive Strength Cube Samples.

concrete to a shallow depth. Consequently, the resulting dielectric reading is assumed to be applicable to only the surface concrete. Due to its sensitivity to water, high dielectric readings indicate more water is in the material than a material with a lower dielectric readings. For this reason high dielectric readings would be an indicator that water has been retained by the sample. The value indicated by the dielectric constant is considered to represent the evaporable water mainly held within the capillary pores of the concrete. The dielectric data for the different curing compounds is shown in Figure 4. As moisture is lost over time the dielectric reading diminishes as well. Based on the data shown in this figure, the dielectric reading of 15 or above corresponded to the initial water-cementitious ratio of the concrete mixture. Work by Lee showed how the surface dielectric can be used in interpret the water-cementitious ratio of the surface concrete by considering the phase of a fresh concrete in the early hardening stages.³ The analysis for the water content was carried out on the basis that the minimum water-cementitious ratio is 0.22 but in some instances the water-cementitious ratio can exceed the initial

water content during the bleeding stages.

Mortar Cube Strength

Mortar cube strength data was collected on cube samples cured with the different curing compounds and presented in the bar graph above as Figure 5. The cube strength was used as a means to represent the strength of surface concrete directly exposed to the curing quality afforded by the curing compound. Based on the data shown, it is not entirely evident but the cube strengths do reflect the moisture loss and quality of curing compound to some extent.

Curing Effectiveness

Table 3 lists the performance factors considered in this study and ranks them from high to low with 1 being the best. The ranking is based on individual performance indicators for the four compounds summarized in Table 3.

This ranking shows that the HRRC curing compound showed the best results where the resin-based lithium compound showed the second best performance. Although it is not elabo-

Table 3. Ranking of Performance Indicators.

Test	Moisture Loss	Dielectric Constant (30 Hours)	Relative Humidity (Time above 80%)	Cube Strength (1 Day)
LiRC	2	2	2	3
LiC	4	3	N/A	4
RC	3	4	3	2
HRRC	1	1	1	1

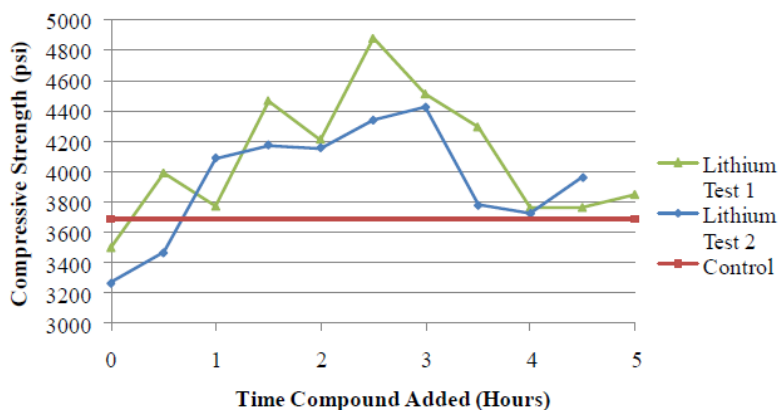


Figure 6. Strength vs. Time of Application of Lithium Compound.

rated, it is pointed out that a correlation appeared to exist between the time that the relative humidity in the filtered chamber stayed above 80% and low moisture loss. The moisture loss data showed basic trends consistent with previous curing studies carried out at the Texas Transportation Institute.² Samples that had less moisture loss also had longer times of relative humidity above the required 80% necessary for hydration to occur in concrete (Table 3). Additionally, samples that showed lower moisture loss also displayed signs of higher dielectric constants as expected based on results from previous work.

The primary objective of validating an approach for evaluating lithium based curing compound effectiveness characterizing the lithium compound was in this sense achieved. In regards to moisture loss, the lithium compound appears to be somewhat ineffective. The relatively high moisture

loss of the lithium compound can be seen in Figure 3. These results are validated by the RC and HRRC results which are consistent with previous work.²

The dielectric constant readings seem to indicate that good performing compounds (low moisture loss) returned relatively high dielectric constant readings. This is consistent with previous work and further validates the data. It is noted that compounds containing lithium read higher than expected dielectric constant readings. This is believed to be due to the mechanism by which lithium interacts chemically with the concrete, subsequently elaborately.

The compressive strength of the cube samples is another indicator of performance of the curing compound. The general trend of the samples tested is consistent with the expected trends of previous work; however the magnitude of the compressive values differs by ap-

proximately a magnitude of two due to the type of sand used in the mixtures. The lithium cube strengths displayed lower cube strength characteristics in this testing series but good strength characteristics in the lithium time test studies. The general trend shows that the lithium compound (LiC) yielded the lowest strength at 1, 3, 7, and 28 days.

Characteristics of Lithium Compound Curing Mechanism

The LiRC compound tested higher than the RC product despite the fact that the LiRC product is primarily a lithium based product with a resin component; it was applied in a configuration consistent with resin based compounds. Apparently, the resin components of the LiRC held the lithium based components in place for a long enough period of time that the lithium components may have hydrated with free water in the air forming discussed gel subsequently discussed. This gel then assisted in the retardation of evaporation.

The LiC was consistently the lowest in regards to compressive strength. The LiRC displayed trends of gaining strength as curing time developed with the LiRC beginning ranked the lowest at 1 day and ending at 1 for 7 day cube strength.

Application Time for LiC

Cubes were cast and lithium compound was added at 30 minute intervals from T=0 minutes to T=300 minutes as described earlier. The results are presented in Figure 6.

The data outlined in Figure 6 shows a possible trend in the time of application of the lithium compound and the compressive strength of the concrete sample at three days. Based on the characteristics of the graph the optimal time

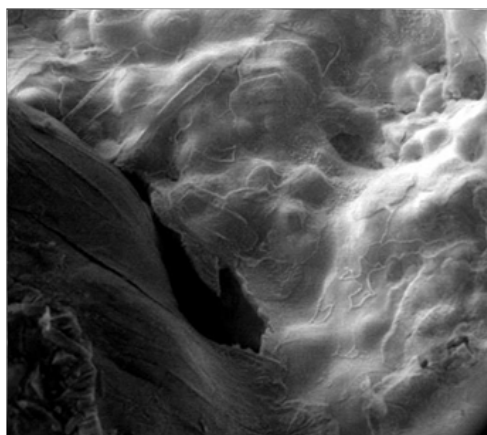


Figure 7. ESEM Image of LiC at Zero hour Application.

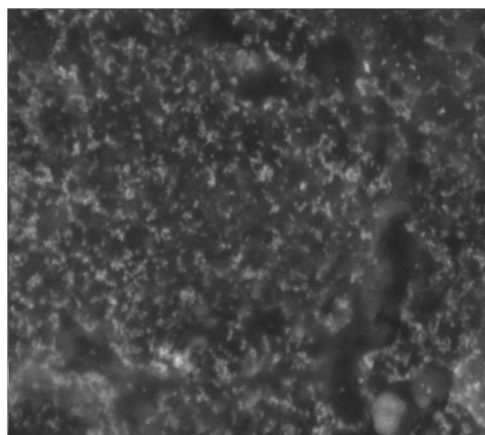


Figure 8. ESEM image of RC at Zero hour application

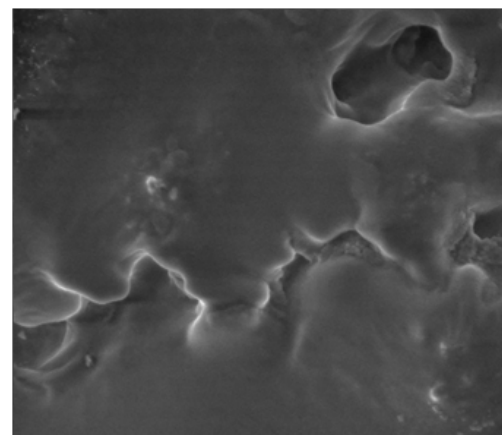


Figure 9. ESEM image of LiC at 3 Hours of application.

to apply the lithium compound is approximately 2.5-3 hours after casting based on environmental conditions.

ESEM Images of Lithium Treated Samples

The appearance of LiC at zero hours application is manifested by ESEM and presented in Figure 7. Figure 7 shows the presence of fines pores as well as cracks, which possibly facilitates moisture loss. On the other hand, RC shows uniform layer without any fines pores or cracks (Figure 8).

From ESEM study, it was observed that the lithium compound formed a very tight layer without any pores or cracks (Figure 9) between application time 30 minutes and 3 hours. A compound layer of this nature has the potential to protect concrete surface from evaporation.

It was observed during testing that the lithium compounds would form a clear gel upon exposure to ambient conditions regardless of direct contact with silicates. It is believed that lithium compounds hydrate and form this gel substance with only the introduction of free water as was observed during the testing procedure. Additionally, referring to Figure 9, during investigation by scanning electron microscope the lithium was observed to have created a definite boundary layer on the treated surface of the specimen. This boundary layer offered evidence that the lithium had chemically

bonded with the silicates present in the cement and that the lithium had formed a gel like substance. This gel like substance is believed to be formed when the lithium bonds with free water therefore indicating that free water was retained at the treated surface despite relatively high moisture losses. This free water held by the lithium gel would return high dielectric readings as the Percometer penetrates only the top layer of the sample.

Conclusions

Four curing compounds were evaluated for curing effectiveness based on strength, moisture loss, water retention, and relative humidity. Although drying shrinkage strain was not included in the data collection effort, the strength parameter does serve as an indicator of resistance to crack development. Nonetheless, the follow points can be made:

- Lithium curing compound (non-resin) is not effective in retarding moisture loss in the concrete curing process at an early age.
- The lithium mechanism was observed to be twofold. Evidence shows that the lithium compound does chemically combine with the silicate in the cement to form a hardened boundary layer. Evidence also shows that lithium by itself can form a hard state clear solid gel in the absence of silicate. It is believed this gel is formed from hydration with free water in the at-

mosphere.

- Results for RC and the HRRC were consistent with previous research.
- A trend was observed regarding a correlation between application time of lithium compound to achieve optimal compressive strength. An application time of 2.5 hours after casting was observed to return the highest compressive strength for the cube specimens.
- Lithium/resin hybrids were observed to retard moisture loss better than lithium compounds alone. This is possibly due to the resins ability to bond the lithium to the treated surface.

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Why 10^{18} FLOPS will give us tools to know

By LUKE WADMAN
JUR STAFF

This last February, the relationship between man and computer certainly changed. Watson, an IBM supercomputer designed to compete against humans in a game of *Jeopardy!*, beat the two greatest human champions of the famous quiz show. Ken Jennings and Brad Rutter fell to Watson to the tune of \$77,147 versus \$24,000 and \$21,600 respectively.¹ While some, like Jennings, may see Watson's victory as a "welcome [to] our new computer overlords," I see a different and far less sinister conclusion.

Watson's achievement is more about computers being able to decipher the nuances of the human language offered on *Jeopardy!* - a challenge so great that few saw it as a remote possibility. A paper published in 2000 by IBM researchers described a QA (question answering) system that was a sort of predecessor to Watson; though this particular system could answer only 35% of complex, *Jeopardy!*-like inquiries correctly and would often take several minutes to come up with an answer.² The fact that computers like Watson can, for the most part, interpret questions given to it in natural human diction may herald intelligent QA systems, similar to "Computer" of Star Trek fame. This computer creates a sort of dialogue with the user, answering initial questions and then is able to answer follow-ups on the same topic.¹

So, intelligent computer systems are well on their way, but they are a far cry from replacing (or enslaving) humanity. In the near future, computer systems like Watson will be integrated into systems like a physician's assistant, which will assist our doctors in diagnosing illnesses. The technology will also be used in businesses to direct customers and answer questions.¹

So what else are these fantastic computers up to? To answer that question, I look back to 2000, and IBM's design of the ASCI White supercomputer. In July of that year, IBM sent 28 semi-trucks full of components to the Lawrence Livermore National Laboratory in California to begin construction of this supercomputer. This initial convoy provided only one quarter of the machine, which when fully assembled spanned an area the size of two basketball courts and needed 6 megawatts of electricity to both power and cool itself.³ The ASCI White's main purpose was to simulate nuclear weapons blasts at a then-unprecedented speed of 12.3 trillion FLOPS (Floating point operations per second), or 12.3 teraFLOPS.³ A FLOP is defined by any floating-point number calculation, whether it is addition, subtraction, division, and et cetera. The fastest supercomputer 5 years prior would have taken 60,000 years to perform a simulation that would take the ASCI White just 30 days.³

For a more applicable comparison to your average college student's laptop, the supercomputer had 8,192 processors, 6 terabytes of memory and 160 terabytes of disk storage. Today's average laptop may have one 4-core processor, 8 gigabytes of memory, and 500 gigabytes of disk storage.³ In short, this 10-year-old supercomputer was 500-2000 times faster than today's average laptop, depending on which components you compare. It cost the LLNL over \$110 million to produce but provided a priceless avenue for government researchers and university academics.³

Now, fast-forward 10 years. A new computing age based not on teraFLOPS (10^{12}), but on petaFLOPS (10^{15}) has arrived. In October 2010, the Tianhe-1A at the National Supercomputing Center in Tianjin, China, began operations at 2.566 petaFLOPS. In more conventional number terms, this comes out to 2.5 thousand million million (quadrillion) floating point operations per second.⁴ The computer's uses include weather models, cancer research, and astrophysics. It is over 200 times faster than the 10-year old ASCI, yet uses less energy (4 MW) and costs less (\$88 million) to produce.⁵

In a long, winding, number-permeated manner some may say is characteristic to an engineer (guilty), I've arrived at my main talking point of this editorial. Computers are continually getting smaller, faster, and more efficient. But where does this trend stop? Though matter is infinitely divisible down to elementary particles like quarks and bosons, we simply cannot continually shrink transistors to improve our computing capacity. This "Interconnect Bottleneck" point has supposedly been reached, and components supposedly cannot get any faster than they are today.

Researchers at Hewlett Packard (HP) may have found the answer. In order to keep up with increasing amounts of data needed digitalization and indexing, an article published in IEEE's (The Institute of Electrical and Electronics Engineers) Computer journal by an HP researcher proposes a solution.

This solution involves combining current technologies, rather than continuing the trend of shrinking and shrinking that has persisted in computing for the past 40 years. The nanostores, as they are called, feature memory storing centers called memristors, stacked along with conventional circuitry that will process the data stored within them. This differs from current computing setups which separate the processors and memory, in which large amounts of energy are needed to shuffle information from the memory to the microprocessor (where it is computed) then back to the memory for storage.⁶ The article goes on to state that these nanostore setups could potentially store trillions of bytes of data along with heaps of processing power. In essence, the proposed memristor nanostores would combine the two most important components of a computer as opposed to the long standing trend of shrinking them individually. This reduces the need for energy to transport information large (in circuitry terms; the actual distances are on the scale of nano - 10^{-9} - meters) distances.

Cutting down on the energy costs required to perform complex mathematical complications is paramount for technological progress to continue growing at rates similar to those of the past 40 years. The energy required for an exaFLOPS (10^{18}) capable computer with today's current technology would be an astronomical 1.6 gigawatts, or about 150% what the average nuclear power plant provides.⁷ Energy costs of the proposed HP technologies range around 1000 to 10000 picojoules per complex calculation, far lower than the most energy efficient of today's supercomputers.⁷ With this proposed technology, our super (and regular) computers would set new standards for space and energy efficiency, while being thousands of times faster than our blazingly fast computers of today.

So now you've made it through all the numbers, statistics, words, and you're wondering to yourself, "Why does this matter? I don't need my computer to be 1,000 times faster than what it is; I already can't keep up with it." But the truth of the matter is this: these supercomputers built with nanostore technology can usher in a new era of human technological advancement, far faster and much different than the one we have seen since the 1960s. Being able to construct complex models to observe the physics, chemistry, and other processes behind nuclear explosions, galaxy formation, or cancerous tumor growth is of foremost importance to developing concrete scientific understanding of these topics.

Combined with the technology behind computers like Watson, new computers will be able to interact with humans much like we do with each other. They can also bring humanity's understanding of our questions and ourselves to a whole new level. There are a number of ethical questions and issues that come about at that point. These questions will seek to address where the line is drawn between humanity and technology. Bottom line, we should not fear that we could be replacing humans with these new machines. We should fear that these concerns might cloud our recognition of a monumental technological accomplishment; a platform capable of exploring and possibly answering our deepest questions far faster than we ever could. The more we know, the more we know.

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Spirit in Matter

BY MORGAN MANLEY
COLORADO STATE UNIVERSITY



This painting was inspired by the idea of multiplicity and unity, which is conveyed by the ancient Buddhist/ Hindu symbol, the Sri Yantra, in the center. Triangles pointing opposite directions come together to create what could look like more triangles, but in reality creates one image of the whole. The central point of light in the painting is meant to symbolize the bindu, a point of unity, emergence, and disappearance of all things. This point also lies at the point of connection between the lower “earthly” half sphere of materiality, and the upper more “spiritual” realm that is not considered solidified. The intention of this connection was to evoke the sense or idea that all things are not separated. Life is connected: in all spirit, there is some bit of matter, and in all matter, there is some amount of spirit.

Winter Water Mandela

BY MORGAN MANLEY
COLORADO STATE UNIVERSITY



Water exhibits geometric beauty in both its solid and liquid forms. This painting was visually inspired by the near perfection and beauty of water, especially in the delicate snowflake. As a mandala, I wanted this work to evoke ideas of water as reflections of humans and all beings. Water, like humans, has a tendency to be influenced by its surroundings. Snowflakes fall from the sky in millions, but not one of them is the same. Ideally this painting will be enjoyed for its clarity and calming and geometric beauty, and also the imperfections that may draw the viewer in for a closer, more introspective gaze.

Confluence

BY AMY KOUSCH
COLORADO STATE UNIVERSITY



This photo was taken in November of 2010. I shot this Poudre River image off of the Grey Rock trail-head area. Camera used was Canon EOS Digital Rebel.

Shells

BY AMY KOUSCH
COLORADO STATE UNIVERSITY



I shot this photograph in Connecticut on the Long Island Sound. An enormous pile of shells was building with the winter tide. This was in February of 2009. Camera used was Canon EOS Digital Rebel.

Mesa Verde

BY MORGAN MANLEY
COLORADO STATE UNIVERSITY



During the summer of 2010, 20 art history students paired with 20 photography students in close camping quarters for a 5 day long adventure class in Mesa Verde. During this time, students were lucky enough to experience firsthand the astounding remains that the Ancestral Puebloans (Anasazi) left behind after the abandonment of Mesa Verde. Hiking and climbing vertical ladders were some of the common methods used to arrive at the many cliff dwellings and ceremonial centers that the Anasazi once scaled the cliffs with small foot holes to access. With very limited tools and resources, the Ancestral Puebloans created building complexes with multi-story towers, giant underground kivas, and astoundingly technical pottery that still leaves us with many questions about these people, today. My photographs attempt to capture the beauty, abrupt abandonment, distinct character, and immensity of the dwelling spaces created by the Ancestral Puebloans at Mesa Verde.



Combine

BY BRAYDEN LOVE
COLORADO STATE UNIVERSITY



This photograph was taken outside of a U Bahn Station in Berlin. I was instantly intrigued by the ceiling of the large station due to its sheer size and beauty. How an epic form of glass and steel could be held so elegantly above me mesmerized me. Not only in the engineering feats it must have had but in the sheer magnificent weightlessness it appeared to have. It was high noon when the photograph was taken, and the sun being directly above my head was cut into pieces of light by the large fan form of the ceiling. This reminded me of a combine hence the title, a separator of the natural sun light and the sterile simplicity of technology.

Environmental justice: incorporating race and class perspectives into environmentalism

BY MEREDITH DICKINSON
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I recently felt disillusioned by my self-anointed identity as an environmentalist. I realized that the bulk of my exposure to environmentally-friendly information was filtered through a White, middle-class lens. In a literature review of the environmental justice movement, I discovered a counter-narrative to the dominant and normalized manifestation of environmentalism. Through an exploration of the history and contemporary campaigns of the environmental justice movement, a distinct counter-narrative emerges to diversify environmentalism and increase its success as a viable movement for contemporary environmental issues. I propose that sociology in general and environmental sociology in particular should increase funding and scholarly interest in the environmentally-based perspectives and experiences of marginalized populations. Environmental justice is a unique and robust vehicle for accomplishing this task.

Environmental Justice Defined

Environmental degradation does not affect all people equally.¹ Sociologist Robert Bullard contends that the presence of 1.3 billion people in hazardous environments is connected to racial and economic exploitation as well as the devaluation of all forms of life.^{2,3} Accordingly, toxic facilities and wastes are routinely located and dumped in marginalized areas and “offered as short-term remedies for the poverty of the poor.”^{2,3} Toxic facilities and wastes are disproportionately located in poor, communities of color.^{4,5} This connection between race and exposure is explained by environmental racism’s definition: environmental policies and practices which disproportionately affect people of color.^{2,3}

Bullard posits that institutionalized racism transforms communities of color into colonies dependant on dominant society.² It is quite fitting that the environmental justice movement has roots in the 1979 Houston-based lawsuit *Bean v. Southwestern Waste Management*, which was the first to use civil rights law to challenge waste facility placement³ and catalyze the agency of a community of color. As this early civil rights- and race/class-based environmentalism progressed, the term environmental racism was replaced with environmental justice. The Environmental Protection Agency (EPA) defines environmental justice as the equitable treatment and involvement of all people, regardless of race, ethnicity or class, in the creation and execution of environmental law.³

Jan Marie Fritz, clinical sociologist and professor of planning and health policy, states that the focus of environmental justice is “environmental problems (in terms of programs, policies, and/or activities) disproportionately faced by those with the least power.”⁶ Even further simplified, the focus of the environmental justice movement is environmental injustice.⁶ It is important to note that, though the original focus was upon disproportionate exposure and environmental racism,⁷ the movement diverged away from environmental racism’s narrow, intention-based model.⁸

Sociologist David Pellow, clarifies that environmental racism, though an important focal point of research, is only one example of environmental injustice.⁹ In fact, environmental injustice includes any oc-

currence of disproportionate exposure experienced by a particular social group.⁹ This contemporary focus on environmental inequality increases the movement’s inclusion of affected populations, while it removes the burden of proving *intentional* racist targeting of communities of color.^{10,11} The term environmental inequality, thus, broadens the scope of analysis as it focuses on “the intersection between environmental quality and social hierarchies.”⁹

History of Environmental Justice

Between the 1980s and 1990s, elements of the civil rights and environmental movements combined to form the environmental justice movement.^{2,3} The beginning of this movement can be traced back to a protest in Warren County, North Carolina.^{2,6,7,10,11,12} Soon after this 1982 protest of a toxic landfill, which led to 500 arrests and ignited the movement,^{2,6} research that supported the protest claims of environmental injustice was published. A 1983 United States General Accounting Office study reported that 75% of all hazardous waste sites in an 8 state region were located in predominantly Black communities.^{2,3,4,6,10,12,13,14} Black communities comprised only 20% of the region studied and were clearly disproportionately affected.^{2,6} By 1987, a national study by the United Church of Christ’s Commission for Racial Justice found that race was the most pertinent variable in the prediction of facility placement.^{2,3,4,10,13,14}

This new environmental movement emerged as a race-based critique of the distribution of environmental hazards.⁸ Initial protests as well as regional and national studies led to the First National People of Color Environmental Leadership Summit in 1991. The summit was the most significant single event in the movement.^{2,3} Along with an anti-toxins focus, the summit broadened the movement to include “public health, worker safety, land use, transportation, housing, resource allocation and community empowerment.”² The following year, the EPA offered official acknowledgement of this growing movement when it published a study on the relationship between race and disproportionate exposure² and created the Office of Environmental Equity.^{3,6}

Throughout the 1990s, solidification and institutionalization of the environmental justice movement continued. In 1993, the EPA established the National Environmental Justice Advisory Council (NEJAC) composed of members from both grassroots and environmental groups, NGOs, state, local and tribal governments, academia and industry.^{3,6} By 1994, President Bill Clinton signed Executive Order 12898, which reinforced Title VI of the Civil Rights Act of 1964.^{8,10} The order called for increased assessment and mitigation of exposure, more data on low-income and minority exposure, and encouraged the direct participation of affected populations.^{3,13} Clinton’s Executive Order resulted in environmental justice’s introduction to mainstream environmentalism.¹⁰ With legal recognition secured, the environmental justice movement was poised to affect change.

Disproportionately affected residents and activists utilized the new, national-level recognition to accomplish several important victo-

ries. In 1997, Louisiana's Claiborne Parish and its Citizens Against Nuclear Trash (CANT) won an 8-year lawsuit and prevented the construction of a uranium-enrichment plant.^{2,3} The proposed site was within one mile of a 97.10% Black community.³ The following year, St. James parish and environmental justice activists successfully blocked the construction of a Shintech chemical plant. St. James' population was 83% Black, though they constituted only 34% of Louisiana's total population.^{2,3} The proposed Shintech site was in an area with twelve "polluting plants" and 60% unemployment.³ In 2000, residents of Camden, NJ blocked a cement plant from entering an area of 95% people of color who already suffered health effects from industry.³

These isolated victories, though substantial, merely scratched the surface of the issue. The scale of US environmental injustices is illustrated in a study conducted in 1999 by the Institute of Medicine. Despite significant successes spanning two decades, the study found that people of color and the poor continue to face higher rates of exposure to pollution and resultant diseases.^{2,3} For instance, despite its Shintech victory, St. James Parish ranked "third in the state for toxic releases and transfers."² Sadly, a July 1994 *Journal of the American Medical Association* found that Black children suffer from lead poisoning at a rate more than double that of their White counterparts.^{2,3}

History of Environmental Paradigms

Dorceta Taylor, Associate Professor at the University of Michigan whose research interests include environmental history and ideology as well as environmental justice, posits that because race shapes environmental experience, the environmental activism, agendas, and paradigms of people of color will differ from those of Whites.¹⁴ Essentially, Taylor argues that different locations in society yield different environmental experiences which, in turn, shape the definition of environmental issues in differing ways.¹⁴ Though the United States' environmental movement has been marked by several distinct phases, only the contemporary mobilization of environmental justice has successfully incorporated the experiences, activism and agendas of persons of color and the poor.¹⁴

The environmental mobilization of the early 20th century was catalyzed by Emerson, Thoreau, and Muir.¹⁴ Their collective works led to the development of the romantic environmental paradigm (REP)¹⁴ which criticized natural resource extraction, urged harmonious interactions between humans and nature, and called for government protection of wilderness.¹⁴ This environmental era was most concerned with the human destruction of nature and the how patterns of consumption would affect future generations.¹⁴ Taylor argues that the emphasis on preservation and outdoor recreation attracted the middle class and elites.¹⁴

Rachel Carson's 1962 book *Silent Spring* catalyzed the next environmental mobilization by including environmental issues that affected humans.¹⁴ Industrial chemical hazards were her specific focus.¹⁴ Carson's work did not employ a race or class analysis of exposure. It did, however, raise awareness about the contamination of communities and resulted in the creation of new grassroots organizations.¹⁴ The new environmental paradigm (NEP), which espoused a more fervent pro-environment agenda than the REP, developed in the years following *Silent Spring*.¹⁴ Unlike followers of the REP, adherents of the NEP were less tied to business interests and less interested in hunting and fishing.¹⁴ The NEP has dominated the movement since the 1960s.¹⁴

Despite the post-Carson era's acknowledgement of the degradation

of human environments, the NEP did not appeal to people of color.¹⁴ During the 1980s, people of color organized against chemical exposure and toxic facilities as research exploring a link between race and hazardous exposure was underway.¹⁴ This era of environmental mobilization ushered in the environmental justice paradigm (EJP).¹⁴ Taylor argues that the environmental justice paradigm appealed to people of color because it linked environmental issues to other pertinent concerns, namely labor, human rights, and social justice issues.¹⁴

Racism and Classism in Environmentalism

A lack of racial and class inclusion within the mainstream environmental movement is evidenced by the demographics of the movement's leadership and membership. Such research finds that environmental and conservation groups in the United States are predominantly White and middle-class.³ A 1992 demographic study of 63 mainstream environmental organizations found that the organization's staff, members, and volunteers were predominately White.¹⁴ In fact, a recent University of Michigan study found that one-third of mainstream US environmental groups still lack even one person of color on staff.¹⁵ At the Kyoto Protocol negotiations, for instance, Jerome Ringo was the only African-American delegate in attendance. Further, he was the only African-American in the entire Louisiana Wildlife Federation that boasts 24,000 members.¹⁵ Ringo explained that "Conservationists were sportsmen . . . people who would fish to hang the fish on the wall. Those people who would fish to put a fish on a plate [emphasis added] didn't join clubs."¹

In the post-Carson era, mainstream environmentalism's wilderness- and conservation-dominated agenda incorporated an anti-pollution stance and the movement chose national-level policy-making over localized actions.¹ Despite these changes, environmentalism's continued lack of inclusivity was highlighted by its 1960s-1970s campaign to regulate pollution. The movement ignored the affect that their anti-pollution campaign would have on poor communities of color as pollution was shifted to areas lacking the financial and political resources to fight it.¹⁵ As demonstrated in a 1992 National Law Journal study, there are "glaring inequities" in the enforcement of EPA laws.^{3,10,11} Further, polluted inner-city and urban environments were not on mainstream environmentalism's radar.¹ For instance, though the Sierra Club's efforts toward the protection of wilderness and endangered species are quite notable and commendable, the organization lacked an urban agenda.¹⁵

The environmental justice movement was, thus, a counter-narrative to mainstream environmentalism's lack of race and class analysis.¹¹ Sociologist Daniel Faber states that environmental justice gave voice to communities of color and constructed organizations to identify and address the environmental issues these communities face.¹⁶ Environmental justice focused upon the issues which directly affected the "lives and livelihoods" of people.⁵ Accordingly, the 1980s saw a reorganization of grassroots environmentalism, including the addition of race-based analysis, which resulted in the incorporation of a large new group of stakeholders.¹

Political science professor, David Caruthers argues that the environmental justice movement succeeded in the successful combination of civil rights and environmental issues.^{1,5,14} Specifically, it illuminated the burden of disproportionate exposure experienced in poor, communities of color.⁵ Julian Agyeman, professor of urban and environmental policy and planning, points out one positive consequence of this fusion of social movements: environmental and public health laws are more effective than civil rights laws.¹⁰ The environmental justice movement continues to call for inclusion of diverse perspectives by

changing the administration of environmental protection in marginalized communities.³ As Bullard and Johnson contend, this social movement will remain necessary as long as policies favor Whites and those with higher levels of education and income.³

Carruthers posits that the environmental justice movement transformed environmentalism by “altering its scope, character, and tactics.”⁵ As such, environmental justice is a counter-narrative to mainstream environmentalism’s lack of inclusive interpretation and mitigation of environmental protection and exposure. Bullard and Johnson contend that environmental protection must be implemented as a right, rather than experienced as a privilege for those able to prevent or escape “environmental stressors.”³ Clearly, transforming a privilege into a right requires resources. Unfortunately, a study conducted in 2001 found that less than 5% of environmentalist grant monies went toward environmental justice work.¹⁷ Unfortunately, in comparison to other major social movements, the environmental justice movement remains distinctly underfunded.¹⁶

Global Environmental Justice

The environmental justice movement expanded its focus to include global issues.¹¹ It has the capacity to operate on a macro-global level while maintaining adaptability to local issues.⁵ Historically, international environmental justice is rooted in the 1984 PEMEX gas explosion in Mexico City and the Union Carbide explosion in Bhopal.⁷ According to Bullard and Johnson, production and consumption patterns “create and maintain unequal and unjust waste burdens within and between affluent and poor communities, states and regions of the world.”³ For instance, both Louisiana-based African-Americans and Nigerians are negatively affected by Shell Oil refineries.² These disparately located environmental injustices create a global link between groups disproportionately burdened by environmental hazards in the United States to those disproportionately burdened abroad.

Bullard argues that the Global North’s private industry, government and military secure benefits domestically and then shift the costs to the Global South.² Schroeder et al agree that costs are “passed off” to marginalized communities.⁷ This contention is amply illustrated in a 1991 memo written by the World Bank’s chief economist, Lawrence Summers: *Dirty Industries: Just between you and me, shouldn’t the World Bank be encouraging MORE migration of the dirty industries to the LDCs [less developed countries]?*^{2,3} This memo explicitly shows that environmental injustice operates in the “international arena between nations and between transnational corporations.”²

Summers’s memo alludes to globalization’s participation in the proliferation of environmentally-based injustice as transnational companies seek out low environmental regulations¹⁶ and cheap labor.² For instance, Sempra Energy and InterGen Services provided energy for Southern California by “installing dirty plant technology in Mexico to evade higher US environmental and community health standards.”⁵ As sociologists Szasz and Meuser contend, “...environmental inequality is a global phenomenon, routinely generated by the normal workings of international political economy.”¹² For instance, from 1989-1994, 2611 tons of waste were exported to non-OECD countries.² Despite the 1991 Bamako Convention and 1995 Basel Convention bans on the export of waste, implementation and enforcement lag.² Public policies and industry practices continue to provide benefits for the countries in the North while shifting the costs to countries in the South.^{2,3}

One striking example of international environmental inequality lies along the US/Mexican border. The *maquiladora* industry is a microcosm of disproportionate exposure to environmental hazards. Despite

a 1983 agreement which called for the return of production wastes from Mexico to the United States, the Center for Investigative Reporting found that the EPA received only 10 notices of waste return during 1989.³ Instead, waste is dumped in the desert, into sewers, ditches, and a water source used by 95% of the region’s population.^{2,3} Effects from high level toxins are often extreme. For instance, in two Border towns, babies are born without brains at 4 times the national average.² Unfortunately, as in the United States, people around the world must decide between the “false choice of ‘no jobs and no development’ versus ‘risky, low-paying jobs and pollution.’”³

Beyond the country-by-country scale of environmental injustice, Bullard argues that global climate change is the most pertinent environmental issue of our time.² He calls for climate justice that “links human rights and ecological sustainability.”²² Julie Sze, associate professor and founding director of the Environmental Justice Project at the UC Davis, contends that the environmental justice framework is vital to understanding the context of global climate change, precisely because the Global South is projected to suffer disproportionate negative effects.¹¹ Unfortunately, prevention and mitigation resources are scarce because the international environmental justice movement lacks the level of information and marginal funding found in the United States movement.⁷

There are several challenges unique to the international environmental justice movement. Carruthers, an expert on politics and policy in Mexico and Latin America, contends that severe economic marginalization coupled with fewer resources stunts activism in Central and South America.⁵ It is also of note that the US environmental justice is not a completely transferable paradigm. In fact, international environmental justice differs substantially from its US counterpart due to a “relative absence of environmental regulation” combined with the “relative significance of race.”⁷ For instance, the United State’s environmental regulator, the EPA, does not have a similar counterpart in other countries, nor are categorical distinctions based on race as salient or as notable.

The Green Economy

One contemporary environmental justice campaign centers on the inclusion of marginalized communities into the emerging green economy. Environmental justice activists strive to ensure that the “green bandwagon”¹⁸ has available space for those historically excluded by society in general and environmentalism in particular. While the mainstream environmental movement frames green jobs as a conservation effort focused on solar panel installation and wind turbine construction, the environmental justice movement seeks to broaden the scope to include clean-up and mitigation of industrial sites and the revitalization of urban areas. Activists seek full inclusion of industrial clean-up, lead and asbestos mitigation, water and air quality monitoring, and urban garden implementation into the green job sector.¹⁸ Thus, the environmental justice movement strives to connect the growing “green economy with the needs of urban minority communities” most affected by historic economic and environmental policies.¹⁸

It is important to note that, before green hit the mainstream economy, there was a significant partnership between the environmental justice movement and environment-related federal work programs.¹⁸ Between 1996 and 2000, the Minority Worker Training Program trained 1,647 youths and placed 65% of them in related employment.¹⁸ In 2003, Sustainable South Bronx, founded by Marjora Carter, launched the local green-jobs initiative, Bronx Environ-

mental Stewardship Training (BEST). Within six years BEST has placed 80% of its 100 graduates. Since 2007, Richmond BUILD has offered training in “construction, energy efficiency, and solar power” with aims to counteract the legacy of poverty, violence and toxic waste from 400 industrial sites.¹⁵

“Green-collar jobs,” as coined by professor Raquel Rivera Pinderhughes, are changing “the face of environmentalism” by incorporating those most affected by the “dirty-energy economy” and race and class hierarchies.¹⁵ Initiatives such as BEST and Richmond BUILD fight to ensure that the green economy includes social justice measures, such as a living wage, safe work environments, and union-style worker empowerment.¹⁸ Brentin Mock argues that increasing the scale of these “original green-jobs programs underwritten by federal funds” is vital to communities of color.¹⁸ Sociologist David Pellow maintains that the United States has the ability to increase the scale and scope of “community-based environmental projects.”¹⁸ Recently, the 2009 American Recovery and Investment Act promised \$10 billion for “community-organization work on energy efficiency and pollution education,” though the allocation of funds was not specified.¹⁸

Environmental Justice Criticisms

There are three main criticisms of the environmental justice movement: one is economic and the other two are scholarly in nature. Concerning economics, the environmental justice movement is often accused of blocking jobs to under- and unemployed areas. Bullard and Johnson counter that, though the Black community is often “lured” by the promise of jobs, polluting industries rarely provide work for local residents.³ In fact, there is no correlation between industrial placement and employment opportunity for local residents.³ According to Bullard and Johnson, communities of color mostly gain “pollution and poverty,” while Whites commute to work from less polluted areas.³ Bullard concludes that to choose between a job, on the one hand, and the health of oneself and one’s community on the other is “economic blackmail.”²

The second main criticism of the environmental justice movement claims that research findings that race and income-levels are linked to exposure rates are faulty at best and completely inaccurate at worst. There is a general agreement that environmental injustice exists and a fundamental disagreement on whether the source of injustice is “economic, sociological, or racial” in nature.¹ Upon reviewing Census data and site placement data on facilities for the treatment, storage, and disposal of hazard wastes (TSDFs), Anderton et al found no reliable evidence of racial discrimination in the siting of TSDFs.¹³ They did, however, find patterns of residential discrimination which they believe responsible for the initial environmental justice research results that claim siting discrimination.¹³

Vicki Been, Professor of Law at New York University, takes issue not with the claim of disproportionate exposure, but rather the timeline of siting and community demographics.⁴ She argues that research on discriminatory siting does not take into account whether the toxic facilities chose to site in a poor, community of color, or if market forces relevant to toxic facility siting attracted people of color and the poor.⁴ Been’s central question: which came first, the siting or the people? Because environmental justice research on toxic siting did not account for community demographics *at the time* of initial siting, the resultant findings cannot claim a direct correlation between community demographics and the decision to site a toxic facility.⁴ Further, studying the racialized nature of the economy would in-

crease the understanding and mitigation of environmental injustices.⁸

This attack on environmental justice research and its core belief in the existence of an unjust distribution of negative environmental exposure has been met with a rigorous, research rebuttal. To begin, Hilda Kurtz, Associate Professor of Geography at the University of Georgia, does agree that spatial statistics do not reliably prove racial discrimination in toxic facility siting.⁸ However, she contends that “expert knowledge(s) grounded in Census and other spatial data are in tension with lay and experiential knowledge(s) of the disparate impacts of pollution on people’s health and livelihoods.”⁸ Further, she adds that spatial analyses lacked data on “social, political and economic context in which inequitable distributions of pollution occur.”⁸

Analyzing environmental justice literature itself, Brulle and Pellow’s 2006 meta-analysis found that race and class were significant factors related to exposure and remediation.¹¹ Similarly, Evan Ringquist’s meta-analysis of 49 environmental equity studies found that:

Some scholars have protested that race-based inequities are limited in scope, produced by misspecified models, or are the artifacts of aggregation bias. While the magnitude of race-based inequities does vary with respect to these factors . . . the results of the meta-analysis show that protests claiming that these factors can explain away such inequities are empirically unsustainable.¹⁹

The accusations of faulty or inflated science, thus, do not hold up, as race and class remain substantial factors of environmental exposure.

Finally, the third criticism of the environmental justice movement concerns its methodology. David Pellow, professor of Sociology at the University of Minnesota, contends that the terms environmental racism and environmental justice are consistently and inaccurately treated as interchangeable.⁹ Pellow proposes the use of the Environmental Inequality Formation (EIF) perspective, which includes and links three major points: process and history, multiple stakeholder relationships, and the inclusion of a life-cycle approach to production and consumption.⁹ Thus, the EIF perspective defines environmental inequality as a process with multiple stakeholders, rather than a unilateral imposition of hazard by one group upon another, that occurs throughout the life cycle of production and consumption, rather than a singular focus on waste disposal.⁹

A case study of a Chicago recycling center illustrates the “promises and pitfalls” of the environmental justice movement.⁹ An environmental justice success, closing an incineration plant and replacing it with a recycling center, appeased government, business interests, activists and local job seekers alike.⁹ The incinerator closing and recycling center opening seemed a perfect match for the national environmental justice group, Communities United for Justice (CUJ) mantra of ‘too much pollution and not enough jobs.’⁹ Unfortunately, the social construction of an environmental justice success engendered a lack of acknowledgment for environmental hazards experienced by African-American workers at the recycling center. As Pellow argues, though the recycling center was socially constructed as a safe and environmentally-friendly alternative to the incinerator, the recycling center produced environmental inequalities for its African-American workers.⁹

Applying the EIF perspective to the Chicago incinerator vs. recycling center case study, the sociohistorical process of shifting allegiances (environmentalists once endorsed incinerators) and shifting social constructions of hazard emerges.⁹ Further, moving beyond environmental racism’s perpetrator-victim dyad, the EIF perspective emphasizes the

role of multiple stakeholders and transforms the African-American workers, or the “would-be victims,” into complex actors with the agency to resist and shape outcomes.⁹ Finally, the EIF perspective adds a life-cycle analysis to the study of environmental inequality by connecting the post-consumer recycling hazards to the hazards experienced in the production and consumption of products.⁹

Conclusions and Recommendations

Fritz, a sociology professor of planning and health policy, contends “There is a tragic reluctance to solve and prevent the environmental problems that are facing minority and low-income communities as well as low-income countries.”⁶ I argue that this reluctance relates directly to the evidenced invisibility of marginalized perspectives on and experiences of environmental issues. For nearly a century, the environmental movement has excluded marginalized populations from participation in the construction of environmentalism. This systematic lack of representation translated into a systematic lack of protection of people of color and the poor. The environmental justice movement seeks to remedy environmentalism’s blind spot and is a crucial step forward in environmental history.

The redefining of environmental issues, “not (only) as wildlife, recreational or resource issues, but as issues of justice, equity and rights gave birth to the environmental justice movement.”¹⁰ Accordingly, environmental justice could transform mainstream environmentalism into a far more diverse and powerful social movement. This transformation requires a reframing that includes marginalized communities and human habitats into mainstream notions of species and environments worth protecting. Specifically, environmental justice calls for the equal protection of humans of all races and classes, as well as the protection of human settings such as the inner-city and rural town.

I posit that environmentalism’s lack of inclusivity clouds the realities of the complex interactions of social and natural systems while it simultaneously marginalizes the experiences of groups and nations. These two acts prevent the scale of collaborative, human ingenuity needed to remedy global environmental issues. As a remedy, I call for increased sociological funding for research on the environmental justice movement as a means to illuminate overlooked and overexposed humans and human settings. It is my belief that research is a tool of inclusion and that environmental justice is a movement most deserving of our support. Further, the burgeoning field of environmental sociology is best positioned to remedy the social failings of environmentalism and must dedicate itself to this mitigative task. As social scholars we must not fall prey to the tragic reluctance¹⁷ inherent in exclusive constructions of environmentalism.

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Eugenics: how Francis Galton's life fostered the establishment of eugenics

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Introduction

The term *eugenics*, as coined by Francis Galton, "is the science which deals with all influences that improve the inborn qualities of a race; also with those that develop them to the utmost advantage".¹ In essence, Galton wanted to understand how human beings passed on and inherited genetic traits; specifically those traits relating to an individual's personality and intelligence. His main objective in seeking this understanding was so to identify, in his opinion what were, the desirable and undesirable genetic characteristics of human beings. Once he had identified what was desirable and what was undesirable, he could then try to eliminate the undesirable characteristics from the gene pool and reproduce more of the desirable ones. In order to achieve this, Galton proposed many plans that primarily sought to identify people who had desirable characteristics and compel them to have children while simultaneously identifying people who had undesirable characteristics and prohibit them from conceiving children. More elaborately, Galton wanted to bring humanity under a "social control that may improve or impair the racial qualities of future generations either physically or mentally".² It was this man that catalyzed the idea of eugenics, initiated the eugenics movement, and grew into something larger than just an idea.

The main purpose of this essay is to determine what factors in Francis Galton's life contributed to him founding and promoting the idea of eugenics. To achieve this, one must look in several different places. First, one must look broadly at Galton's life to see what factors in his upbringing and education contributed to the formation of his ideas. One must also investigate any written works such as his book, *Hereditary Genius*, and other publications to gain an insight into his thoughts. Investigating Galton's closest acquaintances: Karl Pearson and Charles Darwin provides another lens to analyze Galton's ideas. One should also discuss a motive. In this case the motive is simple: eugenics was Galton's attempt at modernity. Finally, one should look at any effects Galtonian eugenics had in other places in the world and on other individuals.

Child Prodigy to Traveling Bachelor

On every Monday closest to the full moon, an illustrious group of individuals consisting of scientists, engineers, philosophers, and industrialists would come together to share ideas and discuss new technologies. This group of intellectuals and elites was the epitome of an Enlightenment think-tank.³ It was through this group that Samuel Galton and Violetta Darwin first met. The two eventually married and had seven children. Their youngest child was born on February 16th, 1822 and they named him Francis.

It was clear from a young age, that Francis Galton was a bright boy with an, at times, almost self-destructive appetite for learning and reading. In his autobiography, Galton attributed his enthusiasm for learning to his family, "I acknowledge the debt to my progenitors of a considerable taste for science, for poetry, and for statistics".⁴ Since he was more intelligent than most children of his age he had a hard time socializing in school environments since no other five-year-

olds had ever read the *Iliad*.³ Throughout his childhood and young adult life, he attended many different schools and tried his hands at many different areas of study. His parents pushed him towards a career in medicine by setting him up with acquaintances to learn about the field of medicine at a young age.⁴ He first studied medicine at Birmingham General Hospital followed by Kings College.⁴ After a sabbatical from medicine to study mathematics at Cambridge, he continued his medical studies at St. George's Hospital until his father passed away in 1844.⁴ After his father's death, Galton received a large inheritance and described this as the moment that his life changed directions.⁴ At this time, Galton had become burnt out on his studies and with the inheritance money, spent most of the next few years traveling and exploring. On his travels he learned all he could about various subjects including geography, anthropology, and sociology; albeit rather informally. His travels took him all around Europe, the Middle East, and Africa. When his traveling days were over, Galton wrote a guide and survival skills book, *The Art of Travel*, for the traveling European Victorian in 1855; which still remains in print in the modern day.³ These days of travel contributed a significant amount of knowledge to Galton, especially on the subject of anthropology. On his travels, he came into contact with people ranging from academic scholars to tribal African subsistence farmers. It was during this time that he first began to notice and record the differences he saw in peoples' physical and mental attributes.

Revival of Quantitative Thinking

As Galton's bachelor days of traveling and exploring came to a close, his intrigue of theoretical science began. He had a unique approach to science in that he never read any other scientists' works or publications and approached a scientific conundrum in his own way. Since his ideas and methods were almost entirely original he stumbled upon things that other scientist never would have and had some successes. However, this also led to others viewing him as arrogant as he ignored some of the scientific rules of the time.³ It is during this time that Galton's passion for statistical calculations and quantitative measurement began to flourish. It appears in his publications, travel journals, and even his book *The Art of Travel*. An example of this can be found in one of his publications in 1858. While traveling in Northern Africa, Galton kept elaborate measurements and created detailed charts to track the amount of rations carried by man or beast, how meals were distributed within the group, and calculations trying to predict average distances traveled per ration.⁵

One of Galton's closest friends, Karl Pearson, contended that it was during his period of travel and exploration that Galton's love of science became rekindled while abroad and influenced him returning home to enter the world of formal education.⁶ Pearson also noted that Galton's obsession with statistics and quantitative measurement had increased while he was away.⁶ Being an incredible statistician, Galton was frustrated with the lack of quantitative methods used by anthropologists. Galton infused statistics into anthropology and his "methods gave [Anthropology] the status and dignity of a real science".⁶ The addition of quantitative methods helped to define the discipline of

Anthropometry, or, the study of physical characteristics of human beings to find variation. Galton's motives were two-fold. First, he wanted to study the physical characteristics of humans in a quantitative way that could be tracked over time. Secondly, he wanted to institute anthropometry back home in Britain. His over-arching goal was to detect if the British population's physique was deteriorating or improving. He addressed the latter by getting a number of British public schools to record the data of their students' age, height, and weight. This practice eventually spread to universities as well.⁶ Galton's focus on quantitative measurement and comparison between humans is one of the first areas where the beginnings of Galton's eugenic ideas are noticed. He wanted to be able to statistically point out physical differences within humans and also wanted to study the deterioration or advancement of the human physique, which is in many ways subjective. Galton also sought to influence the larger population through direct action. He wanted to be able to watch the youth of Britain so that if there were any, in his eyes, deteriorations in the physique, they could be addressed.

Publications of Note

During his travels, Galton spent a lot of time in existential thought about humanity, which he recorded in his travel journals. The information and knowledge he accumulated from his travels provided a basis for many of his writings. His journals contained reflections, copious amounts of notes, statistics, and anything he found interesting. A letter he wrote to the editor of *The Times* in 1873 showcases the accumulated knowledge from his journals. In this letter, Galton spoke of several different races and ethnicities and their "inferiorities" as he compared them to each other and the "Anglo-Saxon" race. He contended that Africans were mentally inferior, that the Chinese are living in a social dark age, and that Indians are inferior to the Chinese. His overall goal in this letter was to promote the idea that the Chinese should be moved to "the coasts of Eastern Africa if they were watched and judiciously diverted in that direction."⁷ In this one passage a few things are noticeable about Galton. First, we can see that he has interacted and is familiar with many different racial and ethnic groups, mostly from his travels. Secondly, Galton's ethnocentrism is rather blatant. Finally, we can see Galton publicly articulating a plan. Galton, as well as other intellectuals of the time, felt that Eastern Asia was becoming overpopulated. Galton came up with a plan to move the increasing populations of China to Eastern Africa and he implies that white Europeans should oversee the move. Although this article in *The Times* does not show Galton advocating for outright eugenics, it does give us an early example of his worldview that contributed to the development of his eugenic thoughts.

One of his first books, *Hereditary Genius: an Inquiry into its Laws and Consequences*, related to the subject of eugenics. The final edition of this book came out in 1892, and it was during this same time period that Galton started to become more outspoken about eugenics. In the preface of his book, Galton stated that during an ethnological inquiry he noticed that mental characteristics perpetuate themselves within families. The book then catalogues his study of four-hundred renowned men from several periods of history, their mental abilities, and their families. He identifies twelve categories of English men to study: Judges, Statesmen, Commanders, Literary Men, Men of Science, Poets, Musicians, Painters, Divines, Senior Classics of Cambridge, Oarsmen, and Wrestlers. In all, his book seeks to show how mental characteristics are passed down through generations to prove that genius is in fact hereditary. Looking at his own life, this must have made perfect sense to Galton. His siblings, parents, and grandparents were all exceptionally intelligent, so it

must have seemed only logical that intelligence was genetic just like height. The research he conducted and included in his book further solidified his view.

Galton's book, however, did not address any environmental factors such as the household one is raised in. Galton fails to notice that maybe his privileged upbringing around successful, intelligent individuals fostered similar traits in him rather than those traits being genetic. The book ended with the beginning of eugenics as Galton espoused the idea that humans possess the capability to control their own future through selective breeding.⁸ Pearson noted the same idea in his biography of Galton. He discusses how fascinated Galton became with the thought that humans had the capabilities and knowledge to improve themselves.⁹ This type of thinking is a major component of Galtonian eugenics. Galton's eugenic ideals built upon the thought that humanity can be improved through selective breeding. Galton just needed to determine what characteristics would be undesirable and how to go about excluding them from the gene pool.

The Plan for Eugenics

Galton's plan for eugenics was multifaceted. He initially wanted to establish eugenic laboratories. At these labs, humans would be studied on heredity, anthropometry, and health. Decisions about desirable and undesirable characteristics would be made as results were obtained. These findings were then to be published in journals and presented as lectures to the larger public to educate everyone on eugenics.⁹ Galton's rationale behind this was simple. He preached that we must have "the acquirement of eugenic knowledge before eugenic action." By this, Galton was trying to say that before anyone would want to promote, carry out, or go along with any eugenic plans, they first needed to be educated on the subject.⁹ He thought that the Eugenic Research Laboratories would provide the scientific backing for eugenics to become accepted as common knowledge. He also spoke about wanting to create a registry of families who have passed tests that certify their physical and mental prowess. This shows that Galton's main course of action in bringing eugenics to the world was through public education.⁹ He came up with a five-step procedure that he felt a society encouraging eugenics should enact:

- 1) Disseminate of a knowledge of the laws of heredity so far as they are surely known, and promotion of their further study.
- 2) Historical inquiry into the rates with which the various classes of society (classified according to civic usefulness) have contributed to the population at various times, in ancient and modern nations.
- 3) Systematic collection of facts showing the circumstances under which large and thriving families have most frequently originated.
- 4) Influences affecting marriage.
- 5) Persistence in setting forth the national importance of Eugenics.¹

This plan shows how Galton wanted to achieve his eugenic dreams. He wanted to put forth the idea of hereditary genius, classify people according to their social contributions, study and track large families in a catalog, understand and encourage specific marriages, and urge the national importance of eugenics. In this plan, Galton and his peers would have been the ones distributing information, collecting data, and carrying out research. This would have granted Galton and other eugenicists an enormous amount of power and control as they would have been determining how to measure and define civic efficiency as well as determine which families had the optimal genes to improve humanity. This plan encapsulates the essence of Galton's eugenic ideals. Galton even went so far as to ascertain that eugenics should "be introduced into the national conscience, like a new religion."⁹ However Galton's dream was never realized in Britain.

Pearson and Darwin

Galton had two notable close acquaintances who contributed to his views: his close friend and protégé, Karl Pearson, and his cousin, renowned naturalist, Charles Darwin. Pearson was Galton's closest friend over the course of his life. He was every bit as intelligent as Galton with a similar aptitude for statistics and a staunch supporter of Galton's Eugenics. He sums up his own take on Eugenics with this metaphor:

The garden of humanity is very full of weeds, nurture will never transform them into flowers; the eugenicist calls upon the rulers of mankind to see that there shall be space in the garden, freed of weeds, for individuals and races of finer growth to develop with the full bloom possible to their species.⁹

It is clear that Pearson agrees with and reaffirms Galton's idea of eugenics. Looking through their correspondences with each other it can be seen how close they were as friends, and how to implement their ideas through their discussions. Their correspondences provided a way for them to bounce ideas off of each other about eugenics and how to implement eugenics in the world. An idea that came across in one of Galton's letters to Pearson was a proposal for giving individuals a physical and mental test. This test would determine if they had the "desirable" genetic characteristics for reproduction. If they passed the test, they would be given a certificate stating they were "valid for hereditary transmission of qualities suitable to a citizen." Pearson responded to this idea by first confirming that it was a great idea. He pointed out some flaws, and then offered some ways by which they could improve upon it. Overall, Pearson fed off and reaffirmed many of Galton's views.⁹

Galton's relationship with Charles Darwin was different from that with Karl Pearson; whereas Pearson was Galton's close friend, student, and protégé, Darwin was his idol. Pearson described this relationship the best, "[Galton had] intense admiration for Darwin, which enforced and exaggerated respect for the authority of his judgment in individual instances."⁹ Galton describes the publication of the *Origin of Species* as a significant event in his intellectual development. Galton's thought about the book are important to note:

[I] devoured its contents and assimilated them as fast as they were devoured, a fact which perhaps may be ascribed to a hereditary bent of mind that both its illustrious author and myself have inherited from our common grandfather, Dr. Erasmus Darwin.⁴

Here, Galton attributes both his and Darwin's high intellect to their ancestors. This supports his belief in the notion of 'hereditary genius.' Galton states that *Origin of Species* is what prompted him to study the subject of heredity and attempt to discover if humans could in fact improve the race.⁴ Upon publication of *Hereditary Genius*, Darwin's high opinion and praise on the text was of upmost importance to Galton.⁴ Darwin did point out a few logistical flaws in Galton's plan and on the whole thought it would be difficult to implement. He pointed out that the plan would require an immense amount of work trying to decide who would be on the registry and he felt that too few people would even qualify to be on it in the first place.⁹ Galton was highly influenced by Darwin both on a personal and intellectual level. Darwin was even included in one of Galton's studies on hereditary intelligence.⁹ Their personal relationship helped build the respect they had for each other and this seeped over into their academic lives through letters to each other about their ideas. Galton was highly influenced by Darwin intellectually, and in many ways this influence helped pave the way for Galton's eugenics as Darwin's critiques only motivated him further.

Attempt at Modernity and Post-Galtonian Eugenics

Today eugenics is associated negatively with genocidal movements, such as the Holocaust (among many others), or as a consequence of totalitarian Communism, as exemplified in George Orwell's 1984. Galton however, saw eugenics as a path to modernity for Britain. Galton's outlook on the effect of eugenics was that it would have many positive impacts on British society, "The general tone of domestic, social and political life would be higher. The race as a whole would be less foolish, less frivolous, less excitable, and politically more provident than now."¹ Galton felt that eugenics could act as a centripetal force in society by combining the idea of 'the individual' with the idea of 'the nation' to bring society together. At the end of his biography, Galton best explains why eugenics would bring society into modernity:

This is precisely the aim of Eugenics. Its first object is to check the birth-rate of the Unfit, instead of allowing them to come into being, though doomed in large numbers to perish prematurely. The second object is the improvement of the race by furthering the productivity of the Fit by early marriages and healthful rearing of their children. Natural Selection rests upon excessive production and wholesale destruction; Eugenics on bringing no more individuals into the world than can be properly cared for, and those only of the best stock.⁴

In addition to this, Galton felt that any civilized nation would adopt the principles of eugenics and apply them to their society. It is clear that Galton felt the next logical step for a nation or society to enter into modernity is through the practice of eugenics.⁴

Francis Galton passed away on January 17th, 1911, but eugenics lived on. As his idea began to spread Galton remained the "patron saint of Eugenics".² This alludes to his vision that eugenics would evolve into something of a religion, so it would be only natural that he be its representative saint. Galton and his ideas impacted many people. The person whom he most influenced was Karl Pearson. Pearson began his career as Galton's Ph. D. student but, as shown earlier, became a successful scientist and scholar in his own right. Another person who Galton had a large impact upon was the American Charles Davenport. Davenport was a staunch supporter of eugenics in the U.S., although his views and methods varied somewhat from Galton's. His overall concern was with preventing the undesirables to enter the gene pool by doing things such as supporting selective immigration policies.² Galton, Pearson, and Davenport were the three most prolific figures from the early days of eugenics.

There were also countless groups and associations that were organized around eugenics. The Eugenics Laboratory and the Eugenics Education Society were two of the early places where eugenic research took place. One was founded by Galton and he ran the other.¹⁰ *The Eugenics Review*, an academic journal, began in 1909 and continued until 1968. The American Eugenics Society was founded twelve years after Galton's death in 1923. Even international groups like the International Federation of Eugenic Societies formed. Overall, we can see that Galton and his eugenic ideas had impacts far outside his own circle as groups formed within other nations and internationally as well.

The last impact that eugenics has had on the world are numerous social and political movements that have had negative outcomes. The Holocaust in Nazi Germany was an atrocity committed that was based on the same principles espoused by Galton. Adolf Hitler adopted eugenic policies to help prevent, what he perceived as, the degeneration of the German nation.¹¹ He and his advisors felt that many groups posed a threat to Germany's future and subsequently sought to purge them

from the gene pool. This resulted in the killing of over twelve million people, six million of whom were Jewish. Another example is the compulsory sterilization laws that were passed in the U.S. The first such law was passed in Indiana in 1907 which began “the involuntary sterilization of any habitual criminal, rapist, idiot, or imbecile committed to a state institution and diagnosed by a physician as ‘unimprovable.’”¹² Following this first law, other similar laws were passed around the country. These laws disproportionately impacted women, and in many cases, women of color. South Carolina demonstrated this in 1956 where all twenty-three forced sterilizations carried out were on African-American women.¹² Galton’s eugenic idea that humans can control and manipulate their gene pool laid the groundwork for these actions and other similar actions to be carried out.

Conclusion

Multiple factors and facets of Galton’s life helped to mold a conglomeration of his ideas into what he eventually called eugenics. Galton’s main theory, which was encapsulated in eugenics, was that intelligence and mental characteristics are hereditary. Galton felt he proved this theory through all of his research. But, what Galton leaves out of his theory are the environmental impacts on an individual’s mental and physical development. It seems almost ironic that we can gain such insight into understanding how Galton came to his conclusion about eugenics looking almost solely at the environments surrounding him throughout his life. While his intellect is what enabled him to achieve so much in his lifetime beyond founding eugenic thought, it was the environmental circumstances throughout his life that fostered that intellect. This conclusion is further supported by looking at how he was raised, who he was raised by, where he was able to travel as a young adult, and who he associated with throughout the

course of his life. Galton’s main course of action for promoting eugenics was through education. He published numerous books, wrote articles in newspapers and magazines, and gave lectures. Galton did this because he felt the key to eugenics becoming an accepted ideology lied within it becoming part of the social consciousness. Francis Galton’s life is an excellent example of how one person and their idea can evolve into something much larger than themselves.

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The “Conscientious Guinea Pigs”: How conscientious objectors contributed to medical science during World War II and beyond

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Introduction

World War II is often described as the “good” war – the United States’ least controversial participation in any war.¹ And yet, among the almost eleven million men who were drafted by the Selective Service System (SSS)² were about 12,000 conscientious objectors (COs) who refused any kind of military service, even as non-combatants, because of their religious, ethical, or moral beliefs. Instead, they spent the war years in Civilian Public Service (CPS) camps, where they performed “work of national importance,”³ working for the Civilian Conservation Corps,⁴ on dairy farms, in mental hospitals, on a variety of civilian projects, including as firefighters and smoke-jumpers, who parachuted in to combat forest fires.⁵ A small group of about 500 COs also volunteered for medical tests, which involved depriving them of proper nutrition, infecting them with exotic diseases, and exposing them to harsh environments.⁶ Although small in number, through their participation in the experiments, these “Con-

scientious Guinea Pigs”⁷ significantly contributed to modern scientific knowledge and medical progress. The experiments yielded many useful results, including a better understanding of the human body’s reaction to environmental factors; ground-breaking research of the physiological and psychological effects of malnutrition, which led to further study of the relation between nutrition and disease; the discovery of new treatment drugs for a variety of diseases, such as typhus, pneumonia, and malaria; and the development of new scientific investigative techniques and instruments.

In addition, by serving the war years in CPS camps and participating in dangerous medical experiments, the COs had refuted many of their initial critics’ assertions that they may be, in Truman’s words, “plain cowards and shirkers.”⁸ Toward the end of the war, when the government released information about the medical experiments, the news media extensively covered the story, portraying the COs as brave men who were committed to both their country and mankind. After the war,

public opinion towards COs had changed considerably, with a majority now seeing COs in a positive light.⁹ In fact, one may say that the COs had made a convincing case for a democratic state allowing its citizens to follow their conscience and refuse to fight in wars. In 1948, the United Nations General Assembly included the “right to conscience” in the Universal Declaration of Human Rights and later explicitly affirmed the right to conscientious objection.¹⁰ Subsequently, laws in the United States expanded the right of COs, allowing a claim not only on religious beliefs but also on moral or ethical convictions.¹¹

Background: The Civilian Public Service

In World War I, the U.S. government had not provided any alternative service for men who refused military service because of their religious beliefs. Instead, all COs had to join the military as non-combatants, performing medical work on battlefields or menial labor around encampments. While 4,000 draftees took these jobs, about 450 men, mainly members of the Historic Peace Churches - Mennonites, Brethren, and Quakers - refused to aid the military in any way. As a result, they were court-martialed according to the 64th Article of War, which stated, “Any person subject to military law who ... willfully disobeys any lawful command of his superior officer, shall suffer death or such other punishment as a court-martial may direct.”¹² For example, Ulysses DeRosa, was sentenced to life in prison for “refusing to shovel refuse at Ft. Riley”¹³ while others received sentences that ranged from death, later commuted to life in prison, to imprisonment that averaged 16½ years.¹⁴

After the harsh treatment of the COs during World War I, which many had considered “unworthy of a democratic nation,”¹⁵ the Peace Churches realized that they needed to find a solution in case of future wars. When events in Europe and Asia raised the possibility of another war, they met in Newton, Kansas, in 1935 to discuss alternatives to compulsory military service for COs who refused even non-combatant service. Their goal was to establish a program like the American Friends Service Committee (AFSC), that is, the Quaker, work camps that was administered by civilians. After World War II broke out in 1939, they met with President Roosevelt in January of 1940 to discuss a civilian public service program that “would provide constructive services to the country and the world.”¹⁶ However, public opinion did not support such alternative programs to military service. A Gallup Poll in January of 1940 found that only 13.2% of those polled said COs should be exempted from military service in case of war.¹⁷

Still, there was the sentiment that while “there is obviously no place [with] a nation at war] for the malingerer, for the man whose pacifism is simply a cloak for cowardice, for the traitor,” a “free country” must not violate the individual’s religious rights, embodied in the Constitution, by forcing him to fight in a war against his conscience.¹⁸ Just before the Draft Bill was passed in the fall of 1940, an editorial in the *Washington Post* supported alternative service, stating, that “no liberal government desires to impair or destroy the liberty of conscience of the individual by commanding him to perform acts that do violence to his innermost convictions of what is right.” There were also more pragmatic reasons, mainly that forcing COs into the military would be counter-productive and create martyrs. The editorial thus concluded that “the United States stands to gain a great deal more than it can possibly lose by refusing to apply coercion of any kind to the few” whose pacifist beliefs take precedence over the citizen’s duty to fight for his country.¹⁹

When Congress passed the Selective Training and Service Act on September 15, 1940, instituting the first peace-time draft in U.S. history, a provision for conscientious objectors was included. Section 5g specifically not only allowed exemption from combatant but also from non-combatant military service based on religious belief:

“Any such person claiming such exemption ... be assigned to non-combatant service ... or ... if he is found to be conscientiously opposed to participation in such noncombatant service, in lieu of such induction, be assigned to work of national importance under civilian direction.”²⁰

While the Act opened the door for an alternative service program administered by civilians, it did not address important issues such as pay, insurance, provision for dependents, program implementation, or, most importantly, what constituted “work of national importance.” Moreover, when Clarence Dijkstra, Director of the Selective Service System, told President Roosevelt of his plans for CO work camps, the President “expressed ... aggressive opposition” and replied that COs would not go “into [CCC] camps because it would make it too easy for them, and he proposed to see that they had an Army officer to drill them.”²¹

However, once the president heard that the Peace Churches would pay for the camps and the public would approve, he relented. In February 1941, the Civilian Public Service (CPS) was formally created when President Roosevelt signed Executive Order 8675 to “establish or designate work of national importance under civilian direction for persons conscientiously opposed to combatant and non-combatant service in the land or naval forces of the United States.”²² The National Service Board for Religious Objectors (NSBRO), which consisted of representatives from the Peace Churches as well as over two hundred other religious denominations,²³ would run the CPS, select camp sites, match COs with the camps, and work with those men who were denied CO status by the draft boards or who refused any alternative service and rather went to prison. For example, 5,000 COs went to prison, including penicillin researcher Donald Charles DeVault who refused to do the work assigned to him in a CO camp.²⁴

On May 15, 1941, less than six months after the first draftees reported for military training,²⁵ the first group of COs also reported to CPS duty at Camp Patapsco, Maryland.²⁶ Within a short time, over 150 camps were set up across the United States, where COs worked 9-hour days without pay for up to six years until 1947, when the last COs were released.²⁷

“Work of National Importance:” The Medical Experiments

It soon turned out that “work of national importance” meant that the men reported to camps under the direction of the U.S. Forest Service, the National Park Service, or the Soil Conservation Service, where they performed primarily menial labor, digging ditches and clearing brush despite many of them being highly educated. Many CPS men grew frustrated because they wanted to do important work and not “plant[ing] trees while the world’s on fire.”²⁸ Samuel Legg, a CO, explained, “We were full of idealism ... Everyone else around us is pulling down the world; we want[ed] to build it up.”²⁹

Moreover, there also was the perception that COs were cowards, who stayed safely in the United States while other young men fought overseas. *The Lincoln County Times* in Oregon expressed the opinion of many locals when it opined, “Why are these conscientious objectors allowed to go out, drink, and publicly flout [sic] their draft status in front of hundred of people who have dear ones in the Uniform of These United States?”³⁰ As a result, in the early years of the CPS, COs

frequently faced open hostility. Shop owners refused to serve them; for example, a store in New Hampshire displayed a sign that read, "No Skunks Allowed! So you conscientious objectors keep to H... out of this Shop!"³¹ Also, the family's of COs, who received no payment while their husbands and fathers were in CPS camps, faced scorn and hatred. Louise Brown, whose husband was in San Dimas CPS camp in Southern California, recounted: "When I looked for jobs they'd ask what my husband did and I'd say he was a CO. I was literally cursed and kicked out the door."³²

COs wanted to prove their usefulness and courage to establish that their refusal to fight with weapons was not cowardice. CO Luke Birky, a smokejumper, explained: "Many of us had been labeled as 'yellow bellies,' cowards, for not wanting to go into the war, ... for some of us at least, there was a secondary motivation ... to try to do tasks that might even be dangerous to show that we had courage also."³³ Therefore, the NSBRO actively lobbied for the work of national importance that had been promised by law.³⁴ As a result of these efforts, several thousand men were assigned to more meaningful work: They fought forest fires, taught at schools for the disabled, or worked in mental hospitals. For example, in June 1942, the first COs arrived at Eastern State Mental Hospital in Williamsburg, VA. One year later, over 2,000 COs worked in mental institutions or training schools for the disabled.³⁵

Another option for COs to prove their usefulness to society was to participate as human subjects in medical experiments. In the summer of 1941, President Roosevelt had signed Executive Order 8807, establishing the Office of Scientific Research and Development (OSRD) to do "research on scientific and medical problems relating to the national defense,"³⁶ which included a committee that coordinated medical research that was conducted by private and governmental research institutions. Many of the research projects required human subjects, and over the next 4 years, about 500 COs volunteered in 41 medical experiments where they contributed more than 150,000 work days.³⁷

To ensure that the medical studies were not used for purely military purposes but that their "destructive aspects are outweighed by their long-run humanitarian significance,"³⁸ researchers sent their project descriptions to the NSBRO, who evaluated them, informed the COs about the nature of the project, and recruited the participants. Hundreds of COs applied to participate because they were desperate to escape the boredom of the camps and prove their worth to the United States and their fellow men. For example, Henry Perry, director of CPS Camp Petersham, urged David Swift, from AFSC, to select one specific CO for an experiment, because "Ralph wants desperately to participate, ... he has seriously spoken of walking out of camp and going to jail [unless he is selected]."³⁹ Rather than taking lives in the war, the COs saw their contribution to science as a way to "help save millions of lives."⁴⁰ Because many experiments were dangerous, a second reason was to prove one's courage, as stated by Neil Hartman, "I was young and I wanted to show that I was not a coward, so when they offered me this chance of being a guinea pig, it fit right in with my scheme of things of proving that I was willing to take risks on my own body, but I just did not want to kill someone else."⁴¹

The medical studies fell into three main categories: (1) the effects of extreme environmental conditions, (2) nutrition, and (3) diseases. They included experiments on fatigue, aviator's "blackout," frostbites, survival on lifeboats, compression, and lice prevention; the effects of different diets under various conditions, such as al-

titude, heat, cold, bed rest; and, finally, finding treatments for diseases, such as infectious hepatitis, atypical pneumonia, jaundice, malaria, and typhus.⁴²

Environmental Studies: The Life Raft Experiments

Some of the first guinea pig experiments, which started as early as September 1942, studied the effects of exposure to adverse environments at sea. While their original purpose was to help ship-wrecked crews or downed aviators, it soon became apparent that the study had much larger implications. Researchers conducted several experiments, including how men could cope with low calorie diets, the minimum amount of water necessary to avoid dehydration, the effect of sea water on the human body, and how best to prevent bodily water loss in various environments. During these experiments, the men endured constant deprivation: the lack of water or food, while being drenched in sea water in a life raft in Boston Harbor for 8-9 hours a day, nausea and vomiting from drinking sea water, and chills and heat exhaustion.

The research clearly demonstrated that the old emergency rations were insufficient and had to be augmented. As one CO wrote to a journalist for *Reader's Digest*, "one of our men followed the official navy ration with 400cc of fresh water per day for eight days. He ended up in the Emergency ward with a temperature of 101."⁴³ Other experimental results determined the safe amount of sea water consumption, which until then researchers had thought to be fatal, and the prevention of water loss by cooling off, all of which the Navy implemented immediately.⁴⁴ According to a June 1943 *Washington Post* article, with the title "Death is Losing One of Today's Great Battles," the research not only led to better life raft rations, but also to a booklet which was included in the emergency kit, "printed on waterproof paper and ... resistant covers" with detailed information for ship-wrecked mariners on how to behave, thus improving their chances for survival.⁴⁵ Ironically, it was more than one year later, in July 1944, that the public learned for the very first time that it was COs who had been the medical subjects in these widely publicized experiments that were "designed to save lives among the fighting forces."⁴⁶

Nutrition Experiments: The Minnesota Starvation Project

Perhaps one of the most important experiments was the Minnesota Starvation Project. Towards the end of the war, it became obvious that it would be a huge challenge to feed the millions of semi-starved people in Europe and Asia. The agriculture was devastated in those countries, and physicians and public health officials acknowledged "the deficiency in their data and their interpretation as applied to populations"⁴⁷ when it came to feeding malnourished people efficiently. In May of 1944, Dr. Elmer Sevringhaus, a researcher at the University of Wisconsin, wrote a letter to the Brethren Service Committee, stating that controlled experiments were absolutely necessary to "plan for the most economical use of the limited food materials for the population of the world." The letter, in which he urged COs to sign up for a study, was included in a recruiting brochure⁴⁸ for what was later known as the *Minnesota Starvation Experiment*. The NSBRO approved the project and pre-selected 100 CPS men from the 400 applicants. The scientists then selected 45 COs for the experiment, stressing that the experiment would involve extreme physical duress to ensure that the COs were committed to the experiment and would not cheat or drop out.

The experiment, which started in November 1944, was a one-year controlled study conducted by Dr. Ancel Keys, a professor of physiological hygiene at the University of Minnesota's School of Public Health who had previously developed the *K ration*, a food ration for parachute troop-



Photo 1. Front and back cover page of a recruiting brochure for the Minnesota starvation experiment. Blair, J. ed. *Will You Starve That They Be Better Fed?* Brochure (1944). Swarthmore Peace Collection, DG002, Series 5, Box 15.

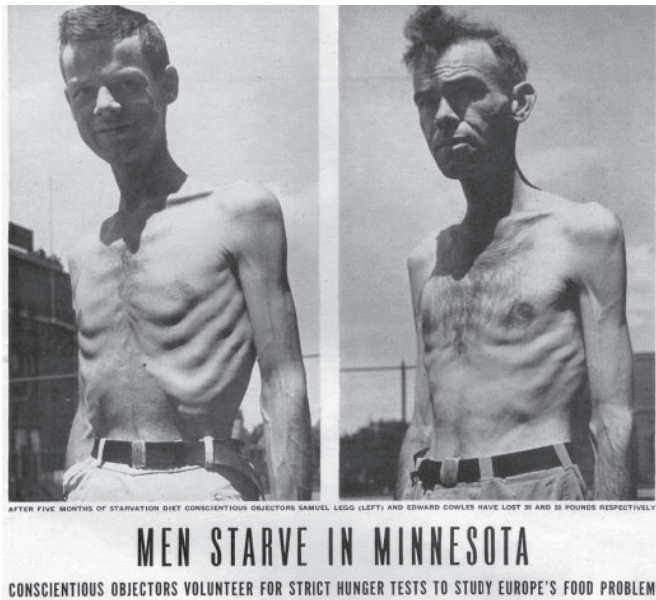


Photo 2. "After five months of starvation diet conscientious objectors Samuel Legg (left) and Edward Cowles have lost 35 and 30 pounds respectively." *Life* reporting on COs participating in Minnesota starvation experiment. 30 July, 1945. Volume 19, no. 5, p. 43.

ers. Keys' goals were first, to find out how starvation affected civilians physiologically and psychologically, and second, how to best re-feed them. To answer these questions, he proposed to simulate these conditions with healthy CO volunteers. The experiment, which ultimately involved 36 volunteers, consisted of three phases: The first phase lasted for three months, during which the volunteers received about 3,000 calories of food per day to establish a baseline. Over the next six months, they then were fed a diet of "food most commonly available under European famine conditions, ... bread, potatoes, turnips and macaroni of approximately 1,500 calories per day, calculated to result in a loss of 20 to 30% of the original body weight." This was followed by a "rehabilitation diet" for three months to find foods which could help them recover quickly. Throughout the experiment, the men had to perform physical activity that equaled an energy expenditure of about 3,000 calories per day. The researchers carefully monitored and measured the physical and psychological effects and collected enormous amounts of data.⁵⁰

The project had an almost immediate impact. In July 1945, while the experiment was still under way, several newspapers, including *Time* and *Life* reported very positively about the COs' hardship during the experiment and their desire to save lives. *Life* showed shocking photos of the emaciated men, headlined "Men Starve in Minnesota."⁵¹ Suddenly, millions of people learned about the starvation experiment and the COs' contributions. As one CO recounted, "there was a long period when nobody gave any attention to it because they didn't even know the experiment was going on. But somewhere it broke ... [and] we were besieged by the ... press."⁵²

The research demonstrated that the recovery of starving people was

“much slower, more laborious and complex than anticipated,” and that starvation had a profound impact on the psychological and social behavior.⁵³ Although the full results were not published until 1950,⁵⁴ relief workers immediately used the preliminary results to re-feed the starved people worldwide. This included the Government and Relief in Occupied Areas (GARIOA) program, which was approved by Congress in 1946 and consisted primarily of food aid to prevent “disease and unrest” in occupied Germany.⁵⁵ The shocking finding of the Minnesota experiment that showed that a starved person “ceases to be a social creature” and is driven only by the “brute desire for self-preservation, rather than any consideration for others,”⁵⁶ also inspired the Marshall Plan. This corner stone of U.S. foreign policy aimed at rebuilding Western Europe to establish democracies and to prevent Communist influence.⁵⁷ The COs were proud of their contribution because as Max Kampelman stated, “it was satisfying to us, the participants, to know that the results were used to help concentration camp victims, prisoners of war, and refugees.”⁵⁸

In the longer term, the starvation experiment led to a better understanding of the relation between nutrition and disease. By analyzing the Minnesota data and comparing the heart death rates in the U.S. with those in food-deprived Europe, Keys realized that diet greatly affected basic body functions, such as blood pressure, cholesterol level, and resting heart rate, all of which had been regarded as fixed until then. He confirmed his theory in his famous *Seven Country Study*, proving that the intake of saturated fat is the main environmental factor for coronary heart disease and establishing the benefits of the Mediterranean diet.⁵⁹ Keys, also dubbed “Mr Cholesterol” for demonstrating this connection between a fatty diet and heart disease, gained fame as the bestselling author of *Eat Well and Stay Well* and graced the cover of *Time* in 1961.^{60,61} In addition, Keys’ results of the behavioral and psychological effects of starvation are still being cited in research on eating disorders, such as bulimia and anorexia, metabolic adaptation, and in studies on weight loss because of illness and injuries.⁶²

Dangerous Diseases: The Malaria Experiment

Some of the most dangerous experiments that COs participated in were the disease experiments, particularly the malaria experiments. In a recruitment brochure for medical volunteers that was posted on the bulletin board at Camp Big Flats, researchers stated that “malaria is considered the outstanding medical problem of the world,” which annually killed between three and six million people.⁶³ Though atabrine was an extremely effective drug for treating both malaria and its symptoms, it did not actually cure malaria. Many of the troops in the South Pacific war theater were infected, and researchers calculated that the relapses that would occur once they stopped taking atabrine would cost the United States 25,000,000 man-days spent in the hospital every year.⁶⁴

Therefore, the malaria experiments, which were conducted at various research hospitals, were designed to find a drug that would actually cure the disease. They involved infecting men with malaria to study the effectiveness of a variety of potential drugs. Some of the experiments involved extremely high doses of drugs that were known to be toxic, or that had only been tested on animals but not on humans, and the researchers told the COs that it was “impossible to rule out the possibility of a fatality.”⁶⁵

One of the 30 men participating in a two month-experiment at Goldwater Hospital, New York, described how all volunteers fell ill two weeks after allowing infected mosquitoes to bite them. The men endured sickness and fever for four days before researchers finally administered the drugs. The drug trials left them frail and weak as

they went home for a week of sick leave, during which they had to send tiny blood samples to the hospital. Because the risk of relapse was high, each man carried a sealed envelope containing atabrine pills and a letter by the hospital with instructions to seek immediate medical assistance if necessary.⁶⁶

The results gathered from the malaria experiments proved impeccable. The first anti-malaria experiment led to subsequent studies, which in turn led to even better treatments. The study’s three scientists, Drs. Shannon, Brodie, and Udenfried, published over a dozen papers on malaria in the next few years and ultimately developed Chloroquine, “the drug of choice to treat malaria for several subsequent decades.”⁶⁷

Perhaps more importantly, during their experiments the researchers also developed a new instrument, a spectrophotofluorometer (SPF), which measured how much of the drug was in the subject’s blood. This instrument, and the principles of fluorescence on which it was based, was later used in a wide range of important scientific experiments. For example, Julius Axelrod, who won the 1970 Nobel Prize for medicine for his work on neurotransmitters, concluded that “the SPF . . . changed the direction of the whole field of neurobiology.”⁶⁸ After the war, the malaria scientists continued their work at the National Institutes of Health, where Bernard Brodie was the head of the Laboratory for Chemical Pharmacology and John Shannon the first director of the newly established Heart Institute and later director of NIH. They assembled an eminent group of scientists with several future Nobel Prize winners among them, published hundreds of scientific papers, and received numerous accolades, including election to the National Academy of Science, one of the highest honors for U.S. scientist. In 1967, Brodie received the Lasker Award, which is often called the U.S. Nobel Prize, “for his extraordinary contributions to biochemical pharmacology.”⁶⁹

Impact and Conclusions

The COs had volunteered as medical guinea pigs because they wanted to help mankind by contributing to medical and scientific knowledge and also to prove that it was not cowardice when they refused to serve in the military. Throughout their participation during the experiments, they impressed the researchers with their dedication and commitment. For example, Allan Butler, MD, who directed the sea water experiment, wrote to the AFSC that the COs were “very intelligent and cooperative [and] permitted us to acquire considerable amount of very accurate information.”⁷⁰ Moreover, the COs and the churches they represented realized that through their work they were winning over the public, which initially had rejected the COs’ motives. In a 1943 report to AFSC about his visit inspecting Massachusetts General Hospital, J. Huston Westover concluded, that Milton Gold, one of the COs had garnered immense respect among everybody at the hospital and “made major contribution to the general public relations while located at the hospital.”⁷¹ Another CO, who participated in the atypical pneumonia experiment in Pinehurst, North Carolina, wrote in July 1944 in a letter to the *Washington Post* how the townspeople had “been impressed by the risk we’re taking . . . and have taken us to their collective bosom, . . . sending cigarettes, ice cream and flowers.”⁷²

Indeed, over the course of the war, the public’s attitude toward COs changed dramatically. In a 1940 Gallup poll, the public had vehemently disagreed with any kind of alternative service for COs.⁷³ In the early war years, COs were frequently mistreated and immensely disliked. For example, a CO recounted how the locals had rather a fire destroy their town than call the CO firefighters from the nearby camp: “We woke up one morning to find out Plymouth had burned down and

they never called the men from the camp... They were willing to let $\frac{1}{3}$ of their town burn down rather than let those damn COs come out.⁷⁴ The media had reported about COs and discussed their right to refuse military service, especially in the time before the Draft Bill was ratified in 1940. However, it wasn't until July 1944 that the government disclosed that COs had participated in medical experiments, such as the life raft studies, even though the results had been widely reported in the press in 1943. The underlying reasoning was probably best expressed by General Hershey, director of Selective Services, when he testified before Congress, stating that "the conscientious objector, by my theory, is best handled if no one hears of him,"⁷⁵ presumably to prevent any negative impact on wartime morale.

In June 1944, the media started reporting positively and more specifically about COs and their service. For example, the *Sioux Tribune* stated that COs should "get credit in the public thinking for what they are doing for the country and its citizen"⁷⁶ while the *Washington Post* editorialized that COs were doing dangerous and difficult work for the nation, and therefore should not be harassed or "accused of dodging the hazards of war."⁷⁷ Only a year later, in 1945, public opinion had changed dramatically, too. *Time* reported that the state of California had introduced legislation to bar COs from jobs as state employees but that the public disagreed with this view of criminalizing COs. According to a Gallup poll, 75% of the public thought that COs deserved better treatment and should receive fair pay for their services.⁷⁸ Moreover, a large majority did not reject COs, and "would accept them during this war as friends, or closer."⁷⁹ Even the government praised COs who had participated in atypical pneumonia studies, calling "their willingness to serve as volunteers ... a courageous act of the very highest order."⁸⁰ While one may speculate that the Allies' victory created a more accepting climate for COs, by 1945, a large part of the population accepted conscientious objection to military service on the basis of religious or ethical beliefs and viewed the COs no longer as cowards or traitors. When the AFSC shared the 1947 Nobel Peace Prize with the British Society of Friends for their humanitarian work, the *Washington Post* stated that while often persecuted, the Friends "now are held in high regard throughout the world."⁸¹

Finally, in 1950, the Selective Service concluded that the CPS was an example of American democracy "in a period of concentration camps, slave labor, and other features of totalitarianism elsewhere."⁸² While this assessment must be seen within the context of the beginning of the Cold War, thus contrasting the free West with the totalitarian East, the government considered the CPS system overall a positive experiment, which contributed to "liberalizing the conscription practices of the US government."⁸³ Subsequent legislation conferred CO status not only based on religious but also on moral and ethical beliefs, firmly established classifications of non-combatant military service and civilian work assignment,⁸⁴ and put COs on more equal footing with those serving in the military. Thus, from 1951-1973, when the United States converted to an all-volunteer military, COs did not work in camps but were assigned to individual employers to perform "civilian work contributing to the maintenance of the national health, safety, or interest" for a period as long as those inducted in the armed forces, usually 24 months. This provision is still in effect, should a draft ever be instituted.⁸⁵ Thus, the CPS camp system, which had started as an "important exercise" that "may have great future significance in connection with fulfilling an obligation for duty within the limits of faith,"⁸⁶ was never repeated. And yet, the COs had left their mark, not only contributing to far-reaching medical discoveries but also working

as draft counselors during the Vietnam war, when COs outnumbered those inducted into the military (33,041 to 25,273 in 1971), taking over leadership roles in their churches, and engaging in migrant programs, the civil rights movement, and national and international peace movements for decades to come.^{87,88} In the end, they proved what a soldier at Fort Bragg said about COs: "After all, a fellow doesn't have to carry a gun to be brave."⁸⁹

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Psychobabble

BY KEVIN JENSEN
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Author's Note: A critique of - and contribution to - modern poetry, seeking to explore the arbitrary function of language by creating meaning through non-vernacular. The poem should be read aloud.

Rather will be I wood could yew?
Ramble think you what I will do
Scuttle buttle bowels divest
Con four mitty I know thee best
Re—ding other's squaking burbles
I contribute my own gurgles
Tren dee, mod urn, trick the rabble
Ha low empty (sigh) co-babble
Pro toe—typical—noncon form missed
Come and witness my poor form ense
Lather up this you sless blather
Put amongs tits brethren slather
There's no requite for this damn age
Instead of form we cramram page
Trumble-on! I'll do my part
A piece of shit or work of art?

Coping with Autism

BY JASMINE RAINEY
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ABC's and numbers decorate the walls of a classroom. Like any other kindergarten class, the teacher instructs the students on their colors, numbers and alphabet. Most students would rather play with toys than complete their work. One student practices writing her name while another one transforms his toy robots into cars as a reward for completing his work.

However, the students in this class have been learning their colors, numbers and letters for five months, and some have still failed to master them. The teacher leads the girl's hand in writing her name, which they've practiced over the last three months. The boy playing with robots can finally count from one to five after weeks of going over the numbers; for him this is a major achievement. If all of the children can recite the letters of the alphabet by the end of the school year, it will be a great accomplishment for these students - these autistic students.

Autism is a pervasive developmental disorder that affects one in every 150 American children and four times as many boys than girls, according to the Autism Society of America website. Autism is an umbrella term that may involve social, behavioral, communication and/or cognitive problems.

Jeanne Ellis Ormrod's "Educational Psychology: Developing Learners," fifth edition, defines autisms as being characterized by "impaired social interaction and communication, repetitive behaviors, restricted interests and a strong need for a predictable environment" as well as "an underlying condition that maybe an undersensitivity or an oversensitivity to sensory stimulation."

In addition to autism, the autism spectrum disorder includes Asperger's syndrome, marked by deficiencies in social interaction, preference for sameness of environment and difficulties with transition, but unlike autism a person still has regular linguistic and cognitive development; and pervasive developmental disorder-not otherwise specified, PDD-NOS—have some characteristics of autism but aren't easily defined as being autistic, according to ASA.

In 1911, the term "autism" was first coined

by Swiss psychologist Eugen Bleuler, but the term applied to patients with schizophrenia. In the 1940s, Dr. Leo Kanner described autism for the first time based on a study of 11 children who had withdrawn from human contact. Researchers in the 1960s found identifiable characteristics of autism and treatments.

Autism cannot be cured and the causes are still largely unknown although researchers believe it's caused by abnormalities in the brain.

"Autism is such an unusual thing because the spectrum is so wide," Dorothy Galvin, a special education kindergarten teacher in Denver, said. Galvin said there's "not a one size fits all" technique for autistic children.

Even if five autistic students have behavioral problems, the learning techniques and coping strategies used would be different for each student. Like people without autism, autistic people illustrate that each individual is unique.

Sarah Hyman, a senior psychology major at Colorado State University and a regular volunteer in special education classrooms, said, that of all of the autistic children she's worked with, no two have been completely similar in their behavior, learning and coping styles.

The needs and routine that most autistic students demand can be very taxing on the parents and teachers of such children. Yet, parents and teachers interact to give autistic children the fullest lives possible and teach them strategies that may help them cope with their individual challenges.

In this article, coping strategies are skills that allow autistic students to better manage situations that they find stressful and techniques teachers provide parents with to help them to manage their child's autism more effectively. Coping strategies may also include strategies that parents have found effective based on their own experimentation.

Each expert source interviewed said that autism is so diverse that efficient and effective coping strategies usually vary on a case-by-case basis. Yet, one strategy is shared among special education teachers: routine and repetition.

"Autistic children like their routines," Galvin said. "They want structure and consistency."

Galvin said she was absent from class one day and it disconcerted her students. They didn't know the new substitute teacher and couldn't necessarily cope with the unfamiliar situation, she said. The paraprofessionals alleviated some of the children's distress, but Galvin can't necessarily prepare the students for when she's absent, she said.

Despite her students' need for routine, Galvin tries to slowly change their daily schedule.

"We might do calendar, shapes, numbers and letters," Galvin said. "We'll start in this sequence for a while, then switch the sequence. We'll switch up the days we do certain things."

Galvin does this in an attempt to eliminate the "rigidity" that her students possess because "life isn't full of schedules," she said.

She works in a coordinated effort with the parents of her students to loosen their need for routine.

"It'd be a blessing for the parents (if the rigidity were lost)," Galvin said. "(The parents) try to mix things up at home. It's a team effort."

Galvin also uses overlearning or repetition to teach her students. She said that they'll sing a song about colors three times each day.

"I didn't do that for a week, and one student forgot all his colors," she said. "After a while it gets kind of monotonous and I don't like it when I start dreaming about the songs (due to the repetition), but I like seeing them grow in their academics. Repetition is very important for that."

Positive reinforcement is also used to make sure a behavior continues. Galvin uses a chart to motivate her students to learn.

Each chart has four stars attached to it and the words "I'm working for _____." The children have personal charts and a picture of what they want to play with is placed in the blank. The stars represent assignments that must be completed before they can have free-time. Once all four stars are removed, the students can play for a few minutes with whatever they were working for.

"One boy is motivated to play with robots," she said. "So he'll get his work done to play with them."

Stars are removed from the chart instead of added because it's often difficult for autistic students to comprehend abstract concepts. For example, Galvin's students would have a difficult time imagining four stars that they need to obtain on an empty chart. By removing stars, they can concretely "see" that they have two stars left that must be removed, Galvin said.

Galvin's methods have helped her students improve.

"A couple of parents were in tears and said they can't believe how much (their children) are learning and speaking," she said. "One of the rewards you have as a teacher is knowing you helped improve a child somehow."

Working as a Denver Public Schools special education paraprofessional for three years, Geneva Lawrence said that the special education classes she has worked in taught students different skills that emphasized independence.

At one school, Lawrence said there were different centers and each paraprofessional and teacher would teach a different subject for 15-25 minutes with the autistic students. The "Self-Help Centers" taught the students how to dress themselves, about hygiene and how to brush their teeth, helping them to be self-sufficient to a certain extent. Other centers focused on working independently, math, reading and writing skills.

Every Friday the children went on an excursion that allowed them to practice "how to behave in social situations," Lawrence said.

"Fifty percent of the students had a lot of behavior problems and didn't know how to react in certain situations," she said.

Some students would throw food at people when they went to restaurants, Lawrence said. "We'd make them clean up the food instead of the waiters, and that showed them that it's not OK (to throw food), and they'd have to take responsibility for their behavior. We'd show them the appropriate behavior and they learned through repetition. We'd keep taking them to restaurants so they'd learn," she said.

Lawrence also said the parents of the students said the trips to restaurants, zoos and other places helped them have an easier time when taking their children out.

When some students seemed frustrated, Lawrence would tell them to try the "blow out the candle" technique of taking in a deep breath and letting it out or "smell the flower," pretending to inhale a scented flower.

"I didn't think it would work, but it really calms them down," she said of the relaxation techniques.

Other students have specific items that calm them, she said. Or Lawrence would have the students look in her eyes. "They

don't like to look at you directly in your eyes," she said. The lack of eye contact is a characteristic of many autistic students' weakened social development. Often times, Lawrence makes the students look her in the eyes and the autistic students will begin to focus only on her eyes, which ultimately calms them down since they're concentrating.

Other coping strategies included touching their hands, heads, using a trampoline or anything that applies pressure to the child. Pressure can be soothing to autistic children who are oversensitive to sensory stimulation, particularly touch.

Although Lawrence has been bit, hit, kicked, scratched, spat on and had her hair pulled on by autistic students, she said she won't be deterred.

"I'm really not afraid of them," Lawrence said. "How they act is just a way to communicate - a way to let people know there are things they don't like."

For Lawrence, any abuse she may endure is worth it when her students learn.

"When they have a breakthrough while teaching them a single letter, it's like...wow, even though it took three months to learn it," Lawrence said, laughing. "It's just the thrill of seeing their faces light up like 'Oh, I got it!'"

Item number one in Ellen Notbohm's book "Ten Things Your Student with Autism Wishes You Knew" is that "behavior is communication." Notbohm writes (in the voice of an autistic student) "All behavior occurs for a reason. It tells you, even when my words can't, how I perceive what is happening around me. Negative behavior interferes with my learning process. But merely interrupting these behaviors is not enough; teach me to exchange these behaviors with proper alternatives so that real learning can flow."

Lawrence said that her students are all really good, and she tries to observe them first as much as she can. If they're interested in something, then she tries to incorporate it into what's she's teaching them.

The coping strategies that Dave Miles, a special education teacher and part-time interventionist for DPS, uses depend on what student he's dealing with.

One 12-year-old boy was extremely angry and also had temper problems, Miles said, and he didn't know what all the triggers for the boy were. For that student, Miles said he had to earn the student's respect, which was difficult because in most classrooms the students automatically give the teacher respect.

As time went on, Miles learned that if the 12-year-old was having a difficult time with his work or spending too much time on a task, he would start to lose control. Miles learned that for autistic students who have trouble focusing, shortening the time spent on a task helps them learn more efficiently.

For the 12-year-old student, Miles gave him time updates.

"I'd say 'you have 30 minutes' to keep him aware that it's going to be coming to an end," he said. "If he was struggling, I'd let him know it was coming to an end."

Miles also developed a timeout card for the boy to use when he couldn't deal with his surroundings.

Wherever they were, Miles and the boy would establish a "safe spot," a place where the student could retreat when he was losing control. The boy also had a folder and would slip his timeout card into his folder to let Miles know where he would be.

The timeout card proved useful for the boy's parents.

The student's parents could now take him to more places and not worry about him running off to some unfamiliar, unsafe place. "Sometimes he would just run away, and he wouldn't even know where he was going," Miles said. Now, the boy and his parents could establish a safe spot at a restaurant, the zoo or wherever. He could put his time-out card in his folder,—left where his parents could find it—run to his safe spot if he became frustrated, and his parents would know where to find him.

Miles said it felt good to provide the family with a coping strategy that relieved some of their stress and worry, "but some of the things you (teach) don't always last," he said.

He stresses consistency in whatever he teaches as well as constant tweaking of his methods. If there's no consistency then the skills fade quickly, he said.

Whatever he does, Miles attempts to help his autistic students lead as close to "normal" lives as possible.

Growing up with dyslexia with his twin brother, Miles learned early on the challenges that having a disability could bring, but he also learned that having a disability didn't mean he had no future.

"Just because they're special education doesn't mean they can't succeed," Miles said of his students and special-need children in general.

Temple Grandin is autistic and did indeed prove that autistic people can be successful.

Grandin was diagnosed with autism when she was 2 ½ years old in 1949. She had very low social reactions, lacked emotion and was sensitive to loud sounds and physical contact.

"High school kids teased me," she said. "High school students can be really mean and nasty. They called me things." The students called her "tape recorder" since she repeated words.

From elementary school to the first year of high school, none of Grandin's teachers excited her about school or learning. "I wasn't really into studying," she said.

Then, in the 10th grade, she had a science teacher who ignited a passion for science in her. He took her obsessive interests and directed them toward science projects.

"He got me interested in science," Grandin said. "Good teachers make the most difference in the world. I can't emphasize enough what a good teacher does." Her 10th grade science teacher was a good teacher.

Grandin began to study more and devoted extra time in the science lab and to riding horses, the only two places where she wasn't teased.

After graduating high school, Grandin attained her bachelor's degree in psychology from Franklin Pierce College, her master's degree in animal science at Arizona State University and her doctorate in animal science from the University of Illinois in 1989.

Grandin has written several best-selling novels about autism and animal behavior. In addition to being a novelist, she travels around the nation speaking about autism and cattle handling, is a successful livestock handling equipment designer, has designed numerous facilities that handle cattle in the U.S. and has written over 300 articles about facility designs, animal handling and welfare. She presently is an associate professor in the animal science department at Colorado State University.

Like many autistic people, Grandin has an intolerance of being touched due to her skin being oversensitive. She wrote in the "Journal of Child and Adolescent Psychopharmacology" that "Occupational therapists have observed that a very light touch alerts the nervous system, but deep pressure is relaxing and calming." By arousing the nervous system, a light touch can create a wave of overwhelming stimulation. For Grandin, a light hug is extremely painful.

According to the Autism Research Insti-

tute's website a touch that is firm enough to stimulate deep touch receptors somehow produces a calming effect instead of a painful one. The site also states that stroking autistic people's skin with different cloth textures can desensitize their hypersensitivity to touch.

Sensory stimulation also varies for each individual. ARI's website said sensory stimulation is similar to the idea that a cool breeze may bring relief from the heat for one person and may make another person shiver. Therefore, a hug for Grandin is painful, but it may be soothing for other autistic people.

For autistic children who become overwhelmed, angry or anxious, this coping strategy of deep pressure may relieve some of their frustration. Some autistic children wrap themselves in numerous blankets or climb between mattresses to seek out "deep pressure." Grandin used to climb between the sofa cushions and have her sister sit on her.

While in elementary, Grandin developed and later patented what she called a "squeeze machine," improving the initial design throughout the years. She came up with the idea for the first human squeeze machine when she had an anxiety attack at her aunt's Arizona ranch. She jumped in the squeeze chute used to hold cows as they're vaccinated and asked her aunt to squeeze the sides against her.

In her book, "Thinking in Pictures," Grandin writes that after the first moments of panic, a "wave of relaxation" washed over her.

She used plywood panels to construct her squeeze machine, using the same design as the cow squeeze chute. Presently, one design has foam-padded panels and allows the user to control the pressure exerted.

This concept of using pressure to calm an autistic person can be applied in the classroom through smaller items like pillows, blankets and mats.

In Galvin's classroom, one autistic student suffers from sensory processing disorder. According to the article "Sensory Processing Subtypes in Autism: Association with Adaptive Behavior," published in the "Journal of Autism and Developmental Disorders" children with autism "frequently reported to exhibit behaviors associated with sensory sensitivity (e.g., covering ears to loud, unexpected sounds; restricted food preferences), sensory under-responsivity (e.g., failure to orient to name or react to pain) or sensory seeking (e.g., rocking, hand flapping, noise-making)."

When visiting the general education classroom, the noise level may become too much for Galvin's student to process. He can be-

come very disruptive and make noises.

The teacher of the general education classroom said he has a "calm-down box." If the teacher sees he's about to lose control, she'll signal for him to get his box by looking at him and sweeping her hair back with her hand. His box contains a weighted pillow, a toy phone called a "whisper phone" and other little objects that calm him down.

Just as people without autism have diverse interests and recreational activities, people with autism also have diverse methods of relaxation. The squeeze machine works for Grandin, the pillow and phone for Galvin's student, and singing for others.

Galvin would say the point to remember is to observe the student before he or she becomes too frustrated or overwhelmed, and give him or her time to calm down with whatever method works best for that student.

The squeeze machine as well as her other accomplishments, has give Grandin world-wide recognition.

To date, Grandin has been on "ABC's Prime-time Live," "Larry King Live," "20/20" and the "Today Show." According to Grandin's website, Bravo cable did a half-hour show about her life, and she said that HBO is currently in the process of producing a story about her.

Grandin has autism but has proven that it's not a disability that hinders achievement. She is a success.

In her book "Emergence: Labeled Autistic," Grandin writes that many people believe that autism is a condition that exists for life. However, in her book she states, "To these people, it is incomprehensible that the characteristics of autism can be modified and controlled. However, I feel strongly that I am living proof that they can."

Grandin's books helped the parent of a son who has PDD-NOS understand some of the behaviors her son displayed.

Adelaida Nieves was always told that her son seemed different. When her son, Evan, was 6, his teacher asked her if she'd ever heard of PDD-NOS. At the time she didn't but after years of research, she'd know as much as possible about the disorder.

Grandin's books helped Nieves understand some of Evan's behaviors that weren't explained in any of the other material she had read.

Because Grandin's book explained that autistic people often suffer from lack of sensory integration, Nieves understood she was fortunate that Evan could be very affectionate and lov-

ing constantly hugging her, but he liked to touch people's hair and at times he would hug her tightly.

She said she thinks Evan grew out of touching people's hair and wasn't as affected by a lack of sensory integration as others because of all the activities he was enrolled in. He boxed, participated in karate and played sports.

Nieves said the impact of the activities helped Evan relax and acclimate his body to touch.

When Evan would become frustrated or overwhelmed, he displayed it through self-talk and echolalia, the repetition of words.

"He'd say something like 'I'm going to the store, store, store,'" Nieves said. It took years for Evan's speech to develop, she said.

Nieves's son was in individualized education program classes throughout the majority of his primary school. She said that she and her husband taught him most of his learning and coping strategies with little or no assistance from his teachers.

"It was so impersonal," Nieves said of Evan's teachers and school system. The teachers weren't prepared to teach children with autism, she said.

Nieves gave one example of when Evan had moved to a general education classroom with only a paraprofessional to assist him.

The teacher should tell the paraprofession-

als what they'll be instructing in advance, so they can figure out how to convey it to the students to maximize the learning process, Nieves said. "The teacher barely did that for my son."

Music soothes and helps Evan learn, Nieves said. "He learned his colors through the Ninja Turtles" and the different colored masks that the turtles wore, Nieves said.

For some unknown reason, music has a positive effect on most autistic people. In Grandin's book "Thinking in Pictures," she mentions that one of the only times she feels emotions is when listening to music.

Galvin, also said that her students seem to learn better when singing.

"One little girl, stands at the board and sings all of her numbers," Galvin said. "I say whatever works."

Nieves said that finding effective strategies can be difficult.

"Being a parent, there's no manual," she said. "It's always trial and error. Mirrors would get Evan going. We learned not to do things to stimulate him in a negative way."

Miles expressed an admiration for parents like Nieves, who have special-needs children.

"My time with these kids is limited six hours a day for four days a week," he said. "I can checkout from it at the end of the day. They can't."

While some autistic children will always re-

quire constant care, the coping and learning strategies that teachers, psychologists and parents provide autistic children can help many become productive, self-sufficient adults.

For parents like Nieves, the lack of programs and help for autistic adults is disappointing. She said most of the research coming out on autism focuses on children and how to help them early. Nieves wants to eventually create ways to help autistic adults find jobs and help them to continue to grow, so they're not jobless like her son.

With the growth rate of autism rising from 22 percent in 1992 to over 1000 percent in 2008 (Fighting Autism Web site), Nieves would like to get more help for autistic adults sooner rather than later.

For other parents who have children with special-need children, Nieves said: "Never assume that you can't do anything until you try. A... doctor said, Evan would never be able to learn anything, and he was wrong. People with disabilities are people with potential."

Additional Source:

(2008) "History of Autism." Autism-Help.org <http://www.autism-help.org/autism-history.htm>

Debating the Issue: IFRS or U.S. GAAP

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Abstract

The issue of the United States converting to International Financial Reporting Standards (IFRS) has been a heated debate in the accounting community over the past several years. The quickly approaching decision date set forth in the 2008 Securities and Exchange Roadmap has increased the urgency of this dialogue. In this paper, I present a comparison of the major issues surrounding both sides of the debate. Proponents of the plan believe that worldwide comparability will result from adoption leading to more informed capital allocation decisions. On the other hand, antagonists believe that comparability actually suffered in firms that recently adopted the standards. Early evidence from countries that have adopted IFRS suggests that the implementation of the standard has brought increased comparability of financial reporting. However, despite this perceived success, not all constituents are convinced that a switch to IFRS in the U.S. is warranted. Opponents are concerned about high convergence costs and the move from a rule-based reporting to a more judgment-based accounting.

Introduction

"To be, or not to be, that is the question." When Shakespeare wrote this infamous line he was completely unaware that one day it would encompass the world of accounting in today's society. The Securities and Exchange Commission has recently proposed a movement that would eliminate Generally Accepted Accounting Principles and equalize reporting with International Financial Reporting Standards. The SEC's proposal would allow many multinational companies to report their earnings according to IFRS principles for fiscal years ending on or before December 15, 2009 as early as 2010. An estimated 110 U.S. companies would fall into this reporting category based on their market capitalization and other factors.¹ On November 14, 2008 the SEC proposed a Roadmap outlining that all U.S. companies would abandon U.S. GAAP and report under IFRS beginning in 2014. The SEC was open for comments on the matter, which led to the topic of this paper. The objective of this paper is to set forth an unbiased presentation of both sides of the issue of whether or not the U.S. should move from Generally Accepted Accounting Principles to International Financial Reporting Standards in order to create uniformity with the rest of the world, where financial presentation is concerned. Comparability and effects on investors, previous success, the cost of conversion, SEC proposals and early adoption, education and training, and finally the need for an oversight board will be discussed.

I examine and present a summary of the views expressed in the comment letters to the proposed Roadmap issued by the Securities and Exchange Commission on November 14, 2008. In general, I find that the Big Four accounting firms are supportive of the U.S. movement to adopt IFRS. Their key arguments are that adopting IFRS will bring greater comparability to financial reporting and will make the U.S. more competitive in a global market. On the other hand, I find that there are numerous letters opposing a move towards adopting IFRS. These opposing constituents express frustration that IFRS will bring increased judgment to financial report-

ing, ultimately resulting in a lack of comparability and consistency in accounting.

This paper proceeds as follows: key milestones in the development of IFRS are presented in section 2, arguments in support of IFRS are discussed in section 3, section 4 presents arguments in opposition, and section 5 describes what lies ahead followed by conclusions in the final section.

2. Development of International Financial Reporting Standards

A brief overview of key milestones in the development of IFRS:

- 1973 – The International Accounting Standards Committee (IASC) was formed with hopes these standards would be accepted worldwide.
- 1994 – The International Organization of Securities Commissions (IOSCO) completed and communicated its review of the current IASC standards.
- 1994 – The formation of the IASC Advisory Council was approved in order to provide oversight to the IASC and manage its finances.
- 1995 – The IASC developed its Core Standards Work Program, which led to the creation of a comprehensive set of core standards.
- 1997 – The Standing Interpretations Committee (SIC) was established to provide interpretation of International Accounting Standards (IAS).
- 1999 – The IASC Board approved a restructuring that resulted in the current International Accounting Standards Board (IASB).
- 2000 – The IOSCO recommended that multinational issuers be allowed to use IAS in cross-border offerings and listings.
- 2001 (April) – The IASB assumed the standard setting responsibility from the IASC and adopted the existing IAS standards and SIC Interpretations.
- 2002 (February) – The International Financial Reporting Committee assumed the responsibility for interpreting IFRS.
- 2002 (July) – The European Commission required European Union listed companies to prepare their consolidated financial statements in accordance with IFRS as endorsed by the EC from 2005 forward.

This became the most critically important milestone in the development of IFRS because it was the main driver for the expanded use of IFRS.

- 2002 (September) – The Norwalk Agreement was executed between the FASB and the IASB who agreed to use best efforts to make the existing financial reporting standards fully compatible as soon as was feasible.
- 2004 (December) – The European Commission issued its Transparency Directive, which required non-European Union companies with listings on the EU Exchange to use IFRS.

- 2005 (April) – The SEC published the first Roadmap.

This Roadmap discussed the possible elimination of the U.S. GAAP reconciliation for foreign private issuers that use IFRS. It also laid out a series of milestones that if achieved would result in the elimination of the U.S. GAAP reconciliation by 2009 at the latest.

- 2006 (February) – The FASB and IASB published a Memorandum of Understanding.

This memorandum reaffirmed the Boards' shared objective to develop high quality, common accounting standards for use in the world's capital markets. The Boards decided to proceed along two tracks for convergence: 1) a series of short term standard setting projects designed to eliminate major differences in certain focus areas, and 2) the development of new common standards, since accounting practices under both directives are regarded as candidates for improvement.

- 2006 (August) – The CESR and the SEC together published a work plan identifying areas of IFRS and U.S. GAAP that raise questions in terms of high quality and consistent application.
- 2007 (November) – The SEC eliminated the U.S. GAAP reconciliation for private issuers after determining that the 2005 Roadmap has been sufficiently met.
- 2007-2008 – The SEC explored future use of IFRS by U.S. companies.

In August of 2007 the SEC issued a Concept Release asking the public to comment on the possible use of IFRS by U.S. domestic registrants. Also, in August 2008 the SEC approved an updated Roadmap for public issuance on November 14, 2008, which anticipated mandatory reporting under IFRS beginning in 2014, 2015, or 2016 depending on the size of the company.

- Pressing Onward

The momentum to converge to a single set of global uniform accounting standards, with IFRS as the chosen proponent is continuing to build, and is a very active topic on the SEC's agenda. The updated Roadmap proposed milestones to be considered in determining whether reporting under IFRS should be mandated for U.S. companies and states that further assessment by the SEC must be conducted in order to declare a definitive statement on the matter in 2011.²

3. Support for International Financial Reporting Standards

3.1 Comments from the Big Four

Each of the Big Four accounting firms: PricewaterhouseCoopers, KPMG, Deloitte & Touche, and Ernst & Young, strongly support the decision to implement IFRS in the United States. Each firm has recognized the interconnectivity of the capital markets and highlights the need for increased transparency and worldwide comparability due to the recent financial crisis. They believe that a single-set of high quality accounting standards will allow investors to make better capital allocation decisions. With more than 110 countries currently operating under these standards, IFRS is deemed to be the best solution. It has also been recognized that IFRS will make it easier for U.S. and worldwide regulatory bodies to monitor systematic risks in the global capital markets and to achieve the objectives of the Group of Twenty.^{3,4,5,6}

3.2 Comparability and Effects on the Investor

The most common characteristic of IFRS that lends itself to widespread support in the U.S. and countries abroad is the aspect of a single set of accounting standards that can lead to worldwide comparability. In recent years, IFRS has gained increasing acceptance in capital markets worldwide and is anticipated to be adopted in more countries in the near future. This has led many to believe that IFRS has the highest potential to become the set of accounting standards that best provides a common platform for companies to report and investors to compare financial data.⁷

Investors and issuers in capital markets are of utmost concern with the current economic downfall. Due in large part to the technological advancements that have graced society, cross-border trading and investing have reached a global peak. U.S. investors have the ability to access real-time security transaction data from security markets around the world and to trade on global exchanges through access to the Internet. With the increase in global trading and investing, it goes without saying that investors need to have access to fair and accurate disclosures that enable the comparison of financial information. With the ease of cross-border investing and trading it is necessary that investors have the tools to compare their investment opportunities with global markets.⁷ Former Chairman Christopher Cox commented in a speech to the International Organization of Securities Commission that both the IASB and its governing body, the IASC Foundation, are doing their best to make sure that investor's interests are the primary concern in the continuing development of IFRS.⁸

Much like comparing apples to apples, investors must be able to compare U.S. financial statements with those of countries that report under IFRS. The current differing accounting principles and presentations of financial statements make it hard for even the savviest of investors to compare financial statements prepared under U.S. GAAP with those prepared under IFRS. According to the SEC, U.S. investors would be able to make better-informed investment decisions if they could obtain high quality financial information from U.S. companies that are comparable to the information from foreign companies operating in the same industry. Capital formation and investor understanding would be enhanced if the world's major capital markets all operate under a single set of accounting standards that generate comparable, high quality financial information from public companies.⁷

3.2 Previous Success

The European Union, Canada, and Australia have recently converted to IFRS and have had much success with their adoption. Prior to this conversion, each Member State of the European Union had individually established its own accounting principles. Each state had allowed the use of other jurisdiction accounting standards along with its own. It was very evident that the European Union was in desperate need of a single set of high quality accounting standards under which all Member States could report. They chose to adopt IFRS and have been pleased with the results overall. With the increasing globalization of capital markets, Canada recently decided to converge Canadian GAAP with IFRS over a transitional period in order to establish a single set of high quality accounting standards. Australia has also recognized the need for comparability and consistency across global financial markets and chose to adopt IFRS as well.⁷

4. Opposition to International Financial Reporting Standards

4.1 Comparability and Effects on the Investor

While there is much support for the idea of increased comparability of financial statements under IFRS, there is also extensive opposition to the matter. Moody's Investors Service conducted a study

into the financial statements of thirty, large European companies to understand how their reporting changed when they switched to IFRS under the European Union adoption in 2005. Generally, it was determined that profits rose, balance sheets deteriorated and comparability suffered.⁹ While Ernst & Young as a whole is in clear support of IFRS, David Lindell, the head of Ernst & Young's global IFRS practice comments that even though IFRS has been successfully implemented in a timely manner, there is still a long way to go before consistency and comparability are improved.¹⁰

Ernst & Young also reports that there are four issues explaining a lack of consistency and comparability. The first is that IFRS reports have a strong national identity, but the main focus has been on how companies recognize, measure, and disclose items. There has been a significant lack of focus on the presentation of the results. Because of this, companies have been preparing their financial statements by adopting approaches that are most similar to their previous national standards, inherently, reducing the ability to compare across industries. Second, is that there is no specific guidance for industries. Consequently, IFRS implementation has required a significant amount of judgment to be used in selecting and applying IFRS accounting treatments throughout industries. Third, some companies are not confident that their performance is communicated to the market appropriately under IFRS. Finally, IFRS financial statements are much more complex than financial statements prepared under U.S. GAAP. There are concerns that the preparation of financial reports will become a technical compliance issue instead of a mechanism for communicating performance and the financial position of many companies.¹⁰

The director of investor protection for the Consumer Federation of America, Barbara Roper, is worried about comparability under a principles-based accounting rulebook like IFRS. She believes that the flexibility allowable under IFRS is likely to be taken advantage of by executives painting their companies' financial statements in the most positive light. She also notes that IFRS is not consistently applied from country to country let alone company to company.⁹

The Moody's Investors Service report provides several examples of where comparability is currently suffering. Among the thirty companies that Moody's investigated, it found that these companies use ten different ways to report dividends, interest, and taxes in the Statement of Cash Flows. There are multiple views on whether cash flows should be classified as operating, investing, or financing under IFRS, unlike the specific rules under U.S. GAAP. Therefore, IFRS allows companies to decide for themselves how to classify cash flows. The Vice President and accounting specialist for Moody's, Trevor Pijper, states, "The layout of the cash flow statement reflects a lot of theoretical differences on the board of IASB. You can scatter items all over the statement, as long as you report in a way that allows people to put it together in a way that suits them." He also adds that this is something that the IASB is not planning to correct immediately.⁹

Another area of decreasing comparability is inconsistent interpretation and application of accounting policies. Reporting on this significant concern is Danita Ostling, a partner at Ernst & Young and the firm's IFRS leader in America. She says the nature of the principles-based IFRS compared to the rules-based U.S. GAAP places the responsibility on companies to establish clear accounting policies. According to Ostling, companies should consider the substance of the transactions that they are entering into and decide how the principles of IFRS should be applied. Ostling's solution to inconsistently applied accounting policies is for companies that report under IFRS to create a comprehensive accounting policy manual which will

make sure that IFRS principles are consistently applied throughout the company and its subsidiaries. In her opinion, this policy manual will give investors visibility into a company's accounting policies and will ultimately lead to increased comparability. She believes that investors will be able to see if there are differences and where these differences are coming from through policy visibility.⁹ Ostling's idea is something that should be well considered. Requiring accounting policies, which are now consistently interpreted differently across global markets, to have uniform application is a good start. However, policy manuals will not correct the lack of comparability within industries. Her solution also seems to send the message that the company can decide how they want to report certain aspects in order to shed a better light on their company, as long as they note their decision in the policy manual.

4.2 Cost of Conversion

One of the largest corporate concerns of IFRS is the cost of implementation. Many companies are worried that the costs will be more than they can handle. The SEC estimates that the cost of each company to transition from U.S. GAAP to IFRS will be approximately \$32 million over the first three years of filing 10-K forms under IFRS.¹¹ With a minimum of approximately 110 issuers eligible for adoption, costs are estimated to be nearly \$3.5 billion.⁷ The SEC expects that the majority of the costs incurred will be in the first year of adoption. There are many costs that are included in the approximate \$32 million of transition costs. These include: expenses incurred in determining the effects of adopting IFRS, changes to systems needed to support IFRS reporting, the higher costs of accounting personnel, outside consultants, and auditors who are familiar with IFRS. The costs of acquiring an audit firm with the proper experience in IFRS reporting is also a major necessity that companies must consider.¹¹ The SEC claims that costs will decline by nearly seventy-five percent in companies' second year filings but the initial cost is still hard for companies to swallow.¹²

5. Looking Ahead

5.1 SEC Proposals and Early Adoption

The SEC outlined two proposals in the 2008 Roadmap that address the disclosure of U.S. GAAP by U.S. issuers that elect to report financial statements under IFRS in their Commission filings. Proposal A would make issuers provide a single reconciliation from certain U.S. GAAP financial statements to IFRS, in a footnote to its audited financial statements as required by IFRS 1. IFRS 1 also requires that entities explain how the transition from U.S. GAAP to IFRS has affected their financial position, financial performance, and cash flows. This information would help users of the financial statements understand the differences between financial statements prepared under U.S. GAAP and those prepared under IFRS.⁷

In Proposal B, U.S. issuers that elect to report under IFRS would also provide a reconciliation from IFRS to U.S. GAAP as required under IFRS 1, and would disclose, on an annual basis, certain unaudited supplemental financial information covering a three-year period. The unaudited financial information would be disclosed yearly in the issuer's report on Form 10-K. The SEC argues that this proposal would increase comparability in multiple ways. An example is the comparison of the most recent three-year period compared to the earlier three-year period, shown on a consistent basis under IFRS and U.S. GAAP. This would also allow investors to understand the differences between U.S. GAAP and IFRS as well as current trends. This proposal would increase the likelihood that issuers would maintain U.S. GAAP controls, procedures, and records after they elect to report under IFRS. Reverting from IFRS back to U.S. GAAP would also be possible through Proposal B.⁷

The SEC strongly promotes early adoption of IFRS for issuers based on certain criteria. The extent to which the issuer has experience with IFRS reporting is one example of these criteria. The SEC proposes that this offer be applicable for filings of fiscal years ending on or after December 15, 2009.⁷ The Commission also asserts that there are two key benefits with early adoption. The first benefit being that early adoption in global industries will likely benefit investors by increasing comparability. The second benefit is that experiences of companies that choose early adoption will increase the effectiveness and efficiency of conversions, which will also lower transition costs. The Commission also plans to consider early adoption experiences in the final decision set to be made in 2011.⁷

Grant Thornton LLP, Deloitte & Touche LLP, Ernst & Young LLP, PricewaterhouseCoopers LLP, and KPMG LLP all strongly support early adoption. However, each firm agrees that the early adoption criteria should be expanded to include a larger population of issuers. In reading the comment letters of each of the above listed companies, there is much consistency in opinions on Proposal A and Proposal B. Each firm supports the idea of comparability of IFRS and U.S. GAAP for a certain period of time, allowing investors to understand the differences; because of this there is overwhelming support for Proposal A over Proposal B. A common consensus is that Proposal B would place a cumbersome burden on companies to maintain two accounting standards. Adding to the dislike of Proposal B is that it discourages companies from considering early adoption because it eliminates the benefits that early adoption provides. None of the firms see the need to keep the possibility of reverting back to U.S. GAAP open and feel that Proposal A eliminates this possibility.⁷

5.2 Education and Training

Another big concern with the adoption of IFRS is the issue of education and training. A survey conducted by KPMG LLP and the American Accounting Association concluded that professors believe that their students will be at a major disadvantage if the U.S. does not adopt a set of globally accepted accounting standards and if colleges and universities do not incorporate IFRS into their curriculum *immediately*. In polling 500 professors, it was found that seven out of nine conclude that the hardest part about incorporating IFRS is finding room for it in the curriculum, but seventy percent of these professors indicated that they have already taken steps to incorporate it. Manny Fernandez, KPMG's National Managing Partner, states that, University professors realize that teaching IFRS is critical to the preparation of students to succeed in the professional environment, but they also realize that finding space in the curriculum is a challenge. Given the state of the current regulatory environment, seventy-nine percent of the polled faculty thinks that U.S. GAAP should continue to be taught for the next three to five years, while increasingly incorporating more IFRS concepts on a compare and contrast basis as the conversion date approaches. Fifty-nine percent of the faculty believes that the CPA exam will include significant content on IFRS by 2012 and 2013. Fifty-four percent believe that comprehensive coverage will occur in intermediate accounting books by 2011 and 2012.¹³

One of the seven milestones proposed by the Commission is education and training as it relates to IFRS. In the SEC comment letters there are differences in opinions on education and training from the Big Four. However, all four believe that the Commission must set forth a decision to require the adoption of IFRS before the extensive investment in education and training will be made. Deloitte & Touche LLP has formed the IFRS University Consortium to help provide colleges and universities with teaching material, making it the only one of the Big Four to take such active steps for higher education.¹⁴

Nevertheless, Ernst & Young is following closely behind by announcing a million-dollar investment in the creation of a new Academic Resource Center to provide university faculty with real-time curricula to meet the fast changing needs of the global financial market.²

5.3 Oversight Board

With the inherent nature of IFRS, much more judgment is required and less reliance on clear-cut 'rules' is necessary. This creates the need for a global regulatory body to facilitate the consistent application of IFRS worldwide. The final matter of concern for the U.S. is to determine who has the ultimate authority over International Financial Reporting Standards because the U.S. wants more accountability. As seen in the timeline presented in section 2, the International Accounting Standards Board, based in London, is currently the accounting standard setting body established to develop global standards for reporting. The IASB is overseen by the International Accounting Standards Committee Foundation, which is also London based. Twenty-two trustees, with diverse backgrounds, govern the IASC Foundation. The IASC Foundation is responsible for the activities of the IASB as well as other IFRS initiatives including education of IFRS.⁷

To improve the public accountability of the IASC Foundation, the trustees have proposed amendments to its Constitution to establish a connection with a Monitoring Group consisting of securities authorities. The Monitoring Group will participate in voting and approve nominations for IASC Foundation trustees, review funding arrangements of the IASC Foundation for adequacy and appropriateness, and address matters that the IASC Foundation trustees are responsible for such as oversight of the IASB. The SEC is convinced that the accountability of the IASC Foundation will be improved with the interaction of securities authorities and the trustees created by the Monitoring Group. Effective oversight is critical to mandating that U.S. issuers prepare financial statements in accordance with IFRS.⁷

6. Conclusion

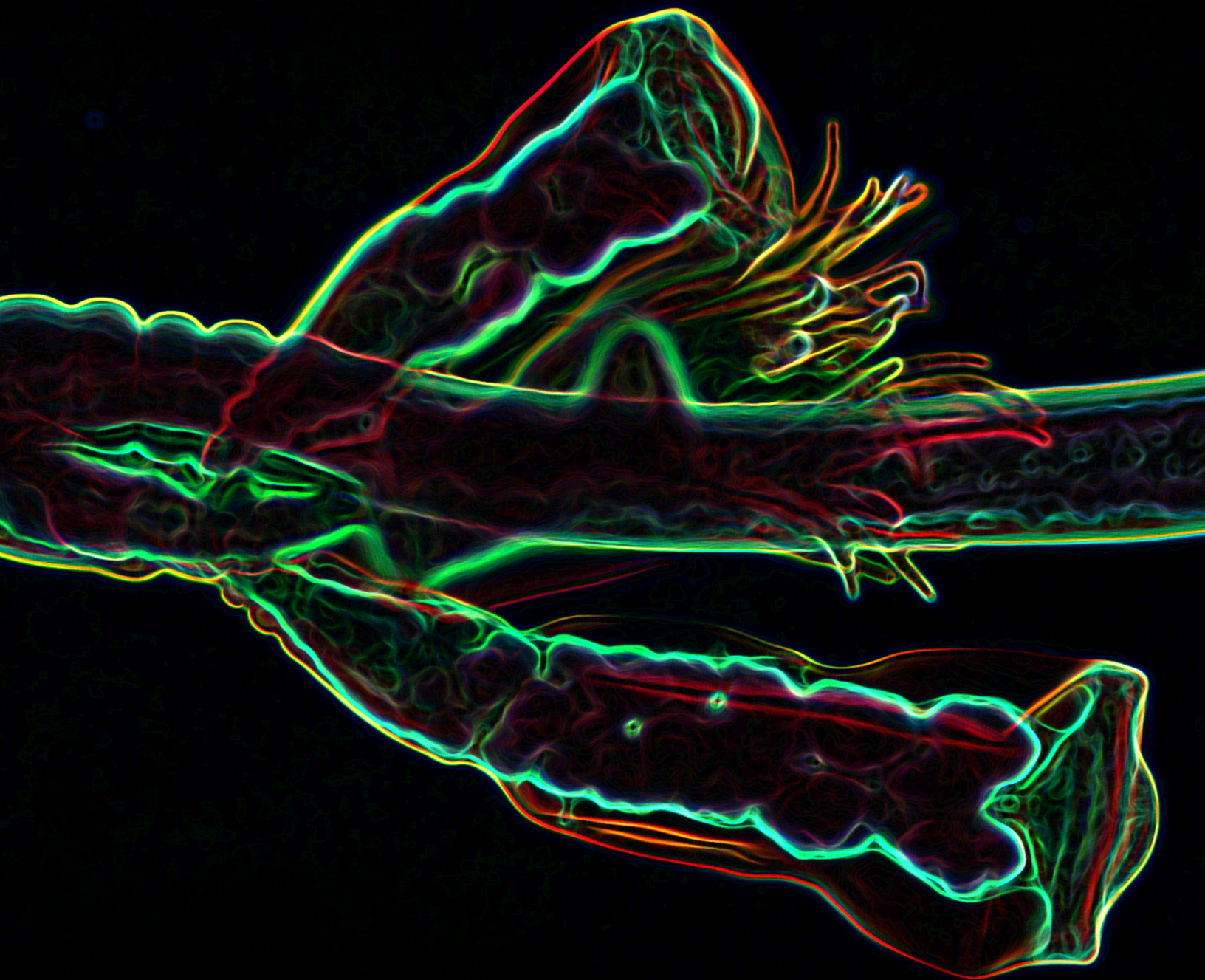
Clearly, there has been a recent explosion of International Financial Reporting Standards in the United States. Adopting a set of accounting standards that have been deemed as "high quality" by over three-quarters of the world creates an enticing proposition, especially with the current state of the economy. Inarguably, regaining investor confidence in capital markets is a goal of high importance for the U.S. and is much more achievable when financial statements foster comparability. With 113 countries reporting under IFRS, it is logical that IFRS is the chosen proponent to allow the U.S. to achieve this goal. Former Chairman, Christopher Cox, strongly endorsed the movement of incorporating IFRS; while the new appointee of the Securities and Exchange Commission, Mary Schapiro, would like to take a step backward and review the matter. There is much concern about moving from the rules based U.S. GAAP to the principals based IFRS because of increased interpretation, lack of industry guidance, and high costs of conversion. The SEC will make the final decision in 2011, but the Roadmap allowed nearly 110 companies to report earnings in accordance with IFRS principles in 2010. With the final decision date quickly approaching, there is much debate on whether this movement is in the best interest of the U.S., its companies, and its investors. With the avid support of the Big Four constituents and belief that future competition of the U.S. largely depends on the adoption of IFRS, it seems that this question becomes more of a matter of "when" than a matter of "if." However, we have consistently been taught that there is always room for improvement. IFRS, U.S. GAAP, and the accounting profession in general are certainly no exception.

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