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Editor's Note

The *New Mexico Journal of Science (NMJS)* is the annual publication of the New Mexico Academy of Science (NMAS). Each volume of the *NMJS*, which has been published since 1960, contains research papers and review articles deemed of interest to the scientists, educators, and citizens of New Mexico, in addition to some highlights of the academy's activities from the past year. Some volumes have addressed topics of historical, social, or economic interest while others have emphasized scientific areas in which New Mexico is particularly active. This year, we received submissions from authors at universities both in New Mexico (New Mexico State University) and from across the country. While the *NMJS* is only published once a year, papers are accepted for review and publication consideration on a rolling basis.

This volume of the *NMJS*, while showcasing fewer articles than last year, features an emphasis on university student authors. Furthermore, this issue continues and builds upon the established peer review process changes of recent years which keep the *NMJS* at the standard of professional journals. Additionally, opportunities exist for students and young authors to work with mentors to help get their work published. This volume would not have been possible without the hard work of the authors and reviewers from prominent New Mexico institutions and other organizations including Brown University (Providence, RI); Eastern New Mexico University (Portales, NM); Intel Corporation (Portland, OR); Johns Hopkins University (Baltimore, MD); Massachusetts Institute of Technology (Cambridge, MA); New Mexico State University (Las Cruces, NM); Princeton University (Princeton, NJ); Rowan University of Cambridge (UK); the University of Connecticut, (Storrs, CT); the University of Pennsylvania (Philadelphia, PA); and Yale University (New Haven, CT). The publication of this volume was enabled by huge professional efforts from Associate Editors Ms. Brittney Van Der Werff (NM EPSCOR) and Duncan Lee (Massachusetts Institute of Technology) and Copy Editor Ms. Sara Pichette (NM EPSCOR).

The *New Mexico Journal of Science* is available for free download from the NMAS website at www. nmas.org. This enables the NMAS to reach a wide readership. Prior to 2008, the Academy mailed paper volumes of the journal only to its members. Those hard copies are available to the public upon request. Concurrently, we are also undertaking a digitalization initiative to bring all of the past print-only copies of the *NMJS* into easily available online pdfs and establishing an online indexing system to increase the impact and visibility of the journal to more researchers.

Vladislav I. Sevostianov Editor-in-Chief New Mexico Journal of Science

The Burden of Heart Failure with Preserved Ejection Fraction in American Women is Growing: An Epidemiological Review

Basil M. Baccouche^{* a, b} Emmajane Rhodenhiser ^c Karan Patel ^d Medha Illindala ^e Anjali Mangla ^f Mattia A. Mahmoud ^{b, g} ^{a)} Stanford University School of Medicine, Stanford, California, USA ^{b)} University of Cambridge, Cambridge, UK ^{c)} Brown University, Providence, Rhode Island, USA ^{d)} Rowan University, Camden, New Jersey, USA ^{e)} University of Connecticut, Storrs, CT, USA ^{f)} Yale University, New Haven, CT, USA ^{g)} University of Pennsylvania, Philadelphia, PA, USA

ABSTRACT

Heart failure (HF) is one of the leading causes of death in the United States. Heart failure with preserved ejection fraction (HFpEF), one of two common heart failure divisions, currently has no clinically effective treatment and disproportionately affects women. We performed a reproducible review of epidemiological literature within the United States National Library of Medicine's PubMed database to describe the incidence and prevalence of HFpEF in American women. Both the incidence and prevalence of HFpEF in American women have risen in recent decades (p < 0.05 and p < 0.001, respectively) and are projected to continue rising. In addition, HFpEF has recently become the most common form of HF, accounting for 56% of all HF cases (Paulus, 2020). The upward trend in incidence and prevalence of HFpEF in women within the United States increases the importance of developing effective treatment options.

KEYWORDS: HFpEF, Epidemiology, Cardiovascular Disease, Diastolic Heart Failure, Heart Failure, Heart Failure with Preserved Ejection Fraction.

INTRODUCTION

Defining and Classifying HFpEF

Cardiovascular disease (CVD) is the most common cause of death in the United States (Heron, 2019). Heart failure (HF) is a chronic progressive form of CVD defined by the inability of the heart to pump enough blood to maintain sufficient corporeal perfusion (Natterson-Horowitz et al., 2021). HF is commonly divided into two types depending on whether the left ventricular ejection fraction (LVEF) is compromised or preserved, resulting in HFrEF or HFpEF, respectively (Federmann & Hess, 1994). The LVEF is the fraction of left ventricular blood volume ejected during systole compared to the left ventricular blood volume at the end of diastole (Kosaraju et al., 2020). Heart failure with reduced ejection fraction (HFrEF), commonly referred to as systolic heart failure, occurs when the left ventricular blood volume circulated to the rest of the body. Heart failure with preserved ejection fraction (HFpEF), commonly referred to as diastolic heart failure, occurs when the left ventricular blood volume circulated to the rest of the body. Heart failure with preserved ejection fraction (HFpEF), commonly referred to as diastolic heart failure, occurs when the left ventrice stiffens, impairing the ability of the ventricle to accommodate blood filling during relaxation.

Treating HFpEF

Despite success in development and implementation of drug-based therapies for HFrEF, no analogous treatment of HFpEF has been shown to effectively reduce its morbidity or mortality (Ilieșiu & Hodorogea, 2018). This lack of effective HFpEF treatment is particularly alarming as HFpEF currently accounts for 56% of all cases of heart failure, a number which has risen significantly in the past decade (Paulus, 2020). In addition to its symptomatic burden on the patient, HF presents a substantial financial burden to the American healthcare system, responsible for nearly \$40 billion in expenditures, a figure projected to increase in coming years (Bui, Horwich, & Fonarow, 2011; Heidenreich et al., 2013).

Compared to men, women exhibit increased susceptibility to both HF and HFpEF, with the latter seen at a prevalence nearly two-fold higher in women than in men (Chang et al., 2014; Goyal et al., 2016; Goyal et al., 2017; Tadic et al., 2019). Understanding sex differences in exposure and response to cardiovascular events may illuminate advances in HFpEF prevention and treatment. The purpose of this review is to chronicle the epidemiology of HFpEF in American women through a review of the United States National Library of Medicine's PubMed database. HFpEF's rising prevalence, combined with a lack of effective drug or device-based treatment, presents a growing need to synthesize and advance our understanding of this chronic progressive condition.

MATERIALS AND METHODS

To perform a review examining HFpEF in American women, we used the Sciome Workbench for Interactive computer-Facilitated Text-mining (SWIFT)-Review, which uses statistical text mining to sort search results for high-efficiency manual screening (Howard et al., 2016; Baccouche & Shivkumar, 2020). The complete results of 38 unique search terms processed by the United States National Library of Medicine's PubMed database were screened using our predefined inclusion criteria (Table 1) and a reproducible PRISMA-compatible strategy (Figure 1). **Inclusion Criteria**

-Consists of primary research

-Includes the outcome HFpEF in American women

-Epidemiological study design/goals

-Conducted on human subjects

-English language

-Full-text freely available to University of Cambridge

Table 1. Study inclusion criteria.

Search terms were chosen to cast a broad net, thereby reducing the risk of missing key studies with narrowly defined terms. The search terms and associated Boolean operators are as follows:

[HFpEF AND (women OR American women OR USA women OR female OR American female OR USA female OR epidemiology OR (epidemiology AND women) OR (epidemiology AND American women) OR (epidemiology AND USA women) OR (epidemiology AND female) OR (epidemiology AND American female) OR (epidemiology AND USA female)]

OR

[Diastolic heart failure AND (women OR American women OR USA women OR female OR American female OR USA female OR epidemiology OR (epidemiology AND women) OR (epidemiology AND American women) OR (epidemiology AND USA women) OR (epidemiology AND female) OR (epidemiology AND American female) OR (epidemiology AND USA female)]

OR

[Diastolic dysfunction AND (women OR American women OR USA women OR female OR American female OR USA female OR epidemiology OR (epidemiology AND women) OR (epidemiology AND American women) OR (epidemiology AND USA women) OR (epidemiology AND female) OR (epidemiology AND American female) OR (epidemiology AND USA female)].

RESULTS

From the review, six studies were identified which fit our search criteria. This paper presents epidemiological data on HFpEF in women within the United States over time and stratified by age, where data were available. Much of the data represented by these studies are taken directly from precise records of a predefined population, and thus the use of confidence intervals is not appropriate (as the parameter of interest is known). For this reason, some figures in this paper do not include confidence intervals, but p-values for trend are included in figure captions where available. Table 2 summarizes the study design, population source, and sample sizes of each of this review's included studies and provides study-specific commentary. All study populations were located within the United States.



Figure 1. Reproducible, PRISMA-compatible review workflow.

Study Authors & Date	Study Design	Population Source(s)	Sample Size	Comments & Limitations
Chang et al., 2014	Prospective Cohort	Community-based	6,399	Much of the study's descriptive and analytical statistics fail to stratify the HF category into subcategories, limiting its usefulness for this review.
Gerber et al., 2015	Prospective Cohort	Community-based	2,762	Comparably low sample size reduces the power of this study.
Goyal et al., 2016	Prospective Cohort	Community-based	5,046,879	Large sample size mitigates probability of error/misrepresentation.
				HFpEF data available by sex and over time, permitting detailed categorical descriptive analysis.
				Echocardiographic data not available to confirm diagnosis of HFpEF; HFpEF instead defined based on ICD-9-CM codes for diastolic HF in the absence of systolic HF, since LVEF data was unavailable.
				Much of the region- and time-specific data is not stratified by sex, a seemingly major oversight given the well-documented sex-based disparity in HFpEF susceptibility.
Goyal et al., 2017	Prospective Cohort	Community-based	1,889,608	Large sample size mitigates probability of error/misrepresentation.
				Echocardiographic data not available to confirm diagnosis of HFpEF.
Ramachandran et al., 2018	Prospective Cohort	Community-based	12,857	Much of the region- and time-specific data is not stratified by sex, a seemingly major oversight given the well-documented sex-based disparity in HFpEF susceptibility.
Tsao et al., 2018	Prospective Cohort	Community-based	15,217	Incidence of HFpEF over time by race is not stratified by sex, limiting the ability to perform a descriptive analysis of HFpEF incidence in women over time by race.

Table 2. Overview of review results.

Incidence and Prevalence

Data from Tsao et al. suggest that the age-standardized incidence of HFpEF in US women over time has increased significantly in recent decades (Figure 2).

To corroborate Tsao et al.'s findings, Vasan et al. observed that the prevalence of HFpEF increased significantly (p < 0.001) over the 3-decade period from 1984 to 2014 (Vasan et al., 2018). Gerber et al. collected and age-standardized data on the incidence of HFpEF in women



Incidence of HFpEF in US Women Over Time





Incidence of HFpEF in US Women Over Time

Figure 3. Age-standardized incidence of HFpEF in women in Olmsted County, Minnesota, USA, from 2002 to 2010. Data retrieved from Gerber et al., 2015. *P* for trend unpublished.

in Olmsted County, Minnesota, from 2002 to 2010, shown in Figure 3 (p-values for trend not published).

Chang et al. report that between 2005 and 2009, the age-adjusted incidence of HFpEF in white women was 9.9 per 1,000 persons/year, and in black women was 13.3 per 1,000 persons/year (Chang et al., 2014).

Age and Sex Distributions

Another key study by Goyal et al. used hospitalization data from the Nationwide Inpatient Sample to provide information on the distribution of sex within HFpEF patients over time, shown in Figure 4 (Goyal et al., 2016).

In 2017, Goyal et al. observed that among 1,208,763 hospitalizations of women for HFpEF from 2008 to 2012, the majority (>60%) occurred in persons 74 or older, shown in Figure 5.



Distribution of HFpEF by sex from 2003 to 2012

Figure 4. Distribution of HFpEF by sex from 2003 to 2012. Data retrieved from Goyal et al., 2016. P for trend < 0.001.

DISCUSSION

Key Findings

The results of our review suggest that both the incidence and prevalence of HFpEF in American women have increased significantly in recent decades. The juxtaposition of continuous advances in the treatment of other high-impact causes of mortality (like cancer, HFrEF, and diabetes, to name a few) against the lack of progress in treating HFpEF will likely exacerbate this increase in the decades to come.



Age-Stratification of Female HFpEF Hospitalizations from 2008 to 2012

Figure 5. Age-stratification of hospitalizations of women for HFpEF from 2008 to 2012 in the US (n = 1,208,763). Data retrieved from Goyal et al., 2017.

Strengths and Limitations

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Table 2 displays an overview of the studies included in the final review. Many of the studies had large sample sizes, lending credibility to their findings and our descriptive analysis. In addition, despite a frequent lack of echocardiographic data or left ventricular ejection fraction (LVEF) data to confirm the diagnosis of HFpEF, most sampled data used validated ICD-9-CM codes to diagnose HFpEF. Even if possible, it would be economically and laboriously impractical to individually validate HFpEF diagnosis via the collection and evaluation of echocardiographic/LVEF data.

The findings of Gerber et al. in 2015 (Figure 3) should be interpreted with caution, as p-values for trend were not published. Other trends (Figures 2 and 4) included p-values for trend from the original studies and should be weighted more when qualitatively assessing the findings of this review.

Given that there is a significant disparity-by-sex in the development of HFpEF, a non-trivial limitation in Chang et al., 2014, Goyal et al., 2016, and Ramachandran et al., 2018 is that analysis of HFpEF is not sex-stratified by each demographic factor, limiting the ability of this paper to analyze and compare findings. This appears to be an oversight in an epidemiological analysis of HFpEF, as sex will likely confound findings. For this reason, many potential risk factors (such as location) were not analyzed within this paper since sex-stratified data were not presented. It is suggested that future data collection and epidemiological analysis of HFpEF by demographic (race, geographic location, socioeconomic status, age, etc) be stratified by sex to avoid this preventable confounding effect.

In preparing search terms for the review, we were cognizant of several different terms used synonymously with HFpEF within the field of cardiology, including but not limited to diastolic

heart failure and diastolic dysfunction. In order to avoid missing relevant studies, we cast a wide Boolean search net with the intention of using SWIFT-Review to reproducibly and efficiently narrow the large number of results.

Although there is often slight variance in the LVEF cutoffs in the diagnosis of HFpEF, this variance (typically choosing between 50% or 55% as the threshold for preserved ejection fraction) is minor enough that between-study variance is unlikely to significantly affect conclusions. LVEF cutoffs were not defined across all studies.

Further Steps

Future epidemiological studies on the association between risk factors and HFpEF incidence are strongly encouraged to present results explicitly stratified by sex to account for the growing sex disparity in susceptibility to HFpEF. The robustly documented rise of both HFpEF incidence and prevalence in American women over the past several decades, coupled with the shortcomings of modern medicine in meaningfully attenuating/reversing HFpEF progression, call for accelerated action in the research, development, and implementation of new HFpEF solutions.

AUTHOR INFORMATION

Corresponding Author

*Basil M. Baccouche Stanford University School of Medicine 291 Campus Drive, Stanford, CA 94305 E-mail: basilbac@stanford.edu

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Efficient Protocol for Expression and Purification of DUSP5

Stevan Salinero Lee Uranga Marat Talipov* New Mexico State University, Las Cruces, NM, USA

ABSTRACT

Dual Specificity Phosphatase 5 (DUSP5) is a human protein that targets specific kinases and dephosphorylates phosphoserine/threonine and phosphotyrosine residues. DUSP5 is found to be involved in cardiovascular diseases and many cancer pathways, including skin and breast cancer. For this reason, availability of an efficient protocol of expression and purification of DUSP proteins can play a crucial role in their studies towards better understanding of the disease process and development of better therapeutic approaches. For example, purification of DUSP5 could be used for the in vitro assays of the inhibitors of DUSP5 identified from the in-silico studies. This report provides the full procedure for protein purification thereby allowing the collection of desired amounts of DUSP5 using Glutathione S-transferase (GST) tag. The described method shows an efficient way to solubilize and purify DUSP5 for further protein studies.

KEYWORDS: DUSP5, expression, purification, and phosphatase.

INTRODUCTION

Protein expression is a process in which DNA is transcribed into mRNA and then translated into a protein (Overview of Protein Expression Systems | Thermo Fisher Scientific - US, 2019). This process occurs in both prokaryotic and eukaryotic cells and is a useful tool for studying individual proteins in living organisms. Protein expression through a bacterial system such as *Escherichia coli* (Min et al., 1994), takes advantage of the bacteria's short replication time of approximately 20 minutes and allows for a rapid expression of the protein of interest. The expressed protein can then be extracted from *E. coli* cells via the protein purification. The *E. coli* protein expression system is a common tool to express proteins from other organisms including human (Kucharsca et al., 2009).

Dual Specificity Phosphatase 5 (DUSP5) is a protein involved in many disease processes such as cancer (Rushworth et al., 2014; Liu et al., 2018) and cardiovascular diseases (Alleboina et al., 2019). Specifically, DUSP5 targets extracellular regulated kinases (ERKs) and dephosphorylates their phosphoserine/threonine and phosphotyrosine residues (NCBI, 1994). DUSP5 has two domains: an ERK-binding domain and a catalytic phosphatase domain (Kucharsca et al., 2009). Due to DUSP5's involvement in many disease processes, it is currently under investigation as a target for developing new drugs and repurposing exist-

ing FDA-approved drugs (Bongard et al., 2019; Bongard et al., 2017; Neumann et al., 2015). Development of the DUSP5 inhibitors is challenging due to a variety of issues including the necessity of optimization of the ADMET properties, efficient membrane transport, and, most importantly, selectivity issues related to the high similarity of the catalytic sites of phosphatases. Due to these challenges, a large scope of potential inhibitor candidates needs to be tested on DUSP5, which in turn necessitates a robust protocol for DUSP5 expression and purification in large quantities. Herein, we provide the full details of such protocol, which represents an optimized version of the protocol published by the Ramchandran group (Rushworth et al., 2014).

MATERIALS

- Lysis buffer 50 mM tris-HCl buffer (pH=8.0), 1% triton X-100 detergent, 0.5 M NaCl, 10 mM EDTA, 10 mM EGTA, 10% (w/w) glycerol, 2 mM PMSF, 5 mM DTT, 0.4 ug/ml antipain, and 0.2 μg/ml leupeptin.
- *Tris Sucrose buffer* 30 g of sucrose per liter of tris-HCl buffer (pH = 8.0).
- *Washing buffer* 50 mM tris-HCl, 50 mM NaCl, and 5% (w/w) glycerol.
- *Elusion buffer* 20 mM glutathione (oxidized), 1 mM DTT, and remainder washing buffer.
- 1XPBS 140 mM NaCl, 2.7 mM KCl, 10 mM Na₂HPO₄, and 1.8 mM KH₂PO₄ all at a pH of 7.3.
- *Lysozyme for tris-sucrose* lysozyme concentration of 2.5 mg/ml.
- *Terrific broth (TB)* yeast extract, tryptone, glycerol, and phosphate buffer (media was sterilized via autoclave).
- *Cracking buffer (CB)* 250 mM tris-HCl (pH 6.8), 4% SDS, 20% glycerol, 10% 2-mercaptoethanol, ddH₂O, and 0.1% Bromophenol Blue.
- Antibiotics chloramphenicol and carbenicillin.
- Precision Plus Protein standards (purchased from Bio-Rad).

All reagents were purchased from Sigma-Aldrich, Inc. All buffers were filtered or sterilized prior to proceeding.

RESULTS & DISCUSSION

A cloned full length wild type Dual Specificity Phosphatase 5 (DUSP5) cDNA was used for transformation, as described by Ramchandran et al 2014 (Rushworth et al., 2014). DUSP5 was previously tagged with a glutathione S-transferase (GST) for simpler handling and purification. This was done through the PGEX-6P1 GST vector (Plasmid DNA Isolation, 2021), provided by the Ramchandran's lab. GST-DUSP5 was then transformed in Rosetta 2 Cells (RosettaTM 2 Competent Cells, 2006) using a standard Novagen kit (Plasmid DNA Isolation, 2021) to prepare the cells. Once prepared, cells were plated and allowed to incubate over-

night at 37°C. The plates were prepared using a terrific broth (TB) solid media. After colonies formed, a single cell colony was used to incubate overnight in a mixture of liquid terrific broth (TB) and the appropriate antibiotics, that is carbenicillin (Crb) and chloramphenicol (Cam). A final concentration of 100 μ g/ml Crb and 20 μ g/ml Cam was added to 2 ml of TB. This mixture was incubated once again over night at 37°C and 200 revolutions per minute, to allow for cell growth. Once finished, 1 ml aliquots were frozen in liquid nitrogen with 80 μ l of dimethyl sulfoxide (DMSO) to prevent crystallization and allow the cells to be stored for a longer period in -80°C freezer. These samples were used as the freezer stock for the rest of the experiment.

Solubility evaluation consisted of a three-day protocol. On day 1, 100 mg/ml Crb and 20 mg/ml Cam (final concentration) was added to 2 ml of TB and then inoculated over night with the freezer stock obtained from previous exercise. This was done at 37°C and 200 rpm, not to exceed a 16-hour period. On day 2, 25 ml of the TB broth were prepared, with appropriate antibiotics, adding 0.15 ml of overnight culture to the mix. This mixture was again agitated at 200 rpm and 37°C until the optical density (OD) 600 reached the value of $OD_{600} = 0.5-1$. A small portion of the cell culture (i.e., $0.3/OD_{600}$ ml) was saved for uninduced control to be used in SDS-PAGE gel electrophoresis. The remainder of the mixture was induced with a final concentration of 0.4 mM isopropyl β -D-1-thiogalactopyranoside (IPTG) and continued to shake at 37°C for three hours. A portion of the mixture $(0.3/OD_{600} \text{ ml})$ was saved for the induced control of overproduction via SDS-PAGE gel electrophoresis. The final mixture was then spun down and the pellet was saved for the third day's procedure (the supernatant was discarded). Both controls, induced and uninduced, were also spun down and the pellet reserved with the supernatant being discarded as well. At this point the cracking buffer (CB) was added to each of the controls to crack open the pelleted cells, which were then frozen to better stain the cells. On day 3, the frozen pellet was resuspended using 250 mM cold tris-sucrose buffer, 7.5 mM EDTA, 1mg/ml lysozyme, and 100 mM NaCl making sure the mixture was well dissolved. Next, the mixture was incubated at 4°C for 2 hours on a tilting table followed by 5 minutes in a 37°C-hot bath. Once well dissolved, it was centrifuged at 4°C and 13,000 rpm for 15 minutes followed by separating the supernatant from the pellet. About 75 ml of CB was added to the pellet and 10 ml of CB was added to 15 ml of supernatant. The samples were then heated to 95°C for 10 minutes along with the uninduced and induced control cell samples. About 5 ml of each sample was run through SDS-PAGE gel electrophoresis to check the solubility of DUSP 5. DUSP 5 protein is approximately 42 kDa in size and the GST-tag is approximately 30 kDa resulting in a 72 kDa total size when running the sample through an SDS-PAGE. The supernatant contains soluble protein whereas the pellet contains insoluble protein.

Using the product from a large-scale solubility test, the pellet was resuspended in a 20% by mass (of the pellet used) tris-sucrose buffer. Once the pellet had been resuspended, the lysis buffer with lysozyme was added to the mixture. Next, the solution was incubated for one hour at 4°C while being stirred to ensure that all solids were dissolved in mixture including the sides of the container. The solution was then sonicated using Branson Digital Sonifier 250. The sonication settings were set for *E. coli*: sonication was performed in four 12-second intervals at 60% amplitude with one-minute interval breaks in between so the solution is kept consistently cold. Once finished, the solution was run through the centrifuge at 8000 rpm for another hour at 4°C followed by separation of the supernatant from pellet. Another SDS-PAGE

gel was run to ensure consistency.

At this point the protein was fully resuspended in the supernatant and was ready to be purified using the gravity column chromatography. About 5 ml of Glutathione Sepharose 4B Beads (Glutathione Sepharose[®] 4B, 2021) were added to a hand gravity column for separation of product in the supernatant. Once added, the column was calibrated with the lysis buffer to ensure the beads didn't dry and destroy the protein. After the calibration, the supernatant containing DUSP5 protein was run through the column, followed by multiple washes of lysis buffer, and washing buffer described in the Materials section. Next, the column was eluted using two column volumes of the elution buffer. Used eluent was collected in 1 ml aliquots to check for protein presence/concentration in SDS-PAGE gel electrophoresis. Once all protein was eluted from the column, the beads were washed with 1X PBS buffer until all impurities were removed and the solution came out clear. The beads (GE Healthcare, 2008) were saved and stored at -20°C in 70% ethanol to prevent them from drying. The centric cones were then used to concentrate DUSP5 and minimize the impurities. To further concentrate the desired protein, filter centrifuge tubes with 10 kDA sized pores were used. This was done by filtering small aliquots of solution at ten minutes, followed by centrifugation at 13000 rpm. Once the entire solution was filtered, an SDS-PAGE gel was run to ensure DUSP5 was available in sufficiently high purity. The solution was then frozen in -80°C cooler for future use and study.

The SDS-PAGE gel electrophoresis of the GST-tagged DUSP5 protein (72 kDa, see Figure 1) (DUSP5, 1994) showed the protein band in the expected molecular weight range, see Figure 2. DUSP5 was predominantly found in the supernatant, which indicates that it is a soluble protein. The observed impurities (Figure 2) were removed using chromatography, as will be described below. The protein mixture was sent out for sequencing (DNA Sequencing Services | ACGT, 2015), which revealed a positive match for DUSP5 human protein as shown in Figure 5. The standard BLAST sequence comparison algorithm (Cloud-Based Informatics Platform for Life Sciences R&D | Benchling, 2021) showed perfect match of the obtained primary sequence of amino acids with the primary sequence of DUSP5 known from the literature (DUSP5, 1994), see Figure 3.



Figure 1. The SDS-gel electrophoresis of the concentrated DUSP5 solution. The lanes are marked as follows: **lane 1** marker, **lane 2** uninduced cells control, **lane 3** induced cells control, **lane 4** wash run-off, **lanes 5-7** three 30 kDa filter run-offs, **lanes 8-10** 10 kDa filter run-offs. Run-offs were collected in 1.5 ml aliquots to view placement of protein through electrophoresis.



Figure 2. Initial SDS electrophoresis gel showing the solubility of DUSP5. The lanes are marked as follows: **lane 1** uninduced cells control, **lane 2** induced cells control, **lane 3** pellet, **lane 4** supernatant, and **lane 5** is the marker lane.



Figure 3. Comparison of the primary sequence of the expressed protein and DUSP5, showing the exact match. Only a part of the sequence comparison is shown for the better visibility.

Column chromatography showed positive results with the use of the Glutathione Sepharose 4B beads binding to the Glutathione S-transferase (GST) tagged DUSP5. After running gel electrophoresis on the elutions of DUSP5 protein obtained from chromatography, visuals showed the removal of impurities from the previous product. Figure 4 shows that the bands present were all in the allotted range of 50 to 75 kDa, with no other bands being present. With the use of a 10 kDa microcentrifuge filter, the protein was further concentrated to a usable concentration over 100 ng/uL. Subsequent gel electrophoresis showed, through band size alone, that the protein was significantly concentrated (Figure 1). The subsequent sample quantification using NanoDrop spectrophotometer showed that the concentration of DUSP5 in the final sample increased to 567.2 ng/ul. Further tests were performed using mass spectrometry (Mass Spectrometry Service - Applied Biomics, 2021), which gave a protein match score of 97 and total ion score of 75 (Figure 5). This was the highest match of any human protein present in the data base leading to the conclusion that DUSP5 was successfully expressed and purified.



Figure 4. This gel shows the results of the column chromatography. **Lane 1** marker, **lane 2** un-induced, **lane 3** = induced, **lanes 4-9** first through sixth elutions. Elutions were collected in 1.5 mL aliquots to better view when protein was eluted, shown in the gel above through electrophoresis.

Spot number	MALDI well number	Match Quality	Top Ranked Protein Name [Species]	Accession No.	Protein MW	Protein Pl	Pep.Count	Protein Score	Protein Score C.I.%	Total Ion Score	Total Ion C.I.%
1	D1		Dual specificity protein phosphatase 5 OS=Homo sapiens OX=9606 GN=DUSP5 PE=1 SV=2	DUS5_HUMAN	42,020	8.7	7	97	100	75	100
2	D2		Histone deacetylase 7 OS=Homo sapiens OX=9606 GN=HDAC7 PE=1 SV=2	HDAC7_HUMAN	102,863	7.2	10	57	96	37	97
Control											
1 fmol	F6		Beta-galactosidase OS=Escherichia coli O9:H4 (strain HS) OX=331112 GN=lacZ PE=3 SV=1	BGAL_ECOHS	116,388	5.2	18	182	100	115	100
1 fmol	F7		Beta-galactosidase OS=Escherichia coli O9:H4 (strain HS) OX=331112 GN=lacZ PE=3 SV=1	BGAL_ECOHS	116,388	5.2	14	176	100	135	100
1 fmol	F8		Beta-galactosidase OS=Escherichia coli O9:H4 (strain HS) OX=331112 GN=lacZ PE=3 SV=1	BGAL_ECOHS	116,388	5.2	17	239	100	178	100
1 fmol	F9		Beta-galactosidase OS=Escherichia coli (strain K12) OX=83333 GN=lacZ PE=1 SV=2	BGAL_ECOLI	116,409	5.3	16	175	100	121	100
high confide low confider no confiden	nce nce ce										

Figure 5. Mass Spectrometry results showing positive match for DUSP5 (Mass Spectrometry Service - Applied Biomics, 2021).

CONCLUSION

The dual specificity phosphatase 5 (DUSP5) protein attracts significant attention due to its connection to cancer and cardiovascular diseases. Therefore, availability of an efficient

protocol for expression and purification of this protein is imperative for the biochemical and drug development studies of this protein. In this research contribution, we present a detailed procedure of the GST-tagged DUSP5 expression/purification in large quantities necessary for the subsequent studies. The identity and purity of the expressed DUSP5 protein was validated by the primary sequence analysis, chromatography, and mass spectrometry.

AUTHOR INFORMATION

Corresponding Author

*Dr. Marat Talipov Department of Chemistry New Mexico State University 1175 N Horseshoe Dr. Las Cruces, New Mexico 88003 E-mail: talipovm@nmsu.edu

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Outstanding Science Teacher Award

ABOUT THE AWARDS

Since 1968, the New Mexico Academy of Science (NMAS) has awarded the Outstanding Science Teacher Award to honor New Mexico science and math educators. This award recognizes teachers who provide opportunities for students to succeed. Nominations are open to all preK-12 teachers and informal science educators throughout New Mexico. NMAS presents a plaque and a monetary award to each teacher. The American Chemical Society also presents a monetary award to the winning teachers.

2021 Recipients

The 2021 New Mexico Outstanding Science Teacher Award winners are Meagan Strain from Desert Hills Elementary in Las Cruces and Kerrie Thatcher from Jefferson Montessori Academy in Carlsbad.

Meagan Strain is a 5th grade science teacher at Desert Hills Elementary in the Las Cruces Public Schools. She has taught for 9 years; and for the past two+ years she has been the departmentalized 5th grade science teacher, teaching all 5th grade students an hour of dedicated science each day – this is remarkable as the need for time for math and English language arts is great and science often loses out in elementary schools. She is able to teach science all day in her classroom and dive more deeply into science than is common in elementary school. She genuinely cares for and supports her students and their families and is passionate about the success of her students. She understands how vital science education is and attends to equity by engaging all students in quality science learning. She also involves her larger school community by continuing to advocate for time spent in science teaching and learning. Her students enjoy having science every day and many say that this is their favorite class. They collaborate through hands-on science and engineering experiences, they read, write, speak and listen about science concepts, they give presentations to their peers, and they engage in the foundations of scientific arguments using the process of "claim, evidence, reasoning." Ms. Strain has also served on the district Elementary Science Leadership Committee. This committee has been a critical component in promoting science education in Las Cruces Public Schools by creating district Science Instructional Guides for teachers and building content during Remote Instruction.

Kerrie Thatcher is a 6th-12 grade science teacher at Jefferson Montessori Academy (JMA), a Charter School authorized by Carlsbad Municipal Schools. She has taught for 10+ years and is also the science fair mentor and Special Education Coordinator. She is revered at JMA as a science nerd; and wows the younger students with her wacky Halloween experiments and Star Wars knowledge. Ms. Thatcher has taught integrated science, biology, physical science, horticulture and chemistry; and was the driving force in creating a science fair requirement in 2015 for middle school and secondary students that focused on student interests and was fueled by parent and staff volunteers. What began as a school science fair has become annual regional, state, and international fair participation by both general education and special education students. In 2019, a weekly STEM club was created to allow experienced science fair students to mentor elementary and middle school students with their research and projects. Ms. Thatcher believes that the science competitions are an excellent opportunity for students to learn how to handle themselves in interviews, respond to criticism appropriately, and be supportive of each other. Ms. Thatcher collaborates with other teachers to reinforce math concepts and English Language Arts skills in student science presentations. Her dedicated mentorship of both middle and high school science students has led to a successful track record of awards and recognition for these students including competing and placing in the International Genius Olympiad in New York for 5 years. The most amazing testament to her ability to turn science into a passion among students is the past graduates who return to talk about science or volunteer as a science fair judge for a new batch of "Thatcher's Science Kids."

2021 New Mexico Research Symposium











ABOUT THE RESEARCH SYMPOSIUM

The 2021 New Mexico Research Symposium was held virtually November 8 through 12 due to COVID-19. Over 100 people registered for the online event and nearly 20 posters were showcased in the virtual poster session. Abstracts of these posters are included in this annual volume of the NMAS *New Mexico Journal of Science*. The Symposium closed with an awards ceremony honoring the two 2021 Outstanding New Mexico Science Teacher Award recipients, Meagan Strain from Desert Hills Elementary in Las Cruces and Kerri Thatcher from Jefferson Montessori Academy in Carlsbad, and the student poster competition winners.

SYMPOSIUM WELCOME FROM 2021 NMAS PRESIDENT

On behalf of the New Mexico Academy of Science, I would like to welcome each of you to the 2021 Research Symposium. NMAS is pleased to partner with New Mexico EPSCoR, the UNM Center for Water and the Environment, the American Chemical Society, and New Mexico Space Grant Consortium to sponsor this annual conference to promote science and science education in our community. The COVID-19 pandemic this year again has prevented us from gathering in person. Fortunately, EPSCoR's resources have enabled us to gather virtually. Big compliments are due to NM EPSCoR's resourceful and hard-working staff led by Sara Pichette and Brittney Van Der Werff. This year's theme is Space Exploration, a national endeavor where our state has played a big role. Our keynote speaker is Dr. Larry Crumpler, the Space Research Curator at the New Mexico Museum of Natural History and Science. At NASA, he was on the teams that designed the Mars rovers and helicopter. Dr. Crumpler will speak about the latest discovery enabled by Perseverance rover and Ingenuity helicopter. High-resolution images will show you that Mars has a lot of visual resemblance to our state's deserts and volcanoes. Please join us for his outstanding presentation and answers to your questions. As we do every year, the symposium presents the awards for Outstanding Teachers in our state. We will have a few days of interesting and engaging presentations by students and professors. Student posters will be presented and judged online, and awards will be given to the authors of the best posters.

Gretchen Gürtler, NMAS President



OPENING KEYNOTE SPEAKER: LARRY CRUMPLER, PH.D.

Dr. Crumpler is a member of the Perseverance Rover Mission science team and was a member of the development team for the Ingenuity helicopter. Prior to this mission, Dr. Crumpler was a member of both the Spirit and Opportunity missions for the Mars Exploration Rover, where he downloaded information from the rover daily into his office at the Natural History Museum. Is opening keynote address, "The Exploration of Mars: A New Era of Discovery with Perseverance and the Ingenuity Helicopter" summarized the exploratory timeline of Mars while highlighting his personal connections to the red planet.

ABOUT THE SPONSORS

New Mexico Academy of Science

Founded in 1902, the New Mexico Academy of Science (NMAS) has been in continuous existence since 1915. NMAS is a member of the National Association of Academies of Science (NAAS) and an affiliate of the American Association for the Advancement of Science (AAAS). NMAS works with teachers, state agencies, and the legislature to establish appropriate standards for the teaching of the sciences. NMAS goals are to foster scientific research and scientific cooperation, increase public awareness of the role of science in human progress and human welfare, and promote science education in New Mexico. Visit <u>www.nmas.org</u> to learn more.

New Mexico EPSCoR

The New Mexico Established Program to Stimulate Competitive Research (NM EPSCoR) is funded by the National Science Foundation (NSF) to build the state's capacity to conduct scientific research. The infrastructure and activities of the New Mexico SMART Grid Center are designed to support shared-use equipment, engage new research and community college faculty, and support the STEM pipeline by training teachers, undergrad-uate and graduate students, and post-doctoral fellows. Research findings are communicated broadly through various outlets, including local museums. Visit <u>www.nmepscor.org</u> to learn more about NM EPSCoR, and visit <u>www.nsf.gov/epscor</u> to learn more about the NSF EPSCoR initiative and other jurisdictions.

American Chemical Society

The American Chemical Society (ACS) is the world's largest scientific society and one of the world's leading sources of authoritative scientific information. A nonprofit organization, chartered by Congress, ACS is at the forefront of the evolving worldwide chemical enterprise and the premier professional home for chemists, chemical engineers and related professions around the globe. The Central New Mexico Local Section of the American Chemical Society was founded in 1946 and generally serves the northern two-thirds of the state of New Mexico. The Local Section specifically includes the following New Mexico counties: Bernalillo, Los Alamos, Rio Arriba, San Miguel, Sandoval, Santa Fe, Socorro, Taos, Torrance, and Valencia.

UNM Center for Water & the Environment

The mission of the Center for Water and the Environment at the University of New Mexico is to increase the participation of underrepresented minorities (URM) in science, technology, engineering and math (STEM) professions while conducting cutting-edge research into technological and engineering-based solutions to problems with water and the environment, in a framework that considers the social, economic, policy, regulatory, and legal implications. Practical solutions to problems related to water availability in arid environments and in times of drought, and problems associated with energy generation and consumption are particularly relevant, in light of the criticality of these issues to the state of New Mexico, the southwestern United States, and their global importance. Learn more at <u>cwe.unm.edu</u>.

New Mexico NASA EPSCoR

NM NASA EPSCoR provides competitive seed funding and advice to faculty who are conducting research that aligns with NASA Mission Directorates and/or NASA Field Centers (including JPL). The goal is to provide funding to develop competitive research and technology projects and programs for the solution of scientific and technical problems of importance to NASA. NM NASA EPSCoR also contributes to the overall research infrastructure, science and technology capabilities, and/or economic development of the state. Various funding opportunities are available from NASA EPSCoR such as the Research Cooperative Agreement Notice, International Space Station Flight Opportunity, Suborbital Flight Opportunity, and Rapid Research Response.

UNDERGRADUATE STUDENT POSTER ABSTRACTS

Poster session abstracts are listed alphabetically by last name of registered presenter. An asterisk (*) indicates the poster received an outstanding undergraduate poster award at the 2021 New Mexico Research Symposium.

Kinetics for the Synthesis Pathway from Cystamine to Taurine

Lauren Anderson, Eastern New Mexico University Steven Karpowicz, Eastern New Mexico University

Taurine is an amino sulfonic acid that is found widely in animal tissues and is shown to have antioxidant and antiatherogenic properties. It can be found most in the retina, brain tissue, the heart and muscles throughout the body, and when deficient is associated with cardiomyopathy, renal dysfunction, developmental abnormalities, and severe damage to retinal neuron. Its biosynthesis is not fully understood and multiple reaction pathways leading to taurine have yet to be explored in depth. Its synthesis has been poorly studied and multiple pathways have yet to be explored in depth. The experiments conducted aim to establish the kinetics and characteristics of the cystamine to taurine pathway. Fluorescence and Raman spectrophotometers follow changes in product concentration for both enzymatic and non-enzymatic reactions that are involved in this pathway. Rate constants for four reactions are determined from fitting experimental data to kinetic models. The identities of reaction products are confirmed by mass spectrometry. Kinetic values permit the prediction of biological rates of reaction, to determine if this taurine synthesis pathway is biologically relevant.

Soil Analysis of Trinity and Surrounding Area

Jay Attel, The University of New Mexico

New Mexico's landscape made it a perfect choice to detonate a weapon so destructive it would change the world forever. Our goal was to investigate what this devastating weapon has done to affect the local soil ecology seventy-six years later. To do this we went to the Trinity site in New Mexico and began taking soil samples. We were not authorized to take soil samples on Stallion Ranch, of White Sands Missile range, so we took our first sample in line with the blast site and outside the base gate. In total, we took 8 samples, spaced ten miles apart, in a straight line north towards the city of Albuquerque. Each sample was collected eighteen inches below surface soil with sterile equipment. We used 16S metagenomic sequencing to discover what deviations and diversity there would be between samples. After careful analysis of our findings, we did not find any significant difference in the soil ecology of Trinity and surrounding areas compared to a control sample. This is good news for New Mexicans as most of the land we sampled was either ranch or farmland. All our samples were teeming with life having thou-sands of reads for proteobacteria and actinobacteria to hundreds of reads for lower read bacteria like verrucomicrobia and planctomycetes. Each sample generated identification of thousands at Kingdom and phylum levels which were also evenly distributed in all other samples, showing uniform ecology between our samples.

Does Energy Mix Affect Consumer's WTP for EV? A Choice Experiment Study

Laura Laemmle, New Mexico State University Jamal Mamkhezri, New Mexico State University

Margarita Leal Marrufo, New Mexico State University

As electric vehicle (EV) adoption rates in the U.S. grow, it is of continued importance to understand the ways consumers respond to the features of these markets and the changes associated with the use of new technology. Currently, a few key states (e.g., California) and large companies (e.g., Uber) have enacted aggressive zero-emission regulations for the transportation sector by a deadline, usually 2035. However, eliminating the emission at the tailpipe without addressing where the electricity to fuel EVs comes from may result in economic inef-ficiency and possibly a loss in the social welfare. Further, electricity source is increasingly relevant to the U.S.

Tyler Didier, The University of New Mexico

transportation sector as growing numbers of EVs coincide with how the U.S. produces and consumes electricity. Many studies have investigated the way consumers respond to both vehicle attributes and related aspects of EV ownership. However, there currently has been no study looking into energy source as an EV attribute or estimating consumers' WTP for clean electricity as an EV fuel source in the U.S. This study will investigate whether electricity source affects consumer attitudes towards EVs and evaluate willingness to pay (WTP) for clean energy as an attribute of EVs. We will also explore American drivers' attitudes towards carbon emission levels, policy incentives for EVs, and ultimate changes in electricity costs. The goal is to model how these factors affect each other and the various state markets for EVs. The survey will use discrete choice experiment methodology to model how consumers respond to tradeoffs associated with EV adoption and use. Understanding the significance of energy sources to consumers in the U.S. can help shape policy, especially as states move forward with renewable energy and clean transportation initiatives. This information is also relevant to policymakers attempting to address supply and demand issues in EV markets as these markets and their infrastructure continue to develop.

Properties of CaF₂ using X-Ray Diffraction and IR Ellipsometry

Jaden Love, New Mexico State University Carlos Armenta, New Mexico State University H. Kim, National Institute of Aerospace Nuwanjula S. Samarasingh, New Mexico State University Stefan Zollner, New Mexico State University

In this undergraduate student poster, we describe the structural and optical properties of calcium fluorite (CaF_a), an insulator with an ultrawide band gap of 12 eV and a large exciton binding energy of 1 eV. The wide range of transparency from 125 meV to 10 eV makes CaF, a desirable substrate for optical devices, such as tunable filters based on phase change memory materials. Most studies of the optical constants of CaF, were performed in the 1960s. Revisiting these optical constants using modern ellipsometry equipment and specimens from different manufacturers with (100) and (111) orientation seems timely. CaF₂ crystallizes in the fluorite structure with space group Fm-3m and a lattice constant of 5.4626 Å. The Ca atoms are located in the Wyckoff (4a) position at the origin. The F atoms are at the (8c) positions (¼, ¼, ¼) and (¼, ¼, ¾). There is a three-fold degenerate Raman-active T2g mode and a three-fold degenerate infrared active T2u mode, which splits into a transverse optical (TO) doublet and a longitudinal optical (LO) singlet. The T2u mode can be observed with Fouriertransform infrared ellipsometry and described with a Lorentzian. The TO and LO energies are 261 and 477 cm-1, respectively, with an amplitude A=4.1, a broadening of 4 cm-1, and a high-frequency dielectric constant of 1.98(1). A dip in the reststrahlen band is due to two phonon absorption described with an anharmonically broadened Lorentzian. In the visible and near-ultraviolet (up to 6.5 eV), normal dispersion can be described with a pole located at 7.48 eV and a Tauc-Lorentz oscillator at 20 eV. The imaginary part of the pseudodielectric function is negative above 3 eV. This indicates a surface layer of 2 to 5 nm thickness with a larger refractive index than the bulk substrate. We apply the CaF₂ optical constants to determine the thickness of a SiO₂ layer on CaF₃.

Machine Learning with Semi-Supervised Outlier Detection Algorithms for Detecting Cyber-Attacks on Smart Grids*

Candida Marti, Santa Fe Community College Anthony Franklin, CNM Dimitri Rodriguez, Eastern New Mexico University

Cyber-attacks can be considered similar to natural disasters. Currently, while the ability to prevent and respond to these attacks is fairly limited, Machine Learning (ML) may one day become a crucial component in doing so. Common methods of detecting cyber-attacks on smart grids are based on Supervised Machine Learning (SML). SML requires both normal and attack data sets to train a model. In this replication project, we tested

semi-supervised algorithms, using only normal data for training. We compared the trained models to the conventional supervised approach to see which had the most success classifying normal data from outliers (attack data). The dataset includes measurements and data logs from Snort, a simulated control panel, and relays provided by The University of Alabama in Huntsville.

Using an outlier detection toolkit for Python called PyOD, we tested seven of the most popular semi-supervised outlier detection algorithms. These included linear models (One Class Surface Vector Method (OCSVM)), proximity-based models (Histogram-Based Outlier Score (HBOS)), Local Outlier Factor (LOF), Clustering-Based Local Outlier Factor (CBLOF), k-Nearest-Neighbor Outlier Detection (KNNOD) and ensemble models (Feature Bagging, Isolation Forrest (iForrest)). We measured the success of these models using precision, recall, and F1 score. Precision measured how many data points were classified as attacks. Recall measured how many data points were correctly classified as attacks. F1 score is the harmonic mean of the model's precision and recall.

The best operators in our experiments proved to be OCSVM, CBLOF, and KNNOD. We then compared those models to the most popular scikit-learn supervised models - SVM and KNN. Our results found that the SVM model produced the best recall by a significant margin, but poor precision by a larger margin. This results in frequent false positives. The best performance overall was the two-class KNN model. However, OCSVM, CBLOF, and KNNOD were able to perform around 98% as well as the KNN model. OCSVM was the most successful semi-supervised model with a balanced recall and precision, resulting in the best F1 score out of the three. Future work may include improving the recall score of our OCSVM model to produce greater F1 results than supervised models.

The impacts of these findings are hard to overstate. Because of minimal frequency in real-life settings, attack data may not be a reliable form of training data, thereby making the implementation of cyber-attack detection with ML rather inefficient. However, with some improvement, our study may suggest that in the future semi-supervised models could provide the solutions needed to implement ML in detecting and responding to cyber-attacks on smart electric grids.

Fabrication of Low Cost, Paper-Based Electrodes*

Michael Nelwood, Navajo Technical University Justin Platero, Navajo Technical University

Bisphenol (BP) is a chemical additive used to strengthen polycarbonate plastics and epoxy resins. Bisphenol, however, is a known toxicant often categorized as an endocrine-disrupting chemical (EDC). Bisphenol absorption in the body can result in metabolic disorders, such as type-2 diabetes, obesity, immune toxicity, and other serious diseases. Approximately 90% of humans accumulate BP levels through exposure to food containers, plastic bottles, thermal printing papers, and other everyday plastic products. Herein, we report the development of low-cost, flexible paper-based electrodes for the electrochemical detection of BP compounds. We applied carbon screen-printed paste onto our paper substrate electrodes for our three-electrode system. We demonstrate our paper-based electrodes can detect BP for optimal concentration in the laboratory at physiological pH conditions. Further, the sensitivity of these electrodes and linear electrochemical response makes them well suited for real-time applications and point detections.

Metagenomic Analysis of Bacteria in the Middle Rio Grande in New Mexico

Aida Nevarez, UNM Valencia Ben Flicker, UNM Valencia Nicolette Sanchez, UNM Valencia Victor French, UNM Valencia

While soil and aquatic bacteria are critical to ecosystem function, their abundance and diversity in the Rio Grande river ecosystems has not previously been studied. In this study we used the 16s rRNA sequencing

method to elucidate the diversity of bacteria in two different regions of the middle Rio Grande in New Mexico: Los Lunas and Belen. Both water and soil samples were collected for whole-genome extraction. We also compared the three sites in abiotic factors such as dissolved oxygen, conductivity, and temperature. We will present the bacteria found using these sequencing data and make comparisons of the species diversity between these two communities. We will also provide comparisons of the species diversity and characteristics of those bacteria from Fall 2019, Winter 2020, and Summer 2020 collections.

Design and Fabrication of Flexible, Paper-based Electrochemical Sensors to Detect Heavy Metals in Groundwater*

Justin Platero, Navajo Technical University Khalid Abdelazim, Harvard University Katelynn Wilson, Navajo Technical University Makeiyla Begay, Navajo Technical University Thiagarajan Soundappan, Navajo Technical University Michael D. Nelwood, Navajo Technical University Jasmine Charley, Navajo Technical University Samantha Francis, Navajo Technical University

The history of mining and mineral extraction across the Navajo Nation has resulted in considerable contamination of the land and groundwater resources, which is a significant environmental concern. Through a partnership between Navajo Technical University and Harvard University, we have designed and fabricated flexible, paper-based sensors in tandem with electrochemical techniques such as cyclic voltammetry and differential pulse voltammetry to determine heavy metal concentrations in test samples. We have selected to fabricate paper-based electrochemical sensors because; they are low-cost, easy to make, environmentally friendly, and can be deployed for field testing across the Navajo Nation. Furthermore, the linear electrochemical response and sensitivity of these electrodes, for detecting heavy metals, make them well suited for real-time sensors in field-testing applications.

Can Aspect in a Pinon/Juniper Biome Be Used to Predict Climate Change Impact?

Kayl Rainer, UNM Taos

In Northern New Mexico we have a diverse range of biomes, but our focus is on the Pinon and Juniper biome. This biome has many positive impacts: a firewood source for humans, habitat, and food for animals, and removes the pollutants from the air including carbon dioxide.

We used points along two transects over 25m to gather unbiased information on the amount of vegetation or lack thereof. We took our data on the transect in the east direction on the south-facing side and took our data in the west direction on the north-facing slope. Our results showed that there was much more dead vegetation and less trees on the south-facing side than on the north-facing side. Even though both sides are very similar, the difference is the higher amount of sun and heat the south-facing side receives, compared to the shady north-facing side.

I hypothesized that the amount of sun that affected the south-facing mountain, can be a projection for the north-facing side faced with global warming. We tested, by taking data on both sides. On the south-facing slope, we recorded there were 10 alive coniferous, 4 dead coniferous, and 38 of no vegetation. On the north-facing slope we found there were 22 alive coniferous, 2 dead coniferous, and 27 of no vegetation.

My results found that the sun and heat had created many effects similar to effects global warming would inflict. My hypothesis was correct, I conclude that we can predict the effects global warming will have on the north-facing slope, based on the current state of the south-facing slope. If this happens and we start to see a decline in our Pinon and Juniper biomes, we would be losing out on things they provide, like cleaning the air of man-made pollutants, providing a home and food for animals, and keeping winter snow.

Triggering Eye Movements in Mice to Understand Stable Visual Perception

Maximino Robles, New Mexico State University Alon Poleg-Polsky, University of Colorado

Joshua Hunt, University of Colorado Gidon Felsen, University of Colorado

Our project is motivated by the question of how the brain suppresses perception sometimes. Specifically, during motion signals of motion that we voluntarily generate with our eyes. To have a model for answering this question, we first need to reliably elicit these voluntary eye movements. Presenting a drifting grating, the Felsen and Poleg-Polsky labs did that in mice except the eye movements were involuntary. Presenting a moving center that radiates dots, other scientists did that in primates and the eye movements were voluntary. We want the same stimulus to work on mice because they're more ethical subjects. Therefore, we hypothesized that a mice-adapted stimulus would work on mice. We discovered that the moving center of our stimulus elicited eye movements. Next, we discovered the moving center of the stimulus elicited involuntary eye movements. Next, we discovered the moving center of the stimulus elicited more eye movements when on the left side of the screen. Since this came from expanding dots, the next step should be to try contracting dots. Ultimately, our data doesn't support the hypothesis that our mice-adapted optic flow stimulus would elicit voluntary eye movements. We could expect difficulty in eliciting voluntary eye movements in mice because they have such large field of vision and spread out photoreceptors that they may not need voluntary eye movements. Our results were relevant because they say something about the potential of mice as models to understand how we make sense of a moving world when we ourselves move in it.

Soils Uranium Level Variability Within Sites Around the Navajo Nation

Tionna Tapaha, Navajo Technical University David Willie, Navajo Technical University Irene Anyangwe, Navajo Technical University Zabari Obyoni Bell , Navajo Technical University Palmer Netongo, Navajo Technical University

The Navajo Nation has over 500 abandon uranium mines. The impact of the uranium spills from these mines on soil bacterial flora is unclear. We undertook a project to therefore assess the impact of uranium levels and soil bacterial population in five sites in Crownpoint. For proper sampling, we collected four samples (15 meters apart) from each of the following sites; Navajo Technical University (NTU) main campus, Dalton Pass, West Mesa, Nahodishgish, and St. Paul. We used the Fluorat-02 5M analyzer to evaluate the uranium levels by phosphorescence, enhanced with sodium polysilicate. We also determined the pH levels, the physiochemical properties and cultured bacteria from these soil samples. The soil was mostly clay at NTU Main Campus and West Mesa with an average pH of 4 and 5.5 respectively. Mostly sandy soil was found in Dalton Pass (pH 7.4), loamy soil in St. Paul Mission (pH 7.9), and silt in Nahoodishgish (pH 8.3). The most acidic soils also recorded the highest levels of sulphur (960mg/kg on average) and uranium i.e. 600 mg/Kg (range 2.5-2105mg/Kg) in West Mesa and 760mg/kg (range 126-917 mg/Kg) in NTU. This significant variability within sites was very concerning but reiterated the need for proper sampling in such studies.

GRADUATE STUDENT POSTER ABSTRACTS

Poster session abstracts are listed alphabetically by last name of registered presenter. An asterisk (*) indicates the poster received an outstanding graduate poster award at the 2021 New Mexico Research Symposium.

Zero-Power AC Sensor/Energy Harvester for Smart Grids

Omar Aragonez, The University of New Mexico Nathan Jackson, The University of New Mexico

A sensor capable of sensing and harvesting energy is of interest to create a self-sustained system, for smart grid applications. The device operates by using a piezoelectric cantilever that couples the magnetic field from current through a wire to a permanent magnet-proof mass. This generates an oscillating force on the piezoelectric cantilever which converts mechanical energy to usable electrical energy. The research investigates the sensitivity of the sensor and its capability of harvesting energy by optimizing the cantilever dimensions with various wire sizes and configurations.

The concept has been validated but optimization of the cantilever, placement of the magnetic proof mass in relation to the various configuration wires, and high current have not been investigated. The positioning of the magnetic proof mass on the cantilever with relation to the wire is crucial for optimizing performance of the energy harvesting device. Cantilever stiffness and cable configuration are crucial to determining optimal placement but are not considered in previous studies.

This piezoelectric cantilever energy harvester concept has been validated for both the macro and micro levels. Recent research has focused on maximizing power outputs by optimizing magnet configuration and magnetic pole orientations for single solid wires with low current. The same has been done for household appliance zipcord style wires. Previous studies focused on custom-made energy harvesters and did not investigate the effects of stiffness on the optimal location of the magnetic proof mass or the use of solid vs stranded wires.

The optimal location of the magnet proof mass in relation to the wire was determined by maximizing the magnetic flux through finite element modeling as well as experimentally by measuring peak voltage output from the piezoelectric cantilever. The cantilevers investigated in this study are tuned to operate at a resonant frequency of 60 Hz using NdFeB magnets as a proof mass. Once the optimal position was determined the optimal power was measured as a function of varying current.

The two types of cantilevers investigated had the same width and length but varying thicknesses due to different number of piezoelectric layers. The different number of layers alters the stiffness, as well as the amount of piezoelectric material available to produce a charge. Experimental and finite element modeling determined that the optimal location of the magnet for a solid wire was between 33° and 40° depending on the cantilever stiffness. With optimal placement, the power output of the devices was as high as 2.46 mW for a 20 A current source.

This is conducted using a macro-scale cantilever with the goal to gain insight to apply to micro-electromechanical devices. As the device is scaled down to MEMS the power will decrease, and the stiffness will change but the location of the magnets should remain for optimal performance.

GIS-Based Methods for Electric Vehicle Charging Station Site Selection*

Jason Banegas, New Mexico State University

Many studies have incorporated particular models with various methods and algorithms to resolve the site selection problem for Electric Vehicle Charging Stations (EVCS). This paper systematically reviews research that evaluates Geographic Information Systems (GIS) based EVCS location techniques and the variables used for decision making. We classify and characterize those techniques and variables to determine important linkages

within the literature. A variety of databases were referenced to extract research published from 2014 to 2021 pertinent to this specific location problem, and 40 papers were selected after thorough evaluation. The models used in each paper were examined along with the methods for selecting variables and ranking alternate locations. Site selection for EVCS requires a Multi-Criteria Decision Making approach to meet the sustainability, efficiency, and performance goals of communities adopting electric vehicle mobility. Our results indicate that map algebra and data overlay methods have been used more frequently with GIS-based analysis than other techniques, while geographic and demographic variables are commonly the most significant site selection factors. The reviewed methods have most often been applied to urban locations; however, the transfer of these techniques to a rural EVCS site selection problem has been rarely explored in the current literature. This research assessment contributes relevant guidance for the application of methodologies useful in policymaking and provides recommendations for future research based on these findings.

A Four Corner Study on Willingness to Pay for a Distributed Feeder Microgrid that Reduces the Probability of Wildfire

Clara Harig, The University of New Mexico

The 2020 Wildfire period was severe for states in the Western United States. In the four corner states, our team sent out a contingent evaluation (CV) questionnaire asking approximately five thousand people their willingness to pay (WTP) for microgrids that could help decrease wildfire disasters on the electricity grid. When a wildfire is sparked, turning off critical lines can help decrease the damage from the fire, but this decision shuts off electric-ity to the people receiving electricity via that line. Introducing a microgrid could reduce the number of shutoffs. Updating the grid's infrastructure with a microgrid can reinforce the resilience and reliability of the entire grid during wildfires, but this recommendation comes at a high cost.

User Controllable Privacy Management Mechanism in the Smart Grid System: Ontologybased Approach*

Raisa Islam, New Mexico Tech Md Umar Sharif, New Mexico Tech

Dongwan Shin, New Mexico Tech

Smart grid system is one of the most complex cyber-physical systems consisting of distribution, generation, and customer domains, and millions of connected end devices. The widespread implementation of the smart grid raises concerns about the privacy of the data it collects. Since users' personal and non-personal data are going to be accessed by different entities involved in the smart grid and by third parties, the privacy concern can be a big obstacle in the adoption of the smart grid among people. Hence, there is an urgent need to provide the user with a privacy solution to support selective sharing of their usage data with different entities. In this paper, we propose an ontology-based user privacy management approach that will enable the user to make an informed decision while releasing their data based on sensitivity and privacy factors, thus manage their privacy. Green Button Initiative is an smart grid application that allows the user to download and share their energy usage data with third parties. We presented a proof-of-concept implementation extending the Green Button Initiative to test the feasibility of the proposed approach. Lastly, we conducted a comparative user study to investigate the effectiveness of our proposed approach.

Public Support for Community Microgrids*

Jesse Kaczmarski, The University of New Mexico

Utility-owned community microgrids can provide communities with decentralized grid access to distributed energy resources and improve reliability and resiliency. However, the feasibility of installing microgrids requires rigorous cost-benefit analysis, which should incorporate social values. Currently, the gap in our understanding of ratepayers' preferences for community microgrid services leaves stakeholders guessing. Using a survey-based contingent valuation method, with a referendum-style elicitation format, this paper provides evidence of public support for community microgrid installations in Arizona, Colorado, New Mexico, and Utah (the Four Corners). The Four Corners region is unique in its potential for renewable electricity capacity as well as heterogeneous state policy objectives regarding the transition to clean energy. A split-sample survey of 4,783 Four Corner's rate-payers resulted in between 40-45% of respondents voting to support a community microgrid installation (after controlling for hypothetical bias) with a median willingness-to-pay (WTP) of \$25.44 (divided among 24 months) if the ratepayer received direct benefits, or \$13.92 if they received indirect benefits. Ratepayers in Utah were willing to pay the most relative to the other states. Results highlight the impacts of ideological, institutional, and socioeconomic factors on public support and WTP.

The Price Elasticity of Demand for VMT in the United States from 2000-2020: A Dynamic Panel-Data Analysis

Miguel Perez, New Mexico State University Jamal Mamkhezri, New Mexico State University

Margarita Leal Marrufo, New Mexico State University

In economics, an influential concept is found in the measure of elasticity. This sensitivity, or measure of aggregate quantity demanded relative to price movements, offers insight of good use for policymakers, industry, and academia. Our discussion provides a view into the realm of travel demand for light-duty vehicles in the United States, specifically, the relationship between the change in the quantity of vehicle miles traveled given a change in its determinants.

Vehicles as a facet of technology are rapidly developing into more efficient machines. The variety of vehicles available is expanding. There are now alternatives to traditional gas-fueled vehicles, but not without new costs. As well, the transition to greener economies is virtually evident, so moving forward society is faced with a new level of uncertainty. By use of travel demand theory and economic activity we explore vehicle demand, to provide decision-makers of today with useful information to set rational expectations for the uncertain future.

Vehicle demand is a derived demand, a person who demands vehicles is in actuality demanding some means of transportation. This means of transportation allows an individual to travel and we can measure this activity by the vehicle miles traveled. Through the demand for travel, we can then figure relevant determinants for estimation. Forecasting approaches vary, but the literature suggests a strong relationship between vehicle demand and income & prices. As well, the literature mentions the prevalent subject of the transition to renewables. For vehicles, the distinction between gas-powered or electric suggests some structural overhaul necessary to transition to such alternatives, due to expected changes in energy demands.

Our study employs annual data of the fifty United States over the period of 2000-2020, organized in segments including explanatory variables related to demographic characteristics, economic activity, income measures, costs of driving, vehicle price, road supply, and employment. Using dynamic fixed-effect panel techniques with log-log functional forms, we estimate price and income elasticities of demand for vehicle miles traveled. To estimate long-run elasticities, we utilize distributed lag models. To correct for endogeneity, we use urban land area and crude oil prices as two separate instrument variables.

Preliminary results reveal a -0.05% short-run price elasticity of demand for driving, meaning as the price of gas increases by 1%, vehicle miles traveled decreases by 0.05%. The long-run price elasticity of demand for driving is approximately four times larger than in the short run. Income elasticity was 0.08, suggesting if income increases by 1%, vehicle mile travel increases by 0.08%. consumption elasticity was 0.05, implying if gas consumption increases by 1%, vehicle mile travel increases by 0.05%. Our preliminary results of elasticities are within the ranges found in the literature.

Metrics of Woody Structure as Indices of Resource use in US southwestern Shrublands

Trevor Roberts, New Mexico State University

Critical aspects of ecosystem function and structure are often expressed through vegetation structural components. Measurements of these structural components serve as informative indices of local ecosystem resource characteristics, such as water availability and soil quality. It is unclear, however, which elements of vegetation structure better correlate with local resource densities and distributions. In order to answer this question, we processed and analyzed shrub cover, height, and density data in a semi-arid desert of the American Southwest. Our analysis focused on comparing estimates of canopy volume to canopy cover in a site experiencing widespread woody-encroachment. We calculated canopy volume on a hectare scale across the site using USGS quality level 2 airborne LiDAR data. Airborne Laser Scanning (ALS) missions were conducted in the winter of 2018/2019. Raw ALS data was processed into classified point clouds before we received it, and it was this dataset that we analyzed. Canopy cover, meanwhile, was calculated in a previous study using multispectral imagery and an unsupervised classification approach. Early results suggest that canopy volume and canopy cover metrics both describe interactions between shrubs well. We have yet to determine which metric is a more suitable index of resource use, but we hypothesize that volume is the more biologically relevant measure given its clearer relationship to available water. Future work aims to better delineate differences between volume and cover distributions as well as quantify shrub resource use in a more mechanistic manner, such as with evapotranspiration or sap flow estimates. Current and future results will support understanding of community interactions and resource use in semi-arid shrublands as well as contribute to the challenging field of high-resolution remote-sensing in short-stature vegetation.

Using Traditional Foods to Teach Science and Culture on the Navajo Nation

Breanna Thompson, Navajo Technical University Irene Anyangwe, Navajo Technical University Abraham Meles, Navajo Technical University David Weitz, Harvard University Vayu Maini Rekdal, University of California - Berkeley

Kathryn Hollar, Harvard University Pia Sörensen, Harvard University

Food has always been a way to bring families together on the reservation. By teaching students the stories and science behind the foods that families make regularly, we can teach science in the context of Diné Philosophy and Navajo culture. In this study, we implement this approach through experiments based on corn, which is culturally and nutritionally important. In our first experiments, we prepared corn tortilla doughs with varying amounts of water. By creating small cylinders of dough, then applying a weight on the top of the cylinders and documenting area and the change in length, we calculate and introduce the physics concept of elasticity. In our experiments, we observe that the elastic modulus increased with the addition of water. In visits to local high schools and on-campus events, demonstration of these experiments increased interest in science and engineering. Future work involves comparing the elasticity of corn flour vs. wheat flour, as well as developing experiments on the nixtamalization of corn. For example, in preparing the Navajo staple food, blue corn mush, we measured the pH of boiled ash from branches of different juniper trees, and observed differences in flavor when using these ashes to make the blue corn mush.

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CONTACT INFORMATION

The New Mexico Academy of Science c/o The New Mexico Museum of Natural History and Science 1801 Mountain Road NW Albuquerque, New Mexico 87104 nmas@nmas.org www.nmas.org

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