

The National Junior Science  
and Humanities Symposium

Abstracts  
of the  
Research Finalists



The abstracts in this publication include  
science research conducted by students  
who participated in the  
52nd National Junior Science and Humanities Symposium  
Washington, D.C.  
April 23-27, 2014

Sponsored by  
The Departments of the Army, Navy and Air Force  
In cooperation with higher education

Administered by  
The Academy of Applied Science  
Concord, NH 03301



# The National Junior Science and Humanities Symposium

## *Program Objectives*

- To promote research and experimentation in the sciences, mathematics, and engineering at the high school level.
- To recognize the significance of research in human affairs, and the importance of humane and ethical principles in the application of research results.
- To search out talented youth and their teachers, recognize their accomplishments at symposia and encourage their continued interest and participation in science, mathematics, and engineering.
- To expand the horizons of research-oriented students by exposing them to opportunities in the academic, industrial, and governmental communities.
- To increase the number of future adults capable of conducting research and development.





# *Table of Contents*

Directors of Regional Symposia	Section I
Student Participants Attending the National JSHS	Section II
Abstracts of Student Papers	Section III



# Section I

## The National Junior Science and Humanities Symposia

Directors of Regional Symposia

Academic Year 2013-2014

### **Alabama**

Catherine Shields  
Jefferson County Int'l Baccalaureate School  
6100 Old Leeds Road  
Birmingham, AL 35210  
Fairbanks, AK 99775-6100

### **Arizona**

Dr. B.L. Ramakrishna  
School of Materials  
Arizona State University  
PO Box 878706  
Tempe, AZ 85287

### **California, Northern & W. Nevada**

Mr. Roger E. Martin  
Bay Area Science Fair, Inc.  
Lawrence Hall of Science San Francisco  
University of California at Berkeley  
Berkeley, CA 94720-5200

### **Connecticut**

Dr. Joy Erickson  
Chemistry Department U 3060  
University of Connecticut  
55 North Eagleville Road  
Storrs, CT 06269-3060

### **Florida**

Dr. Mary Jo Koroloy  
Center for Pre-collegiate Ed & Training  
University of Florida  
P.O. Box 112010, 334 Yon Hall  
Gainesville, FL 32611-2010

### **Hawaii**

Dr. Amanda Lowrey  
Hawaii Academy of Science  
c/o The College of Education  
1176 University Avenue UA-4-4  
Honolulu, HI 96822

### **Alaska**

Dr. Abel Bult-Ito  
University of Alaska Fairbanks  
CSEM & Dept of Biology and Wildlife  
307C Bunnell Building

### **Arkansas**

Dr. Ronald J. Tackett  
Department of Physical Science  
1701 N Boulder  
Arkansas Tech University  
Russellville, AR 72852

### **California, Southern**

Dr. George & Ann Miller  
Department of Chemistry  
University of California Irvine  
Irvine, CA 92697-2025

### **DoDS Europe**

Mr. Brian Zimmer  
DoD Dependents Schools-Europe  
PSC 851 Box 690  
APO AE 09834

### **Georgia**

Dr. Karen Shetterley  
Center for Continuing Education  
University of Georgia  
1197 South Lumpkin St.  
3900 Reservoir Road NW  
Athens, GA 30602

### **Illinois**

Ms. Stephanie Eichholz  
College of Science  
Mailcode 4403, 1245 Lincoln Drive  
Southern Illinois University Carbondale  
Carbondale, IL 62901-4403

## **Illinois-Chicago**

Mr. William Kroll  
Loyola University Chicago  
Dept of Biology  
6525 North Sheridan Rd.  
Chicago, IL 60626

## **Intermountain**

Mr. Mateo Remsburg  
Office of Student Recruitment and High School Services  
University of Utah  
200 S. Central Campus Dr., Rm 80  
Salt Lake City, UT 84112-9104

## **Kansas-Nebraska-Oklahoma**

Dr. Julie Angle  
Science Education  
227 Willard Hall  
Oklahoma State University  
Stillwater, OK 74078

## **Louisiana**

Ms. Shannon Carlson  
Louisiana State University - Continuing Ed  
2234 Pleasant Hall  
Baton Rouge, LA 70813

## **Michigan, Southeastern**

Dr. Maria Ferreira  
College of Education, Room 281  
Wayne State University  
Detroit, MI 48202

## **Missouri**

Dr. Tom Spudich  
Maryville University  
650 Maryville University Drive  
St. Louis, MO 63141

## **New Jersey Monmouth**

Dr. Datta Naik  
Monmouth Junior Science Symposium  
Monmouth University  
West Long Branch, NJ 07764

## **New York, Long Island**

Dr. Panayiotis Meleties  
CUNY York College  
94-20 Guy Brewer Blvd.  
Jamaica Queens, NY 11451

## **Indiana**

Dr. Dave Grabowski  
Dept of Sciences and Mathematics  
Saint Mary of the Woods College  
Saint Mary of the Woods, IN 47876

## **Iowa**

Dr. Susan Assouline  
Belin-Blank Center for Gifted Education  
The University of Iowa  
600 Blank Honors Center  
Iowa City, Iowa 52242

## **Kentucky**

Dr. William Thornburgh  
University of Louisville  
1905 S. 1st Street  
Louisville, KY 40292

## **Maryland**

Dr. Carl White  
Morgan State University  
School of Engineering/CAMRA  
5200 Perring Pkwy, Suite 200  
Baltimore, MD 21251

## **New England, Northern and**

New England, Southern  
Dr. Subhash Minocha  
University of New Hampshire  
Rudman Hall, 46 College Rd  
Durham, NH 03824

## **New Jersey, Northern**

Mr. Jean Patrick Antoine  
98 Brett Road  
Rutgers University  
Piscataway, NJ 08854-8058

## **New York, Metro**

Dr. Panayiotis Meleties  
CUNY York College  
94-20 Guy Brewer Blvd.  
Jamaica Queens, NY 11451



## **New York, Upstate**

Dr. Daniel L. Wulff  
Dept. of Bio Sciences  
University at Albany  
1400 Washington Avenue  
Albany, NY 12222

## **North Central**

Ms. Lise Weegman  
Minnesota Academy of Science  
8700 West 36th Street  
Suite 114W  
St. Louis Park, MN 55426

## **Oregon**

Dr. Geraldine Richmond  
University of Oregon  
Chemistry, 5219  
Eugene, OR 97403-5219

## **Pennsylvania**

Dr. David B. Klindienst  
Pennsylvania State University  
Chambers Bldg  
University Park, PA 16802

## **South Carolina**

Dr. Don Jordan  
Center for Science Education  
University of South Carolina  
Sumwalt Room 323, 1212 Green St  
Columbia, SC 29208

## **Texas**

Dr. Nancy Magnussen  
College of Science  
Texas A&M University  
3257 TAMU, 517 Blocker Bldg  
College Station, TX 77843-3257

## **Washington**

Dr. Ray Myers  
Seattle Pacific University  
3307 Third Ave, West  
Physics Department  
Seattle, WA 98119

## **North Carolina**

Alisa Wickliff  
Center for Math, Science & Tech Education  
College of Education Suite 222  
Charlotte, NC 28223-0001

## **Ohio**

Dr. Emilio Duran  
School of Teaching and Learning EDHD  
128 Life Sciences  
Bowling Green State University  
Bowling Green, OH 43403

## **DoDS Pacific**

Dr. Sylvia Gingrich  
Student Activities Coordinator  
DoDS Pacific/DDESS-Guam  
Unit 35007, APO AP 96376-5007

## **Puerto Rico**

Dr. Julio de Jesus  
Intellexi, Graduate School  
of Environmental Sciences  
University of Turabo  
P.O. Box 418  
Gurabo, PR 00778-00418

## **Tennessee**

Dr. Theodore Labotka  
315 Earth & Planetary Science  
University of Tennessee  
1412 Circle Drive  
Knoxville, TN 37992-1410

## **Virginia**

Dr. Thomas C. & Doreen DeVore  
Department of Chemistry  
James Madison University  
MSC 4501  
Harrisonburg, VA 22807

## **Washington, D.C.**

Ms. Joy P. Williams  
School of Medicine  
3900 Reservoir Road NW  
Washington, D.C. 20057-1423

**West Virginia**

Dr. Jeanne D. Sullivan  
59 College Avenue  
West Virginia Wesleyan College  
Biology Department  
Buckhannon, WV 26201

**W. Wisconsin & Wisconsin**

Dr. Gary Willhite  
Dept of Educational Studies  
University of Wisconsin  
300B Morris Hall, 1725 State Street  
LaCrosse, WI 54601

**Wyoming-Eastern Colorado**

Dr. Mark Lyford  
Life Sciences Program  
University of Wyoming  
100 E. University Avenue Dept 3165  
Laramie, WY 82071

# Section II

## Student Participants Attending The National Junior Science and Humanities Symposium

Participants	Page	Participants	Page
<b>Alabama</b>		<b>Connecticut</b>	
Joshua C. Abreo.....	1	Daniel G. Giebisch.....	14
Katelynne J. Herron.....	1	<b>Isabelle S. Goldstein.</b> .....	<b>14</b>
Rupa Palanki.....	2	Andrew Ma. ....	15
<b>Rohan Palanki.</b> .....	<b>2</b>	Anubhuti Mathur. ....	15
<b>Lucas D. Riddle.</b> .....	<b>2</b>	<b>Isha A. Walawalkar.</b> .....	<b>16</b>
<b>Alaska</b>		<b>DoD Dependent Schools (Europe)</b>	
Abram Haas.....	3	<b>Garrett Davidson.</b> .....	<b>17</b>
<b>Jake T. Herrmann.</b> .....	<b>3</b>	<b>Leif C. Gruetter.</b> .....	<b>17</b>
Sally Liane Kuhn.....	3	Angela Jeanfrancois. ....	18
<b>William B. Mitchell, Jr.</b> .....	<b>4</b>	Michael H. Leek, III.....	18
Ryan C. Nicholson.....	4	Jessica Morton. ....	18
<b>Arizona</b>		<b>DoD Dependent Schools (Pacific)</b>	
Ivy Chang. ....	5	Ji S. Jeong.....	19
<b>Dhruv Iyer.</b> .....	<b>5</b>	<b>Brian Lee.</b> .....	<b>19</b>
Deshna Joe. ....	6	<b>Frederick J. Lee.</b> .....	<b>20</b>
<b>Yuanqi Zhang.</b> .....	<b>6</b>	<b>Florida</b>	
<b>Arkansas</b>		Ana B. Corra.....	21
Dhruba Dasgupta, Jr.....	7	Isabella V. Daza.....	21
Nimit R. Gandhi. ....	7	<b>Owen R. Kelly.</b> .....	<b>22</b>
Sanjit Kalapatapu. ....	8	<b>Caitlyn Ralph.</b> .....	<b>22</b>
<b>Hanya M. Qureshi.</b> .....	<b>8</b>	Andre Sanchez. ....	23
<b>Shruti Shah.</b> .....	<b>9</b>	<b>Georgia</b>	
<b>California (Northern &amp; Western Nevada)</b>		<b>Sonam A. Brahmbhatt.</b> .....	<b>24</b>
<b>Shiloh S. Curtis.</b> .....	<b>10</b>	Marissa L. Hernandez. ....	24
<b>Neil Movva.</b> .....	<b>10</b>	<b>William H. Jin.</b> .....	<b>25</b>
Swetha Revanur. ....	11	Jordan A. McCray, Sr.....	25
Valliammai Vinaithirthan. ....	11	Molly G. Niemczyk.....	25
Emily S. Wang. ....	11	<b>Greater Washington, D.C. Area</b>	
<b>California (Southern)</b>		<b>Megan Chao.</b> .....	<b>26</b>
Saumya R. Keremane. ....	12	<b>Kristi A. Kan.</b> .....	<b>26</b>
<b>Kevin K. Lee.</b> .....	<b>12</b>	Caden W. Petersmeyer.....	26
Daniel Shaw.....	13	<b>Hawaii</b>	
<b>Yousuf M. Soliman.</b> .....	<b>13</b>	Kealyssa M. Castillo-Martin. ....	27
		Charu Joserose. ....	27
		<b>Ariana Kim.</b> .....	<b>28</b>
		<b>Viola Mocz.</b> .....	<b>28</b>

Note: Presenter's name appears in boldface.

**Illinois**

Chase D. Latour..... 29  
**Natalie A. Nickrent..... 29**  
**Conner T. Ruhl..... 29**  
 Brian J. Suarez..... 30  
 Andrew L. Woodruff..... 30

**Illinois (Chicago)**

**Tushar Dwivedi..... 31**  
**Grace M. Niewijk..... 31**  
 Pranav Sivakumar..... 32  
 Talia E. Weiss..... 32

**Indiana**

**Jordan R. Cadle..... 33**  
 Tingyue Cui..... 33  
**Kamna Gupta..... 34**  
 Kevin T. Hunckler..... 34  
 Krishan S. Kumar..... 35

**Intermountain**

**(Colorado, Montana, Idaho, Nevada)**

Ryan Barney..... 36  
**Anthony Cheng..... 36**  
**Melissa S. Ivie..... 37**  
 Daniel W. Liu..... 37  
 Emma J. Mackey..... 37

**Iowa**

**Aparna S. Ajarapu..... 38**  
 Christopher Grebner..... 38  
**Breanna Kramer..... 38**  
 Karleigh Schilling..... 39  
 Abby L. Walling..... 39

**Kansas-Nebraska-Oklahoma**

**Hayden J. Allen..... 40**  
**Disha Dasgupta..... 40**  
 Sarah L. Riley..... 41

**Kentucky**

Lekha P. Devara..... 42  
 Seohyun Im..... 42  
 Ellen K. Kendall..... 42  
**Szofia E. Komaromy-Hiller..... 43**  
**Sanjana J. Rane..... 43**

**Louisiana**

**Cole H. Evensky..... 44**  
**Nicholas A. Larsen..... 44**  
 Morni A. Modi..... 45  
 Neil F. Nathan..... 45  
 Venkatesh S. Sivaraman..... 45

**Maryland**

**Ayush Goyal..... 46**  
 Isobel A. Hawes..... 46  
**John Mountain..... 47**  
 Jerry L. Zhang..... 47

**Michigan (Southeastern)**

**Ella M. Freudenburg..... 48**  
 Bethel A. Mwenze..... 48  
 Sam Natla..... 49  
 Anuush K. Vejalla..... 49  
**Frank Wang..... 50**

**Missouri**

Daniel M. Hall..... 51  
**Katherine E. Hufker..... 51**  
 John L. O’Keefe..... 52  
 Olivia Long..... 52  
**Ezra Umen and Yang Liu..... 52**  
 Sydney L. Zuraski..... 53

**New Jersey (Monmouth)**

Adedayo R. Gbadamosi..... 54  
**Sang Hyun Kim..... 54**  
 Dongyeon Kim..... 55  
**Kunal V. Singh..... 55**  
 Tony Zheng..... 55

**New Jersey (Northern)**

Aditya Balaji..... 56  
 Laura Beth Fulton..... 56  
**Jiyoun J. Ha..... 57**  
**Paige Hammell..... 57**  
 Jaesung Son..... 57

**New Mexico (Southwest)**

Sarah R. Dallo..... 58  
 Kathryn M. Harris..... 58  
 Sean P. Palmer..... 59  
 Melanie B. Schneider..... 59  
**Katherine A. Schneider..... 59**  
**Mary C. Spanjers..... 60**  
 Sierra Venegas..... 60

**New York (Long Island)**

<b>Anthony R. Bisulco</b> .....	<b>61</b>
Leandra Meraglia-Garcia and Daphne Chen...	61
<b>Matthew M. O'Connell</b> .....	<b>62</b>
Ankooor Talwar .....	62
Neil M. Thivalapill. ....	63

**New York (Upstate)**

Maxim S. Diamond. ....	64
Stephanie Ding. ....	64
<b>Adam Z. Illowsky, Sr.</b> .....	<b>65</b>
<b>Jason S. Rosenberg</b> .....	<b>65</b>
Alexis A. Scott, Jr.....	66

**New York City (Metro)**

Waqarul B. Islam. ....	67
<b>Alexandra L. LaGrassa</b> .....	<b>67</b>
<b>Erica Lin</b> .....	<b>68</b>
Rasidha Rahman.....	68
Praveen Rammohan.....	68

**North Carolina**

<b>Tian-Shun A. Jiang</b> .....	<b>69</b>
<b>Megan E. Miller</b> .....	<b>69</b>
Pranay Orugunta. ....	69
Joseph H. Roberts.....	70
Joshua Zhou.....	70

**North Central (Minnesota, N. & S. Dakota)**

Alanna M. Bram.....	71
<b>Carolyn K. Jons</b> .....	<b>71</b>
Matthew T. Lerdahl. ....	72
<b>Timothy J. Renier</b> .....	<b>72</b>
Kevin Zheng. ....	72

**Northern New England  
(Maine, New Hampshire, Vermont)**

<b>Evan T. Brewer</b> .....	<b>73</b>
<b>Deepika S. Kurup</b> .....	<b>73</b>
Andrew D. Sandweiss. ....	74
Keenan G. Wood.....	74

**Ohio**

<b>Bluyé DeMessie</b> .....	<b>75</b>
Shaleen Goel.....	75
<b>Aditya Jog</b> .....	<b>76</b>
Ragavi Lanka.....	76

**Oregon**

<b>Valerie S. Ding</b> .....	<b>77</b>
<b>Vinay S. Iyengar</b> .....	<b>77</b>
Alexandra Ulmer and Sarayu Caulfield. ....	78

**Pennsylvania**

<b>Glen S. Gallik</b> .....	<b>79</b>
Hoang Anh T. Phan.....	79
Priyanga Selvakumar.....	79
<b>David R. Shipe</b> .....	<b>80</b>
Spencer Yacuboski.....	80

**Puerto Rico**

Angelica Arzola.....	81
Hennessy Bas. ....	81
<b>Waldemar Ortiz, III</b> .....	<b>81</b>
Kenaly Ortiz.....	82
<b>Jancel Taveras</b> .....	<b>82</b>

**South Carolina**

Krishna T. Gorrepati.....	83
<b>Bushra B. Islam</b> .....	<b>83</b>
<b>Dana Krzyzaniak</b> .....	<b>84</b>
Brett Winters.....	84

**Southern New England  
(Massachusetts, Rhode Island)**

Easton J. Ehlers. ....	85
<b>Katie Hudek</b> .....	<b>85</b>
<b>Andrew F. Luo</b> .....	<b>85</b>
Vivek Subramaniam. ....	86
Simiao You.....	86

**Tennessee**

Zheer Ahmed. ....	87
Amany Alshibli. ....	87
<b>Grace J. Baek</b> .....	<b>88</b>
<b>Maria D'Azevedo</b> .....	<b>88</b>
Vijaya R. Dasari.....	88

**Texas**

Dara W. Li.....	89
<b>Lisa P. Michaels</b> .....	<b>89</b>
<b>Michael N. Trinh</b> .....	<b>90</b>

**Virginia**

<b>Audrey L. Francis</b> .....	<b>91</b>
Tarun V. Kamath. ....	91
Michelle M. Marquez. ....	92
<b>Samuel E. Rohrer</b> .....	<b>92</b>

**Washington**

Maeve W. Harris..... 93  
**Katherine Landoni..... 93**  
Indira Rayala..... 94  
**Meghal Sheth..... 94**  
Swetha V. Shutthanandan..... 95  
Carrie M. Stump..... 95

**Western Wisconsin, Upper Michigan**

Kaitlin M. Brueggen..... 96  
**Ellie L. Hoopman..... 96**  
**Emily L. Hoopman..... 97**  
Carrie A. Urbanek..... 97  
Casey R. Urbanek..... 98

**Wisconsin**

Jenna R. Lieungh..... 99  
**Andrew K. Saydjari..... 99**  
**Sonali Srivastava..... 100**  
Clarise E. White..... 100

**Wyoming, Eastern Colorado**

Alex L. Henkle and Mason Sundstrom..... 101  
So-Yun Kim..... 101  
**Stephen L. Parish..... 102**  
**Ian J. Wilkins..... 102**

# Section III

*Abstracts of Student Papers*





## **Development of a Novel Antimicrobial Polymer for Biomedical Applications**

*Joshua C. Abreo*

*James Clemens High School, Madison, AL, Alabama JSHS;*

*Teacher/Mentor/Sponsor: Dr. Emanuel Waddell, University of Alabama in Huntsville; Mrs. Robin Hodges, James Clemens High School; Mrs. Carol Bohatch, James Clemens High School*

Polymers are frequently used in a variety of medical applications because they are versatile and flexible, but one of their drawbacks is that they make the patient susceptible to infections. The major goal of this work was to develop a novel antimicrobial polymer, created by attaching copper to the polymer polydimethylsiloxane (PDMS). Once the polymer is created, irradiation of the polymer under an excimer lamp causes the formation of carboxylic groups, and copper ions are attached to these groups when the PDMS is dipped in a copper acetate solution. The copper ions were verified to have been attached to the PDMS using infrared spectroscopy (IR). The IR readings of the copper dipped irradiated PDMS had readings that were a combination of the bands found in the original PDMS and the bands found in the Copper Acetate, showing that the new surface was coated with copper. This meant that the PDMS was coated with a thin layer of Copper ions, causing it to be an effective antimicrobial agent. Bacterial growth on the copper coated PDMS was essentially nonexistent for both *E. coli* and *S. epidermidis*. In addition, the Copper infused PDMS is relatively inexpensive, costing only about 10% more to produce.

## **The Effects of Sedimentation on the Biodiversity of Benthic Macro-Invertebrates**

*Katelynne J. Herron*

*Jefferson County International Baccalaureate, Irondale, AL, Alabama JSHS;*

*Teacher/Mentor/Sponsor: Kelly Breland, Jefferson County International Baccalaureate*

This study was performed to observe the effects a source of sedimentation in stream system, specifically the Turkey Creek watershed, would have on the biodiversity of benthic macro-invertebrates. Turkey Creek has three species of critically endangered fish and one threatened species of Turtle. The Turkey Creek watershed is the only place in the world where the Vermilion Darter is found, and one of the few known environments for the Rush Darter and the Watercress Darter. The main diets of these fish are benthic macro-invertebrates. Five transects were studied: one transect at a source of sedimentation (Beaver Creek), two transects upstream of the source (Tapawingo area), and two transects downstream of the source (Turkey Creek). Depth of sediment was recorded as to compare sedimentation to biodiversity. Biodiversity of macro-invertebrates declined downstream of the source of sedimentation, and depth of sediment rose suggesting that as sedimentation rises, biodiversity of benthic macro-invertebrates declines. The downstream transects had the highest average depth of sediment, (19.3cm, 17.8cm) and had the lowest biodiversity rating on the Simpsons Index, (0.17, 0.13). The downstream transects also rated FAIR on the Stream Quality Scale, by the EPA to measure stream quality by diversity of pollution tolerant invertebrates.

## **Thermoelectric Generator Using the Pyroelectric Effect**

*Rupa Palanki*

*W.P. Davidson High School, Mobile, AL, Alabama JSHS;*

*Teacher/Mentor/Sponsor: Srinivas Palanki, University of South Alabama*

An energy harvester is developed via the pyroelectric effect that utilizes temperature fluctuations due to the sun and the wind on a lead-zirconate-titanate (PZT) disk to generate energy in the 100 micro Joules range. A laboratory apparatus is designed in SolidWorks and constructed to simulate atmospheric effects. A LabView program is written to acquire voltage data. It is shown that this apparatus can provide reproducible results. The effect of varying bulb power (to simulate sunny and cloudy days) and fan speed (to simulate a gusty and gentle winds) on the voltage produced is studied. It is observed that increasing bulb power and fan speed results in an increase in the peak voltage produced from the PZT disk. This device produces alternating current (AC) supply while most devices operate on direct current (DC) supply. A simple bridge rectifier circuit is fabricated to convert the AC supply to DC supply. It is shown that this device is capable of producing up to 125 mW of power when exposed to the sun and the wind for 10 minutes. This is sufficient to power wireless sensor networks that are embedded in civil structures such as tall buildings, bridges and dams.

## **Silver Nanoparticles for Skin Cancer Chemoprevention and Therapy**

*Rohan Palanki*

*W.P. Davidson High School, Mobile, AL, Alabama JSHS;*

*Teacher/Mentor/Sponsor: Dr. Ajay P. Singh, Mitchell Cancer Institute*

Each year, over two million new cases of skin cancer are diagnosed, which is greater than the combined incidence of cancers of the breast, prostate, lung and colon. Therefore, prevention of skin cancer from the harmful effects of UV remains a priority area of research. In this project, the effect of silver nanoparticles (AgNPs) on skin epidermal immortalized, non-tumorigenic keratinocytes (HaCaT) and epidermoid carcinoma skin cancer cells (A431-NS) was tested. A chemical method was successfully utilized for the production of silver nanoparticles. The effect of size and concentration of AgNPs was tested for both skin cancer therapy as well as skin cancer chemoprevention against UV-induced cell damage. Cell viability analysis via colorimetric assay indicate that AgNPs in the size range 10 nm to 100 nm and concentration range 1 mg/L to 10 mg/L are not toxic to nontumorigenic HaCaT cells but are toxic to carcinoma A431-NS cells, thereby proving the therapeutic effect of AgNPs. Furthermore, dot-blot assay results indicate that UV-B radiation causes considerable DNA damage to HaCaT cells and this damage is significantly reduced in the presence of AgNPs in the size range 10-40 nm, thereby proving the chemopreventive effect of AgNPs.

## **High Altitude Battery Charge Using Temperature Differential As Sole Source**

*Lucas D. Riddle*

*Hewitt Trussville High School, Trussville, AL, Alabama JSHS;*

*Teacher/Mentor/Sponsor: Chris Bond, Hewitt Trussville High School*

Many people, while away from instant access to electricity for an extended period of time, often still rely on electrical devices. These devices range from a flashlight to GPS, cell phone, radio communication, camera, I-pod, etc. While current solutions exist for renewable sources of electricity (mainly solar power), I found that mountain climbers or any person in a sub-freezing climate often experience poor weather conditions resulting in a useless solar charging device. One remaining resource available in these circumstances would be body heat produced by the individual, paired with the extreme cold external conditions, together creating a heat differential. Peltier modules, traditionally used as heat pumps in small but real world applications, are constructed very similarly to a thermocouple, which measures temperature differential by producing a measurable voltage. The Seebeck effect, which allows a voltage to be developed in a thermocouple, allows Peltier modules to be run backwards as thermoelectric generators. Utilizing these principles, I have designed and tested a device that utilizes Peltier devices incorporated into a hiking helmet to harness the temperature differential between wearer and external environment in order to charge an external battery.

## **Use of Sodium Nitrite as a Corrosion Inhibitor on Pipeline Steel**

*Abram Haas*

*West Valley High School, Fairbanks, AK, Alaska JSHS;*

*Teacher/Mentor/Sponsor: Gregory Kahoe*

In this project I tested a solution of Sodium Nitrite ( $\text{NaNO}_2$ ) as a corrosion inhibitor for the Trans-Alaska Pipeline System in dead leg areas, or areas of low oil flow. I did this by taking 20 metal samples of the pipeline and soaking half of them in my inhibitor for varying time periods, and then soaking all of them in seawater for a 28-day period. My initial hypothesis was that the metal samples that were coated in sodium nitrite before seawater will corrode less than the ones unprotected. I used the mass loss data collected after the time period, to find how much of the iron the samples lost due to corrosion, I found that the sodium nitrite did not inhibit the corrosion at all. I did a statistical analysis of my data in the form of a 2 Sample T Test, and found that the mass loss of the metal samples originally coated in inhibitor versus the ones not protected, had no statistical difference. My failure to support my initial hypothesis is most likely due to an error in applying the inhibitor to the metal samples, or possibly the way that I measured corrosion.

## **Evaluating the Effectiveness of a Primarily Statistical Approach to Chatbot Design**

*Jake T. Herrmann*

*West Valley, Fairbanks, AK, Alaska JSHS*

“Chatbots” are computer programs designed to engage in conversation, and are becoming increasingly common in fields such as entertainment, education, business, and law enforcement. Most chatbots either use statistics to choose appropriate replies, or are pre-programmed to recognize language patterns. Some research suggests that statistics alone are insufficient as an approach to chatbot design. In order to test the effectiveness of a learning chatbot that takes a statistical approach to conversation, I wrote a program and tested it against 19 humans. Using its 418-KB (180-page) memory file, my chatbot only achieved a success rate of about 26%. However, the chatbot behaved more convincingly when it found obvious matches with a user’s input in its memory file, so I hypothesize that its success rate will increase dramatically if I add more information to its memory. My chatbot’s primary weakness is that it has no short-term memory with which to contextualize conversations. In the future, I plan to conduct several more trials to clarify my conclusions, and I plan to conduct “blind” trials in which the users are not aware that the chatbot is not human. I will focus future research on testing my hypothesis that success rate increases with memory size.

## **Cyanoacrylate (CA) vs. Iodine Fuming of Latent Fingerprints: A Comparative Study**

*Sally Liane Kuhn*

*West Valley High School, Fairbanks, AK*

*Teacher: Mr. Gregory Kahoe, West Valley High School, Mentor: Mr. Gregory Kahoe, West Valley High School*

The purpose of this comparative study was to evaluate both a physical and chemical method of latent fingerprint development. I fingerprinted standard glass lab-ware and developed the prints through the technique of fuming. In different trials I used airtight containers and hotplates to fume cyanoacrylate (CA) and iodine crystals. I used a scale of 0-5 in order to quantitatively compare the results. CA proved to be the superior substance to fume with  $n=3$  and  $x = 4.67$ . The CA prints were not only the clearest but were no longer susceptible to environmental factors such as water and heat. Iodine was the inferior substance since the prints faded so quickly there was no way to properly record them, even through pictures. The iodine ratings were  $n=3$  with  $x = 1.5$ . After contrasting all factors such as cost, set up, time and results, I determined that CA was the best choice for fuming latent fingerprints on non-porous surfaces. In the future I would like to use a dye in conjunction with the CA to better develop latent prints on surfaces of varying color.

## **Effects of Kerosene Co-contamination on Sulfolane Biodegradation**

*William B. Mitchell, Jr.*

*West Valley High School, Fairbanks, AK, Alaska JSHS;*

*Teacher/Mentor/Sponsor: Cyndie Beale, West Valley High School; Chris Kasanke, Institute of Arctic Biology*

Sulfolane is an industrial solvent used to separate aromatic hydrocarbons from crude oil. Sulfolane and kerosene are both environmental pollutants. The biodegradation of sulfolane in the presence of kerosene was investigated. The hypothesis was that kerosene would inhibit the biodegradation of sulfolane. Six test groups of three to five replicates each contained combinations of sulfolane, kerosene, and soil microbes. Groups and their replicates were incubated at 4°C for the duration of the experiment. Samples taken at days 0, 9, and 15 were analyzed using gas chromatography. Analysis of the treatment groups indicated that soil microbes were able to biodegrade sulfolane. In addition, the test group containing microbes and sulfolane had statistically significant greater sulfolane biodegradation on day 9 ( $p=0.020$ ) and day 15 ( $p=0.038$ ) compared to the group with microbes, sulfolane, and kerosene. These results confirmed the original hypothesis that kerosene inhibits sulfolane biodegradation. This is a significant finding because kerosene-like hydrocarbons, such as those found in jet fuel, are common co-contaminants. This indicates that sulfolane biodegradation is influenced by surrounding materials, a possible field for future study.

## **Microfluidic Droplet-in-air Production Prototyping in Dry-film Photoresist Developed Microchannels**

*Ryan C. Nicholson*

*West Valley High School, Fairbanks, AK, Alaska JSHS;*

*Teacher/Mentor/Sponsor: Dr. Cheng-fu Chen, University of Alaska Fairbanks; Gregory Kahoe, West Valley High School; Cyndie Beale, West Valley High School*

Microdialysis, an invasive sampling technique, is widely used in the determination of chemical constituents of extracellular fluids, but is unable to be extensively miniaturized due to a scaling flow resistance. I explored the possibilities of a microfluidic droplet-in-air production process that would lead to the elimination of flow resistance. My mentor, Dr. Cheng-fu Chen (UAF), developed microchannels utilizing a prototyping process that uses a dry-film photoresist as the structural material, which allows microchannel creation through UV light exposure and bonding to polydimethylsiloxane (PDMS). For testing, I pumped air and water through the channels and modulated the airflow rate. Results indicated that droplets were possible, but the airflow rate heavily determined their size, speed, and rates of creation. Lower airflow rates produced droplets that were six times slower than ones from higher flow rates, and the higher flows also produced droplets more rapidly. Droplets of smaller size and higher speed are essential for use in a microdialysis technique, with uniformity being of utmost importance in order to preserve spatial and temporal resolutions. This study provides a foundation from which further testing for promoted droplet creation rates and uniformity, or the effects of temperature on droplets, may be explored.

## Investigation of the Electrical Properties of Metal/Pyrite (FeS<sub>2</sub>) Junctions- Development Towards the Synthesis of Pyrite Solar Cells

*Ivy Chang*

*Hamilton High School, Chandler, AZ, Arizona JSHS;*

*Teacher/Mentor/Sponsor: Mrs. Debbie Nipar, Hamilton High School; Prof. Nathan Newman, Arizona State University*

The nontoxic semiconductor pyrite FeS<sub>2</sub> appeals to us as a good candidate for solar cells because it collects most of the solar light spectrum and is composed of inexpensive materials. A study conducted (Wadia et al, 2009) showed that the substitution of silicon with pyrite as a solar cell material will theoretically decrease the average cost by 100 times. To measure pyrite's potential as an alternate material, the electrical properties of metal/pyrite junctions characterize the contact and pyrite materials parameters important to photovoltaic research. Only rectifying contacts will be able to be implemented in photovoltaic application. A number of metals (Al, Au, Cr, Fe, Ni) were deposited on a natural pyrite substrate and the current-voltage characteristics of the metal/pyrite contacts were measured with variance in temperature. All diodes successfully showed a decrease in current with temperature. Gold and nickel exhibited low-resistance, non-rectifying behavior, making them excellent candidates as Ohmic contacts in the fabrication of pyrite solar cells. Aluminum, chromium and iron formed rectifying, Schottky barriers. Future studies consist of depositing these three rectifying, semi-transparent metals (~5 nm) to enable the entrance of light to quantify the efficiency of the photovoltaic processes as a workable photovoltaic cell.

## I2C: Devices for the Disabled

*Dhruv Iyer*

*Hamilton High School, Chandler, AZ, Arizona JSHS;*

*Teacher/Mentor/Sponsor: Bala Iyer, Hamilton High School; Brian Clark*

People with severe motor disabilities can often feel socially isolated. The purpose of this project was to build a user interface for quadriplegics to interact with others in a virtual setting by playing computer games. Design criteria included requirements for speed, accuracy, functionality, user experience, and cost. Several prototypes were built and tested: Mouse: MEMS Gyroscope based head tracker Arm-actuated accelerometer Tongue-actuated joystick Keyboard: Voice input MEMS Gyroscope based Head-tracker Keyboard testing was performed using a Minecraft obstacle course. Mouse emulation was tested by requiring the subject to click an ordered point on a random grid. The prototype designs were tested both individually and together in keyboard-mouse combinations. The results showed that the head-tracking/tongue-actuated combination was the best, followed by Head-tracking/Arm-actuated, Voice/Head-tracking, and Voice/Arm-actuated. Five additional prototypes were built using the Kinect for Xbox 360 and Kinect for Windows sensors. With the Kinect Xbox sensor, lack of "near-mode" operation was a significant limitation. This was addressed with the use of the Kinect Windows sensor, for which Keyboard and mouse emulation worked well separately but getting both keyboard and mouse emulation at the same time is still work in progress

## **Parabolic Solar Water Heater For The Navajo Nation**

*Deshna Joe*

*Navajo Preparatory School, Farmington, NM, Arizona JSHS;*

*Teacher/Mentor/Sponsor: Yolanda Flores, Navajo Preparatory School; Daniel Winarski, International Business Machines*

The purpose of this science fair project is to design a parabola mirror with copper tubing at the focus, and use a solar-powered pump, that can efficiently heat water solely from solar energy. Likewise, to generate a solar water heater that work with solar arrays to test in rural homes off the grid. The target of this study was these homes in particular because living on the reservation has shown that this is a necessity for many people without much money. This science fair project uses a mirror with a parabolic cross-section to focus sunlight upon a copper pipe. Separately, solar photovoltaic cells power a pump to circulate water through the copper pipe. The result is a totally solar-powered water heater, which could be used on the Navajo Nation for homes which are remote and "off the grid." The question of efficiency is addressed by dividing the heating of the water as measured in Watts (Joules/second) by the Watts received from the sun. The project showed an efficiency of 88%, which proved that a parabolic solar water heater with copper tubing at the focus, and a solar-powered pump, could efficiently heat water solely from solar energy.

## **3D Surface Fabrication Using Conformal Geometry**

*Yuanqi Zhang*

*Saint Gregory College Preparatory School, Tucson, AZ, Arizona JSHS;*

*Teacher/Mentor/Sponsor: Xianfeng David Gu, State University of New York at Stony Brook*

The developing 3D printing technology has revolutionized the manufacturing industry. Although the existing 3D printing method is used in a variety of fields to produce complete models in a single process, it requires expensive hardware and successive layers of materials. This paper proposes a novel approach for fabricating 3D shapes based on surface foliation in conformal geometry. All oriented metric surfaces are Riemann surfaces. The holomorphic differentials on a Riemann surface induce horizontal and vertical trajectories. The horizontal (vertical) trajectories give a foliation of the surface singular at zeros. The surface is decomposed to two families of orthogonal leaves, and can be reconstructed by weaving the two families of leaves. Comparing to conventional 3D printing technologies, this method has advantages: 1. General: the method handles surfaces with different topologies; 2. Rigorous: the method has concrete foundation; 3. Automatic: the algorithm is automatic; 4. Economical: the method only requires paper and scissors. The method has potential for fabricating 3D shapes in real life. Key words: 3D printing; conformal geometry; foliation; trajectory; holomorphic differential; fabrication

## **The Effects of the Work Function and Alignment On Organic Photovoltaic Devices**

*Dhruba Dasgupta, Jr.*

*Little Rock Central High School, Little Rock, AR, Arkansas JSHS;*

*Teacher/Mentor/Sponsor: Dr. Beth Maris, Little Rock Central High School*

Organic photovoltaics (OPVs) are efficient, renewable sources of energy that provide an economic alternative to relatively expensive inorganic PVs. OPVs still face weathering problems, therefore, research over noble metals and inverted devices have surfaced. Silver, a noble metal, could be swapped out for aluminum; however, their work function difference could lead to an efficiency change. Also by inverting OPVs with a noble metal as a bottom electrode, devices could improve their air stability. Two experiments were conducted: one comparing efficiencies of normally oriented devices with aluminum or silver cathodes, and comparing efficiencies of inverted devices using aluminum or silver anodes. For normally oriented devices, it was hypothesized if the cathode's work function was closer to the PCBM's LUMO, the device's efficiencies would be greater. For inverted devices, it was hypothesized the closer the anode's work function is to the P3HT's HOMO, the greater the efficiency. The aluminum OPVs had a greater average efficiency at 1.83% PCE, than the silver devices at .263% PCE. The inverted OPVs with silver had an average efficiency at 0.06% when compared to the aluminum devices at 0.05%. Therefore, normally oriented OPVs have greater efficiencies with aluminum rather than silver, while inverted devices need more research.

## **Single-Walled Carbon Nanotubes/Silicon Based Solar Cells**

*Nimit R. Gandhi*

*Little Rock Central High School, Little Rock, AR, Arkansas JSHS;*

*Teacher/Mentor/Sponsor: Melissa Donham, Little Rock Central High School*

Abstract The purpose of this research was to achieve photovoltaic conversion from high-density p-n junctions formed between single-walled carbon nanotubes (SWNTs) and n-type silicon (n-Si). It was hypothesized that the use of a nitric acid treatment would improve the power conversion efficiency of the devices, due to the formation of new functional groups on the CNTs. This was tested by forming silicon dioxide through dry oxidation and depositing titanium and gold via various techniques, upon which hydrofluoric acid and nitric acid-hydrochloric acid solutions were used for etching, respectively. Upon forming CNT films of various volumes, they were lifted onto the silicon substrate. Current-voltage measurements indicated that under dark conditions, the devices resembled p-n diodes, indicating that high density p-n junctions did form there. Device-1250 (1250  $\mu$ L of CNT solution) achieved the highest power conversion efficiency before and after the nitric acid treatment due to a balance between conduction and transparency. The use of the nitric acid treatment increased the power conversion efficiency of Device-1250 by nearly 83%. Thus, the hypothesis was supported as high density p-n junctions, decrease in series resistance, and increase in shunt resistance occurred as a result of the nitric acid treatment.

## **Peak Wall Stress in Abdominal Aortic Aneurysm**

*Sanjit Kalapatapu*

*Pulaski Academy, Little Rock, AR, Arkansas JSHS*

The purpose of this study was to examine the correlation of peak wall stress in abdominal aortic aneurysm with the maximal aortic diameter, extent of intraluminal thrombus, and aortic wall calcium. The hypothesis of this experiment predicted that all three of these factors would correlate with the peak wall stress in an abdominal aortic aneurysm. Computerized Tomography scans (CT scans) were used to calculate the maximal aortic diameter, percent of intraluminal aortic thrombus, and percent of aortic wall calcium. Peak wall stress was calculated using Finite Element Analysis software to construct a 3-D model of abdominal aortic aneurysm from CT scans. Then statistical analysis was performed to assess the correlation between these factors. This study partially supported our hypothesis, as it showed that there was a direct correlation between maximal aortic diameter and peak wall stress, a weaker positive correlation between thrombus and peak wall stress, and no correlation between calcium and peak wall stress. This study will help doctors prioritize the early treatment of patients with abdominal aortic aneurysm and lower rupture rates.

## **Using Nanotechnology to Enhance Osteoblast Proliferation and Adhesion: Comparison of Different Implantable Biologically Inert Spinal Instrumentation Materials**

*Hanya M. Qureshi*

*Pulaski Academy, Little Rock, AR, Arkansas JSHS;*

*Teacher/Mentor/Sponsor: Annice Steadman, Pulaski Academy; Dr. Ganesh Kannarpady, Ph.D., Center for Integrative Nanotechnology Sciences at the University of Arkansas Little Rock*

Nanotechnology is manipulation of materials at atomic, molecular or supramolecular levels. This study explores such manipulation of materials used in spinal fusion such as PEEK (Polyether ether ketone), Cobalt Chrome (CoCr), Titanium (Ti), and Titanium Alloy by coating with Single-Walled Carbon Nanotubes (SWCNT) and Titanium Dioxide (TiO<sub>2</sub>) nanotubes to study osteoblast proliferation and adhesion. Based on material properties the hypothesis was that SWCNT would adhere better to PEEK given their carbon based structure, and TiO<sub>2</sub> nanotubes would adhere better to Ti substrates given their titanium based structure. Secondly, nanotube coating may enhance osteoblast proliferation and adhesion. The experiment was run in triplicate using an established mouse osteoblast (MC3T3-E1) cell line. The results showed that osteoblast proliferation was impeded on the SWCNT-coated CoCr substrates (P=0.008), yet enhanced proliferation was seen on the SWCNT-coated Ti substrates (P=0.02). In comparison, TiO<sub>2</sub> nanotube-coated Ti Alloy substrates impeded osteoblast proliferation (P=0.011), whereas TiO<sub>2</sub> nanotube-coated CoCr substrates enhanced osteoblast proliferation (P=0.005). PEEK substrates were incompatible with the TiO<sub>2</sub> treatment. Finally, cell morphology differed depending on the substrate used. In conclusion, given its high tensile and shear strength, CoCr is the best substrate when coated with TiO<sub>2</sub> nanotubes to enhance osteoblast proliferation and ultimately, spinal fusion results.



# **Effect of Combined Inhibition of DNA Methylation and Histone Acetylation on Viability of Multiple Myeloma Cell Lines**

*Shruti Shah*

*Little Rock Central High School, Little Rock, AR, Arkansas JSHS;*

*Teacher/Mentor/Sponsor: Dr. Beth Maris, Little Rock Central High School; Mrs. Mary Parson, Little Rock Central High School; Dr. Christoph Heuck, University of Arkansas for Medical Sciences*

As carcinogenesis occurs and abnormal cells begin to metastasize such as in multiple myeloma (MM), they can develop a resistance to chemotherapeutic drugs. Therefore, to prolong the patient's life, oncologists must alter the treatment plan. In many publications, the process of synergism proved to be optimal in cancers similar to MM. Therefore, synergy of HDAC complexes and DNA methyltransferase inhibitors, mechanisms that affect gene expression and therefore cell viability, could potentially be used to treat MM. Combinations of Decitabine (DNA methyltransferase inhibitor) and Vorinostat (HDAC complex) and Decitabine (DNA methyltransferase inhibitor) and Valnoctemide (HDAC complex) were carried out to investigate synergy and inhibition of cell viability in MM cell lines H929 and JJN3. Test combinations of Decitabine and Valnoctemide produced antagonistic effects in cell line H929, whereas in the cell line JJN3, the effect was mainly additive. However, with Decitabine and Vorinostat, in cell line H929, synergism was shown at high concentrations of Vorinostat but at low concentrations there was antagonism. The data for the combination of Decitabine and Vorinostat in JJN3 showed synergism for most of the concentrations tested. With these promising results, synergy of Decitabine and Vorinostat could offer a novel therapeutic approach for MM upon further investigation.

### **Enabling Situational Awareness: A Hat-Based Hands-Free Haptic Navigational Aid for the Visually Impaired**

*Shiloh S. Curtis*

*Laughing Thunder Academy, Sunnyvale, CA, California (Northern & Western Nevada) JSHS*

According to the American Foundation for the Blind, there are over 21.2 million visually impaired adults in the U.S. However, almost all commercially available aids for this population, such as the white cane, must be constantly hand-held, depriving users of the functionality of one hand. Guide dogs can cost \$60,000 and have significant care requirements. Commercially available aids have little ability to detect face and torso level obstacles such as tree branches. To answer this need, I designed and constructed a hands-free assistive hat, the Haptic Navigational Aid for the Visually-Impaired (H-NAV), which uses a Laser Distance Sensor (LDS) to detect nearby obstacles and 12 vibrating motors inside the hatband to alert the user to the obstacles' presence. The motors also indicate the approximate distance to the obstacle using the duration of pulsed vibrations. The H-NAV was designed to facilitate situational awareness and enable the user to avoid face and torso level obstacles. The prototype was tested by assessing users' ability to perform common navigational tasks while blindfolded and wearing the H-NAV, where successful completion required detecting and avoiding obstacles without straying off course. Almost all tasks tested had a success rate over 80%, so the H-NAV functioned as intended.

### **A Novel Use of Infrared Light in Eye Tracking Systems**

*Neil Movva*

*The Harker School, San Jose, CA, California (Northern & Western Nevada) JSHS;*

*Teacher/Mentor/Sponsor: Dr. Smriti Koodanjeri, The Harker School*

Eye tracking is a revolutionary form of input, allowing users to control computers simply by focusing on target elements. However, current solutions rely on inefficient software methods, limiting operability. We propose a solution in introducing infrared (IR) lighting, a hardware innovation that expands usability and enables breakthrough software efficiency. We demonstrate consistent isolation of the pupil unique to IR; little light escapes the dark pupil, while other facial elements scatter IR and appear gray. This greatly simplifies software design and reduces susceptibility to visible-spectrum interference, such as a user's iris color (dark irises are normally indistinguishable from the pupil). Furthermore, using a local IR source enables consistent operation even in poor lighting. We strobe our strategically placed IR emitters in sync with video frame capture, creating an easily identifiable pattern centered on the pupil to assist in tracking. Our system successfully tracks 91% of input frames, and is usable for typing on an on-screen keyboard. Finally, the additional hardware (IR LEDs and IR filter, \$5) carried an insignificant cost compared to the camera (\$40). In summation, using IR lighting greatly simplifies eye tracking, and further development will result in systems potentially far more robust than conventional (visible-spectrum based) setups.

## **Multi-Dimensional Genomic Data Analysis to Assess Correlation Across a Disease and Its Comorbidities**

*Swetha Revanur*

*Evergreen Valley High School, San Jose, CA, California (Northern & Western Nevada) JSHS;*

*Teacher/Mentor/Sponsor: Mrs. Barjinder Sabherwal, Evergreen Valley High School*

Hidradenitis Suppurativa (HS) is a poorly understood chronic skin disease marked by painful cysts. Despite a prevalence of about 1%, no potent treatment or cure exists. A mechanism was developed to analyze HS with respect to its comorbidities (Crohn's Disease, Down Syndrome, Rheumatoid Arthritis [RA], Squamous Cell Carcinoma [SCC], and Hypothyroidism) using multi-dimensional genomic data. Gene, pathways, and microRNA profiles were the dimensions considered. A quantitative model was defined to compute an enriched correlation index; this index was validated using gene expression levels. The index provides a calculation for the distance between a disease and its comorbidities. This investigation reveals microRNA biomarkers that could play a causal role in HS, and also provides evidence that explains the predominance of HS among the female population. Moreover, pathway analysis identified Alzheimer's Disease as a comorbidity of HS. This comprehensive workflow can be employed to gain similar insights into any disease, to commence clinical experimentation, and to pave the path to drug repositioning.

## **Active Magnetic Field Cancellation System**

*Valliammai Vinaithirthan*

*Monte Vista High School, Danville, CA, California (Northern & Western Nevada) JSHS;*

*Teacher/Mentor/Sponsor: Wulf Tobias Hofbauer, Centre for Research and Applied Learning in Science*

Fluctuations of the ambient magnetic field are common in urban and industrial environments, principally caused by the magnetic field associated with electric currents in line wiring and electrical equipment, such as motors and transformers. While generally weak compared to Earth's natural magnetic field, the rapid fluctuations of such stray fields, typically due to the frequency of local power distribution systems and its mechanics, can have a devastating effect on sensitive experiments. The Active Magnetic Field Cancellation System is a design and implementation of an active, closed-loop system designed to cancel such magnetic field fluctuations. The principal functional groups in this active system are magnetic field sensors, magnetic field actuators, and an electronic closed-loop feedback system. In a real-world application scenario, the design, based on high school physics and decidedly low-cost, achieved >20 dB attenuation of magnetic stray fields at powerline frequencies, vastly enhancing the usable resolution of a commercial scanning electron microscope.

## **Illuminating Disease Pathways: Developing Bright Fluorescent Proteins to Improve FRET Biosensing**

*Emily S. Wang*

*Henry M. Gunn High School, Palo Alto, CA, California (Northern & Western Nevada) JSHS;*

*Teacher/Mentor/Sponsor: Jun Chu, Stanford University*

The discovery and development of fluorescent proteins, recognized by the 2008 Nobel Prize in Chemistry, enabled a revolution in biological microscopy and sensing. Biosensors employing fluorescence resonance energy transfer (FRET) between fluorescent proteins are powerful tools to non-invasively report biochemical events within living cells. The development of new FRET sensors remains difficult, however, often due to low FRET dynamic range. Through random and site-directed mutagenesis, I designed and constructed libraries of green and red fluorescent protein mutants, which were screened for photostability, quantum yield, and performance in a FRET-based calcium sensor. I have engineered a new green fluorescent protein Clover3, which is the brightest monomeric fluorescent protein to date. Clover3 confers increased FRET dynamic range onto biosensors and shows improved photostability and quantum yield. Moreover, I developed a new red fluorescent protein mRuby3, which is the brightest red fluorescent protein to date. With superior optical characteristics, Clover3 and mRuby3 are expected to benefit diverse biomedical applications, including the imaging of neural structures, visualization of cancer metastases, and monitoring of signaling pathways to elucidate disease mechanisms.

### **Gene silencing in *Bactericera cockerelli*, vector of tomato *Liberibacter***

*Saumya R. Keremane*

*Martin Luther King High School, Riverside, CA, California (Southern) JSHS;*

*Teacher/Mentor/Sponsor: Dr. Richard Lee, USDA ARS; Ms. Jennings, Martin Luther King High School*

RNA interference (RNAi) can be used to silence genes in a sequence specific manner. This methodology can be used to target critical genes and control plant pests in an eco-friendly manner. Introduction of specific double stranded RNA (dsRNA) into cells initiates the RNAi process and degrades specific mRNAs resulting in gene silencing. Many economically important plant diseases are spread by insect vectors. Psyllids spread diseases like citrus greening and tomato psyllid yellows, associated with bacteria, *Candidatus Liberibacter* spp. In this study, *Bactericera cockerelli*, the vector of tomato psyllid yellows was used to investigate the possibilities of using RNAi as a method of disease management. A gene, *awd* (abnormal wing disc) is required for proper development of psyllids. In this study, the sequence of *awd* from *Bactericera* was determined, dsRNA for *awd* was synthesized and applied to psyllid nymphs. The treated psyllids showed a high mortality rate (lowers population level) and abnormal wing development (affects mobility and the ability of psyllids to spread the pathogen), characters useful in disease mitigation. Gene expression analysis indicated lower level of expression of *awd* gene in psyllids showing abnormal wings. Debilitating the psyllids will reduce the spread of diseases and reduce their severity.

### **Strongly Coupled Electromechanical Modeling of the Heart in Moving Domains Using the Phase-Field Method**

*Kevin K. Lee*

*University High, Irvine, CA, California (Southern) JSHS;*

*Teacher/Mentor/Sponsor: Shannon Bunch, University High; John Lowengrub, University of California, Irvine*

Computational models of the heart have proven essential to the study of cardiac arrhythmias, which are poorly understood yet the leading cause of death in the industrialized world. Existing models provide an unobstructed view of the heart's electrical behavior on both the surface and interior, but they have not been able to efficiently incorporate the beating of the heart due to difficulties in handling the moving domain of the governing partial differential equation system. Here, I develop a novel method for strongly coupling mechanical contraction from beating with electrical propagation using the phase-field method. I represent the geometry of the heart with a diffuse-domain approximation and model the soft-tissue mechanics through Darcy's Law. I couple muscle contraction with the power stroke of the action potential and evolve the shape through a Cahn-Hilliard equation. I demonstrate the model's convergence and that it captures the differences in electrical propagation due to shape, evidence of strong coupling. The theory developed in this work efficiently facilitates more realistic simulations of the heart, thus giving drug developers a more complete tool in designing therapies for heart conditions, yielding critical insight on the mechanisms of fatal conditions, and enabling dramatic improvements in their treatment and prevention.

## **Multi-agent Monte Carlo Equilibrium**

*Daniel Shaw*

*University High School, Irvine, CA, California (Southern) JSHS;*

*Teacher/Mentor/Sponsor: Dr. James Li, Avid Academy; Shannon Bunch, University High School*

Multi-Agent systems use several interacting agents in an environment to simulate a process. In particular, processes that combine both Multi-Agent systems and Monte Carlo simulations (MAMC) are exceptionally useful in calculating the result of complex procedures. However, a major drawback is that MAMC, despite its accuracy, is computationally expensive. In my project, I introduce an equilibrium state and guide the MAMC framework towards that state. Using this approach, I am able to factor additional offline knowledge into the process through a maximum likelihood estimator. The approach also uses the Cross Entropy Method, which significantly minimizes the computational cost. Unlike other paradigms, our model can use the posterior distribution of the previous Monte Carlo method to give a more accurate result. Our equilibrium method gave a substantial improvement in the quality of MAMC results when tested in artificial intelligence Go. My approach is 5 times faster than previous models.

## **Personalized Medical Treatments Using Novel Reinforcement Learning Algorithms**

*Yousuf M. Soliman*

*Canyon Crest Academy, San Diego, CA, California (Southern) JSHS;*

*Teacher/Mentor/Sponsor: Wendy Slijk, Canyon Crest Academy*

Due to the need for an effective personalized medicine engine, I aim to find an optimal personalized treatment policy which is a non-deterministic function of the patient specific covariate data that maximizes the expected survival time or clinical outcome. I developed an algorithmic framework to solve multistage decision problems with a varying number of stages that are subject to censoring in which the “rewards” are expected survival times. In specific, I developed a novel Q-learning algorithm that dynamically adjusts for these parameters. To combat the problem of censored data, I first began by developed a unified approach for SVMs to maintain a constant belief state about the patient. Furthermore, I found finite upper bounds on the generalized error of the treatment paths constructed by this algorithm. I have also shown that when the optimal Q-function is an element of the approximation space, the anticipated survival times for the treatment regimen constructed by the algorithm will converge to the optimal treatment path. I demonstrated the performance of the proposed algorithmic framework through the analysis of chronic depression data and a hypothetical cancer trial. The censored Q-learning algorithm I developed not only operates in non-optimal environments, but it is more effective than the state of the art clinical decision support systems.

## **Designing a Circuit Board to Wirelessly Power a Left Ventricular Assist Device (LVAD)**

*Daniel G. Giebisch*

*Amity Regional High School, Woodbridge, CT, Connecticut JSHS;*

*Teacher/Mentor/Sponsor: Deborah Day, Amity Regional High School*

A left ventricular assist device (LVAD), a heart pump that maintains the cardiovascular system in cases of heart failure, requires energy from an inconvenient external battery pack module. Unfortunately, the wire connecting the heart pump to this module is prone to high risks of infection. The solution to this issue is wireless energy transfer, in which the heart pump receives energy without a wire. The major requisite to a wireless LVAD is a miniaturized circuit board that is implanted alongside the heart pump. This study aimed to design such a circuit board. The project began with a basic schematic that led to the selection of specific components. These components were chosen for space and power efficiency. Then, Altium Designer, a three dimensional modeling program, was used to produce the printed circuit board model. The board was successfully ordered, soldered, and tested for reliability. The circuit transfers 15 volts of input voltage to the motor found in the Heartmate II, the most commonly used LVAD. Once manufactured on a large scale basis, this new circuitry will realize a wireless LVAD that could replace heart transplants as the ultimate treatment for severe heart failure.

## **Spectral and spatial analysis of Fermi Large Area Telescope observations to investigate Weakly Interacting Massive Particle dark matter**

*Isabelle S. Goldstein*

*Ridgefield High School, Ridgefield, CT, Connecticut JSHS;*

*Teacher/Mentor/Sponsor: Dr. Louis Strigari, Indiana University; Michael Yagid, Ridgefield High School*

The Weakly Interacting Massive Particle (WIMP) theory for dark matter predicts the production of gamma radiation from WIMP annihilation and decay. To examine the possibility of WIMP dark matter, gamma ray sources from M31 are partitioned from the Fermi Gamma-ray Space Telescope from the LAT instrument with 5 years of clean and ultraclean cut-data in the 1 - 300 GeV range. Background, halo, and point source distributions are then used in a spectral and spatial analysis. The spectrum is well described by a power law, but the polar averaged radial density is a good fit with a line of sight integral of the linear and squared Navarro - Frenk - White (NFW) density profile with an  $R^2 = 0.9992$ . The NFW fit also exhibits a significantly larger contribution coefficient from decay processes than annihilation. The correlation between theory and predictions suggests that either WIMPs are the source of the radiation, astrophysical processes are influenced by dark matter that follows this density fall off, or astrophysical processes follow this profile randomly. These findings raise fundamental questions on the origin of galactic halo gamma rays, and warrants continued research in the field.

## Temperature-Induced Concurrent Removal and Recovery of Wastewater Ammonia-Nitrogen

*Andrew Ma*

*Greenwich High School, Greenwich, CT, Connecticut JSHS;*

*Teacher/Mentor/Sponsor: Andrew Bramante, Greenwich High School*

Ammonia-nitrogen ( $\text{NH}_4^+$  and  $\text{NH}_3$ ) has a variety of important applications. When discharged through wastewater effluent, however, ammonia-nitrogen causes many environmental problems. The objectives of this research are: (1) designing a novel process and apparatus for wastewater ammonia-nitrogen removal and recovery and (2) developing an original mathematical model to predict removal/recovery results for all input/controlled parameters. In the newly-designed dual-chamber apparatus, increased temperature drives the following net reactions: (#1)  $\text{NH}_4^+(\text{aq}) \rightarrow \text{NH}_3(\text{aq}) + \text{H}^+(\text{aq})$ , (#2)  $\text{NH}_3(\text{aq}) \rightarrow \text{NH}_3(\text{g})$ ;

#2 is accelerated by depressurization. Together, these reactions convert aqueous wastewater ammonia-nitrogen to gaseous  $\text{NH}_3$ , which is reusable. Both mathematical modeling and experiments using synthetic wastewater solutions with varying parameters demonstrated effective removal and recovery; virtually any chemical conversion percentage can be achieved. Compared to existing removal and recovery techniques, this new process has many advantages: it produces unbonded, uncontaminated ammonia, does not require chemical absorption for recovery, does not depend on environmental/biological factors, and utilizes a simpler and concurrent mechanism. Furthermore, the process and apparatus engineered in this research can simultaneously recover all volatile contaminants, including VOC fuels. Overall, this innovation provides the dual environmental benefits of economically incentivized wastewater purification and a viable alternative to energy-intensive industrial chemical synthesis processes.

## The Synthesis and Characterization of EGCG-PLGA Conjugates and Mixtures for Applications in Tissue Engineering

*Anubhuti Mathur*

*Glastonbury High School, Glastonbury, CT, Connecticut JSHS;*

*Teacher/Mentor/Sponsor: Ms. Diane Pintavalle, Glastonbury High School; Matthew Harmon, University of Connecticut Health Center*

In tissue engineering, developing materials with desired physical properties that incorporate biomolecules to enhance biological response is necessary. Epigallocatechin gallate, or EGCG, has been used in medical applications such as in cancer therapeutic drugs. The goal of this project is to explore EGCG's potential as a biomolecule for enhancing the functionality of structures called scaffolds for tissue regeneration. EGCG was encapsulated into scaffolds composed of a well established polymer called poly(lactic-co-glycolic acid), or PLGA, of three types: microparticles, electrospun matrices, and thin films. Analytical techniques, including loading efficiency analysis, Fourier Transform Infrared Spectroscopy, and Scanning Electron Microscopy imaging, confirmed the presence of EGCG in the PLGA scaffolds. EGCG and PLGA were also chemically conjugated. The chemical conjugation was supported using Differential Scanning Calorimetry, through which the glass transition temperature of the conjugates and PLGA were seen to be different. Cartilage cell studies were conducted with electrospun matrices encapsulated with EGCG fiber properties that increased the surface area of the matrix and created a more favorable environment for cells to grow on. Cartilage cells exhibited greater confluency on EGCG-PLGA electrospun than on electrospun matrices of only PLGA. Future studies include assessing cartilage cell performance of electrospun matrices of EGCG-PLGA chemical conjugates.

## **Studying The Role Of Neutrophils In Preventing The Dissemination Of Oral Listeria Monocytogenes Infection In The Intestinal Mucosa**

*Isha A. Walawalkar*

*Glastonbury High School, Glastonbury, CT, Connecticut JSHS;*

*Teacher/Mentor/Sponsor: Dr. Pablo Romagnoli, University of Connecticut Health Center; Ms. Diane Pintavalle, Glastonbury High School*

Listeria monocytogenes (Lm) is a bacterium that causes listeriosis, a foodborne infection with a high mortality rate. In contrast to previous murine models of infection in which Lm has been administered systemically (i.e. intravenously or intraperitoneally), our more relevant model of oral Lm infection has shown that the intestinal mucosa is actively involved in bacterial containment. In this study, we tested the hypothesis that neutrophils, a population of white blood cells, play a significant role in preventing the dissemination of secondary oral Lm infection into the intestinal lamina propria and consequently, into the bloodstream. Here we showed that bacterial counts within the small intestinal duodenum following oral Lm recall are higher when neutrophils are depleted. In addition, using confocal microscopy, we observed cellular aggregates at the bases of the small intestinal villi 1 day post recall (d.p.r.) containing gamma-delta ( $\gamma\delta$ ) T cells that have been shown to participate in the recruitment of neutrophils to the site of an immune response. In conclusion, the results of this study suggest that neutrophils play a key role in preventing the propagation of secondary oral Lm infection within the intestinal mucosa.



## DoD Dependent Schools (Europe)

---

### Can Mathematics Predict Popular Music?

*Garrett Davidson*

*Bahrain School, Juffair, DoD Dependent Schools (Europe) JSHS;*

*Teacher/Mentor/Sponsor: Brian Zimmer*

The research was a quantification of many attributes of songs and subsequent comparison between popular and unpopular songs, namely: do the numbers exhibit an identifiable pattern? ScoreAHit, a company founded upon a similar goal, used mathematics and machine learning to compute an algorithm for predicting whether a song would become popular (i.e. make it to the top 10) following its release. Their research paper outlined their methods, and their algorithm provided a baseline for comparison. This algorithm claimed approximately 60% accuracy, though their data were limited to purely acoustical attributes. Therefore, songs' lyrics and the previous popularity of their artists, which are also influential factors, were not considered. This paper quantifies these factors among both popular and unpopular songs to identify patterns. By taking into account factors such as the repetitiveness of the lyrics, the uniqueness of the language used in them, the popularity of the artist at the time of release, it was found that even more accurate predictions are possible than those of ScoreAHit. Definitive patterns were identified that exposed attributes very obviously differentiating songs which are popular from their unpopular rivals. These patterns could potentially be used to predict the popularity of as yet unreleased songs.

### Lateral Line and Barbel Efficiency of Fish during Percussive and Electrical Stimulation

*Leif C. Gruetter*

*Rota Middle/High School, FPO, AE, DoD Dependent Schools (Europe) JSHS;*

*Teacher/Mentor/Sponsor: Kathleen Tierney, Rota Middle/High School*

This experiment is a continuation of research testing the ability of animals to predict earthquakes. Fish and subterranean Animalia were tested for their ability to sense percussive shocks and electrical impulses, precursors to impending earthquakes. This research discovered that subterranean Animalia were more sensitive to electrical impulses while the fish were more sensitive to percussive shocks. The current research tested reactions of fish to percussive shocks and electrical currents to judge whether barbels or lateral lines of fish were more sensitive to the stimuli. The added electrical current during percussive shock resulted in reactions elongated by an average of two seconds. Percussive shocks were simulated by dropping a three-pound weight onto the table supporting the fish tank. The electrical stimulation was introduced by running a current through the tank. The lateral line was more able to detect tremors than the barbels. When the barbels did detect tremors the reactions produced were more aggressive. The ability of the Hoplo catfish to detect stimuli surpassed that of the other fish. The anatomy of the Hoplo catfish is similar to that of the Namazu catfish which according Japanese legend is the source of earthquakes. The behavior of the catfish tested can predict earthquakes.

## **How Effective is an Individuals Birthdate to their Personality**

*Angela Jeanfrancois*

*Wiesbaden High School, APO, AE, DoD Dependent Schools (Europe) JSHS;  
Teacher/Mentor/Sponsor: Mr. Craig, Wiesbaden High School*

The researcher performed an experiment to search for any relations between a person's birthdate and his or her personality. In particular, the researcher looked at the astrological sign of the individual. Her alternative hypothesis stated that if there is a difference between the traits of people born under a specific sign from the ideal traits for that sign, then that difference will be less than that of people not born under that sign. To investigate this, the researcher constructed a survey containing forty six questions; each question pertained to a specific characteristic trait. Ninety-five participants, of ages fourteen and older, were included in this experiment. After the information was gathered and analyzed, the researcher concluded that there was no correlation between a person's astrological sign and their human behavior. Since most of the data produced high T-test values (averaging 0.26), the researcher was led to reject her alternative hypothesis, and accept the null hypothesis. If there is a difference between the traits of people born under a specific sign from the ideal traits for that sign, then that difference will be no less than that of people not born under that sign or its ideal traits.

## **Observing The Effect of Diet on Heredity in Regards to Behavior, Fertility, and Cognitive Memory Using the Medium of Poecilia Reticulata**

*Michael H. Leek, III*

*Menwith Hill HS, Harrogate, DoD Dependent Schools (Europe) JSHS;  
Teacher/Mentor/Sponsor: Mrs. Michelle Harrington, Menwith Hill HS; Mrs. Michelle Harrington*

Diet has been known to affect the Epigenome in significant ways such as differentiating queen and worker bees. Two different diets were tested, one processed the other natural. The researcher defined a natural diet as a diet which is similar to that which an organism would find in its natural habitat. The USDA defines a processed food as a food that has been combined with another substance. The effect of diet was measured using *Poecilia Reticulata* (guppies). They were used as subjects because of their short gestation period and short lifespan. A change in behavior or memory is considered a sign of significant epigenetic change (University of Utah). Fertility is considered one of the most important factors regarding whether a species will thrive or fail. Fertility was measured by counting offspring produced per birth. Memory was tested using a maze made out of plastic hamster tubing. Dried worms were used as an incentive for the fish. Skype was used on a laptop to view the fish remotely as the fish appeared anxious whilst humans were in the room. The data shows signs of an emerging pattern, however more data would be needed to determine the specifics of the pattern.

## **Is Life on Mars Possible? An Experiment on the Effect of Plant Growth when Placed under Living Conditions Similiar to Mars**

*Jessica Morton*

*Ramstein High School, Ramstein, Germany, AE, DoD Dependent Schools (Europe) JSHS;  
Teacher/Mentor/Sponsor: Margaret Hess, Ramstein High School*

In the last 50 years, Mars has come into the spotlight of the other planets of our solar system. The researcher's hypothesis was that if the growing conditions of a pinto bean plant were changed to simulate Martian growing conditions, then the pinto bean plant's morphology would change from that grown under Earth growing conditions. The experiment was conducted in controlled terrariums; which controlled the temperatures, carbon dioxide levels, soil, and amount of light received. For this experiment, the independent variable was the growing conditions of a pinto bean plant and the dependent variable was the morphology of the pinto bean plants. The hypothesis proposed by the researcher was disproven, as the plants morphologies in the Earth terrarium and the Mars terrarium had undistinguishable differences. The average growth of the Earth terrarium plants was 21.39 cm; where as the average growth for the Mars terrarium plants were 19.42 cm. A p-value of .069 and a significance level of 10% we have moderately strong evidence against the idea that there is no difference in plant growth between the two environments.

## DoD Dependent Schools (Pacific)

---

### **“Effectiveness of *Nelumbo nucifera* in Preventing Obesity in Sprague Dawley Rats”**

*Ji S. Jeong*

*Seoul American High School, Seoul, DoD Dependent Schools (Pacific) JSHS;*

*Teacher/Mentor/Sponsor: Mr. Scott Bittner; Dr. Schlenker; Korea Animal Medical Science Institute*

In the early 1960s, the average American adult male weighed 168 pounds. Today, he weighs nearly 180 pounds. The purpose of this experiment was to test whether the consumption of *Nelumbo nucifera* powder would decrease obesity levels in nine Sprague Dawley rats. The effectiveness of *N. nucifera* powder was determined by measuring the levels of carbohydrates, triglycerides, high-density lipoprotein, and low-density lipoprotein in the nine rats prior to and subsequent to experimentation. The nine rats were divided into three groups and the first group was fed a normal diet, the second a diet supplemented with 45% high fat diet, and the third a high fat diet supplemented with *N. nucifera* powder. The rats were fed the specialized diets for four weeks and blood tests were conducted the first and fourth week to compare the levels of carbohydrates, triglycerides, HDL, and LDL prior to and subsequent to experimentation. The results reflected a decreasing trend in the levels of carbohydrates, triglycerides, and LDL in the rats that were fed the diet supplemented with *N. nucifera* powder. This experiment may provide a new basis for finding a healthy solution for the growing obesity rates in the United States of America.

### **The Effects of Utilizing *Taxiphyllum barbieri* on the Nitrification Rate of Effluents**

*Brian Lee*

*Seoul American High School, APO, AE, DoD Dependent Schools (Pacific) JSHS;*

*Teacher/Mentor/Sponsor: Scott Bittner, Seoul American High School*

This research examines the nitrification potential of *Taxiphyllum barbieri* in the treatment of wastewater. Previous studies show mosses not only consume pollutants in the form of nutrients, but are also durable and low-maintenance plants that could possibly aid in optimizing wastewater treatment in aquaculture. For the experiment, a supply of polluted water was created by placing a group of *Carassius auratus* into an eighteen gallon tank of water in order to raise ammonia, nitrite, and nitrate levels to concentrations of 1 ppm, .5 ppm, and 15 ppm, respectively. In addition, carbon dioxide injections along with phosphorus and chelated iron were added into the wastewater in order to further imitate wastewater conditions. The effectiveness of the *Taxiphyllum barbieri* was tested by placing it inside a three-staged power filter that ran on a portion of the polluted wastewater. The rate of nitrification in ammonia, nitrite, and nitrate levels using the treatment filtration system was compared to the nitrification rate using the control filtration system, which excluded *Taxiphyllum barbieri*. Repeated trials and a comparison of regression slopes between treatment and control filtration systems verified that *Taxiphyllum barbieri* was able to increase the rate of nitrification. However, a two proportion t test using  $\alpha = 0.05$  of the differences between the rate of nitrification between the control and treatment groups reveals P values that are statistically insignificant. These results led to the failure of rejecting the null hypothesis, which states that the rates of nitrification between the control and treatment filtration systems are the same.

# Generalizing Polynomial Growth Functions of Generating Sets for the Standard Integer Lattice

*Frederick J. Lee*

*Seoul American High School, APO, AE, DoD Dependent Schools (Pacific) JSHS;*

*Teacher/Mentor/Sponsor: Dr. Moon Duchin, Tufts University; Mr. Scott Bittner, Seoul American High School*

Although the growth functions of generating sets are useful for the modern approach to determining the computational time and complexity of computer algorithms, a polynomial to describe all growth functions of generating sets in  $\mathbb{Z}^2$  has yet to be found. While the Ehrhart polynomial accurately describes the growth functions of generating sets that contain all lattice points within a convex hull, a generating set  $S$  may be missing points in its convex hull so that the Ehrhart polynomial does not match the growth function. We show that when certain families of generating sets can be described by explicit polynomials equal to the Ehrhart polynomial, a specific subset  $C$  of  $S$  called the corner subset is filled. This paper also covers a novel method of checking whether lattice configurations are linear transformations of each other by comparing their respective growth functions and observed trends in families of generating sets.

## **Keeping Track of Biological Control: Attracting a Natural Enemy of Fruit Flies**

*Ana B. Corra*

*West Boca Raton High School, Boca Raton, FL, Florida JSHS;*

*Teacher/Mentor/Sponsor: Kane More*

The purpose of this research was to find possible attractants and oviposition (egg-laying) stimulants for the fruit fly parasitoid *Utetes anastrephae* in order to attract them to locations and allow them to naturally control the fruit fly pest population. It was predicted that *Utetes anastrephae* would respond to solutions of para-ethylacetophenone (a larval odor) and limonene (fruit component), as well as to the odor of whole *Citrus sinensis* (orange). It was also predicted that the complete orange volatile might be more attractive than limonene, and that females would be more attracted to PEA. A Y-tube olfactometer tunnel bioassay was developed to determine the response of *Utetes anastrephae* to these solutions. The olfactometer was checked every half hour from the period of 0900 to 1600 hours. A positive response was recorded when there was a parasitoid in one of the arms. There were eight replicates with both male and female parasitoids with *Citrus sinensis* L (orange), a para-ethylacetophenone concentration (25ng/ $\mu$ l), and a limonene concentration (25  $\mu$ l/ml). The results showed that both male and female parasitoids moved toward the treatment volatiles significantly more often than they did to the clean air control. However, there were no significant differences in the responses between sexes nor were there differences among the relative attractiveness ( $F= 2.2$ ,  $p= 0.08$ ). The overall hypothesis was supported because the volatiles attracted more parasitoids than the control. Even so, the second prediction about a difference in the relative attractiveness between the orange and limonene was not supported.

## **Effects of *Isaria fumosorosea* on Yellowmargined Leaf Beetle When Applied to Host Plants**

*Isabella V. Daza*

*Homeschool program under the Saint Lucie School Board, Port Saint Lucie, FL, Florida JSHS;*

*Teacher/Mentor/Sponsor: Dr. Pasco Avery, University of Florida, Indian River Research and Education Center;*

*Angie Nino, University of Florida, Indian River Research and Education Center; Dr. Cave, University of Florida,*

*Indian River Research and Education Center*

The purpose of this study is to observe if the fungi, *Isaria fumosorosea* (Wize), will have the effects of a repellent when specifically used against the *Microtheca orchroloma* Stål (Yellowmargined Leaf beetle) when applied to two different host plants. A choice preference test was conducted to determine preference of Yellowmargined Leaf beetle for crucifer plants bok choy (*Brassica rapa* L. var. Baby Pak choy) and turnips (*Brassica rapa rapa* L. var. Seventop) treated with *Isaria fumosorosea* (Wize) or plants treated with distilled water only. The Hypothesis concluded is that the fungus will have effects of a repellent. In the study the researcher used six cages and two types of crucifer plants (bok choy, and turnips); half of the cages contain bok choy and the other half turnips. Study was set up as a randomized complete block design. The researcher ran two trials that were one week long each. The experiment was observed at four and seven days post release. Leaf damage was recorded through the ImageJ software. The data obtained after evaluations were analyzed using one-ways anova. Treatments were compared using Turkey-Kramer HSD tests. The tests rejected the hypothesis, however, there was beetle mortality from ingestion of the fungus.

## **Comparison of Terrain Rendering Using Dynamic Versus Static Mesh Generation And Management**

*Owen R. Kelly*

*Spruce Creek High School, Port Orange, FL, Florida JSHS;*

*Teacher/Mentor/Sponsor: Ms. Anne Cooney, Spruce Creek High School*

This study was conducted to compare two different ways of managing and generating graphical polygons. The quadtree level-of-detail method involves dynamically changing the amount of polygons based on need, and the other method, the static mesh, is a simple brute-force style polygon rendering where the amount of polygons remains constant. The quadtree or polygon reduction method uses the position of the virtual camera and the view frustum (viewing cone) to determine if areas of a mesh require more detail. This system is managed using a quadtree, which allows for the examination of specific areas of the mesh. If a particular area is determined to require more detail, the quad representing that area is split into four smaller child quads, each with as many vertices as the parent quad. The static mesh method is simply a mesh that is completely created at start-up and is homogeneously detailed. In order to effectively compare the performance of these dynamic and static techniques, certain benchmarks such as frame-rate, memory consumption, and start-up time were tested and evaluated. Results showed that although the use of a dynamic level-of-detail generation and management system caused slight stutters in frame-rate, benefits such as very low and efficient memory usage and mesh-size agnosticism greatly outweighed the slight benefits of using a static mesh. Furthermore, one can conclude that with still unknown technological innovations, it is wasteful to use precious memory and computational power on extraneous polygons, when that power could easily be used to support other graphics effects.

## **Exploring the Future of Education: Development of an Instructional Web-Based Application and Its Effect on Student Cognition and Performance (Year 3)**

*Caitlyn Ralph*

*Lake Howell High School, Winter Park, FL, Florida JSHS;*

*Teacher/Mentor/Sponsor: Vanessa Moosavifazel, Crooms Academy of Information Technology; Dr. Jennifer Vogel-Walcutt, Cognitive Performance Group*

As society is replacing traditional practices with technological techniques, research must be done to ensure these changes are not negatively affecting education. The aim was to determine whether converting a paper-based printout (traditional method) into a web-based application (technological method) would alter student learning. To test this, 130 students completed an activity with the traditional or the technological method. The students answered questions that assessed accuracy (performance) and a germane cognitive load survey (Cheon & Grant, 2012) with attached mental effort statement (Paas, 1992). To quantify the effect of this instructional strategy on learning, Paas and van Merriënboer's (1993) training efficiency formula was employed. After conducting t-tests, the results fail to reject the null hypothesis with caution. It was found that the students' germane cognitive load, mental effort, and training efficiency had no significant difference between the methods. However, performance had a significant difference supporting traditional. The results suggest that advantageous, pedagogical technology may gradually be incorporated within a traditional classroom framework, creating a blended learning environment. Students and teachers should be effectively trained in these new instruments to raise their performance. Overall, research needs to guide the efficacious introduction of instructional technology into education.

## **Novel Iron-Catalyzed Hetero Diels-Alder Reaction directed towards Natural Product Synthesis**

*Andre Sanchez*

*Manatee High School, Bradenton, FL, Florida JSHS;*

*Teacher/Mentor/Sponsor: Dr. Larry Gaudioso, Manatee High School; Dr. Scott Schaus, Boston University; Keith Barbato, Boston University*

The purpose of this research was to investigate the use of an in situ generated ortho-quinone methide intermediate as a diene partner in an iron-catalyzed hetero Diels-Alder reaction directed towards natural product synthesis. The goal of the investigation was to establish a practical and cost-effective synthetic route to access the hexahydro-6H-benzo[c] chromene core and to synthesize marine meroterpene (+)-conicol. The research was conducted in three individual phases. The optimization phase was accomplished through a series of reactions, manipulating parameters including stoichiometric ratios, catalyst concentration, buffers, and duration (1). The reactions were monitored by silica-gel thin layer chromatography (TLC) and the products were isolated using flash column chromatography. The Diels-Alder adducts were validated with <sup>1</sup>H nuclear magnetic resonance (NMR) spectroscopy. Once optimal reaction conditions were determined, a series of electron-rich dienophiles were substituted into the parent reaction (2). Optimal conditions of the parent reaction were then extended to the synthesis of (+)-conicol (3). The reaction methodology directed towards the synthesis of (+)-conicol revealed a practical and cost-effective pathway. TLC and <sup>1</sup>H NMR assessments revealed a mixture of (+)-conicol and an impurity. Future studies will need to be completed in order to optimize the reaction and extend its potential.

## **Inducing Chondrocytic Phenotype Phase II**

*Sonam A. Brahmbhatt*

*Rockdale Magnet School for Science and Technology, Conyers, GA, Georgia JSHS;*

*Teacher/Mentor/Sponsor: Dr. Richard Steet, Complex Carbohydrates Research Center*

Many individuals acquire osteoarthritis due to progressive, inevitable cartilage degradation. Current treatments include joint replacements, which leave patients less mobile. Cartilage culturing methods are being researched. The purpose of Phase II of this study was to determine combined effects of growth-factors and culture structure on chondrogenic differentiation of bone-progenitor cells over a two-week time period. It was predicted that cells grown in treated media in 3D culture would produce the most GAGs. Premature-bone cells were cultured in conical microfuge tubes and well plates with regular DMEM media and media treated with growth-factors TGF-1 $\beta$ , dexamethasone, and ascorbic acid. GAG assays were conducted on day 0, day 6 and day 13. The results of the pellet culture experiment were statistically significant ( $p < 0.001$ ). The monolayer experiment yielded data with high variability and no statistical significance ( $p = 0.488$ ). The presence of growth-factors had a statistically significant impact on GAG production by cells cultured in pellet form only. ANOVA results comparing culture structures did not meet the required 99% confidence level, but trends show that pellet culture promoted GAG production in cells grown in treated media. It was concluded that the combination of pellet culture and treated media is favorable for inducing chondrocytic phenotype in bone marrow progenitor cells; further experimentation is needed to support the action of culture structure on GAG production. Noting the positive effects of combining growth-factors with pellet culture can be put to applicable use in developing a method for growing cartilage tissue in vitro for joint replacement and osteoarthritis prevention.

## **A Walk in the Life of a Sibling of a Person with Down Syndrome**

*Marissa L. Hernandez*

*Rockdale Magnet School for Science and Technology, Conyers, GA, Georgia JSHS;*

*Teacher/Mentor/Sponsor: Mrs. Baskett*

The purpose of this project was to compare the typical sibling relationship with the sibling relationship of people with Down Syndrome. The hypothesis was that the two sibling relationships would be different in their underlying themes. The procedure involved comparing themes of responses between 100 siblings of people with Down Syndrome and 70 typical siblings, based on their survey answers. Differences between the two groups' responses were then analyzed. Themes between birth order were also examined. The two sibling relationships were in fact different. The typical siblings seemed more self-concerned in their responses and relationships while the siblings of people with Down Syndrome were more concerned about the life and perception of their sibling. This indicates that siblings of people with Down Syndrome do experience a different sibling relationship than that of the average person. This could be used to help the Down Syndrome community's siblings to realize that they are different, but it is okay. It may also help them realize that most siblings dealing with a brother or sister with Down Syndrome do experience very similar feelings, which increases their sense of community.



## **Novel pertussis Antibiotic Targets of Protein Interactions**

*William H. Jin*

*Gwinnett School of Mathematics, Science, and Technology, Lawrenceville, GA, Georgia JSHS;  
Teacher/Mentor/Sponsor: Dr. Emily Weinert, Emory University; Dr. Susan Kramer, GSMST*

Biofilms show increased antibiotic resistance thus necessitating novel therapeutics. The purpose of this project was to identify key targets of BpeGReg, a protein shown to cause B. pertussis biofilms, that would further the development of those therapeutics. Previously, only the H225 residue of Bpe GReg had been researched; everything else remained unknown. By utilizing UV-spectroscopy in Phase I of research, this research elucidated the effects of mutation to key residues\_ Y43F and S68A\_ on ligand binding and signal transmission. The Y43F mutation resulted in auto-oxidation and loss of oxygen binding, and the S68A mutant weakened oxygen binding affinity seventy-times. This supports our developed model where Tyr43 is a hydrogen-bond donor while Ser68 holds the Tyr (tyrosine). Through Phase II's HPLC activity, interaction pull-downs, and native gels, the middle domain was found to interact with the full-length protein. This interaction has great potential for controlling oligomerization states. Given that Bpe GReg needs to be in a dimer form to be active, peptides simulating the interacting surface of the middle domain could be used to prevent c-di-GMP formation and thus inhibit biofilm formation. This research establishes vital targets of future B.pertussis treatment through the ability to modulate oligomerization states and target heme pocket oxygen-binding.

## **Incorporating Prebiotics into Broad-Spectrum Antibiotic Usage**

*Jordan A. McCray, Sr.*

*Rockdale Magnet School for Science and Technology, Conyers, GA, Georgia JSHS;  
Teacher/Mentor/Sponsor: Mrs. Baskett, Rockdale Magnet School for Science and Technology; Ms. Marshall, Rockdale Magnet School for Science and Technology*

The human gut microbiome provides benefits for the human body such as inducing innate immunity and increased digestion of carbohydrates. Broad-spectrum antibiotics pose a threat to the human gut microbiome as they target a wide range of bacteria, which can include the helpful bacteria in the gut. This project attempted to find an alternative method of treatment that incorporated prebiotics by testing the effects of various herbal medicines on the growth of two model bacteria. An absorbance test with a neutral control, a positive control, and 6 herbal medicines was conducted. The bacteria used were the beneficial model Lactobacillus acidophilus and the pathogenic model E. coli. Two trials were completed and very interesting data was shown. In both Lactobacillus acidophilus and E. coli, Chicory was tied for the best result with one other treatment. It tied with St. John's Wort for having the highest increase of growth on Lactobacillus acidophilus and it was tied with the negative control Doxycycline for having the highest decrease of growth on E. coli. This suggests that Chicory may be an alternative to straight antibiotics and needs to be studied further.

## **In The Mind's Eye: Studying the Gaze Events of Dyslexic Adults**

*Molly G. Niemczyk*

*Rockdale Magnet School, Conyers, GA, Georgia JSHS*

Dyslexia tests are generally expensive, time-consuming, and tedious. This experiment attempted to use video as a diagnostic tool for dyslexia, as this would be more appealing, less expensive, and more accurate than a written test that's results are ultimately based on test-taking skills, rather than quantitative numerical data. It was expected that, if both dyslexics and those without dyslexia watched the same video, dyslexics would display different eye movements than those without dyslexia. The average gaze event duration of the eyes of 20 participants (10 with primary dyslexia, 10 without) was analyzed by a T120 while they watched a 5 minute video displaying randomly moving objects. An ANOVA test was performed, and the data showed a very significant difference between dyslexic and nondyslexic eye movement ( $F=52976.1$ ;  $df=1$ ;  $p<.05$ ). Dyslexic gaze durations were shorter more of the time than nondyslexic gaze durations. In addition, the overall gaze of dyslexic participants was preferential to the top right corner of the screen; nondyslexics focused more on the middle. Based on a preliminary bell curve, primary dyslexia can be diagnosed 95% of the time within two standard deviations of 53,827 ms. This information could lead to the utilization of a universal test for dyslexia.

### **An Experimental Study of New and Existing Algorithms for Minimizing Busy Time on Multiple Parallel Machines**

*Megan Chao*

*Montgomery Blair High School, Silver Spring, MD, Greater Washington, D.C. Area JSHS;*

*Teacher/Mentor/Sponsor: Dr. Samir Khuller, University of Maryland College Park*

We conduct an experimental evaluation of the performance of several approximation algorithms for the busy time scheduling problem in situations with multiple parallel processing machines. This problem is of practical importance as it is related to the problems of minimizing the switching costs of optical networks and reducing energy costs in cloud computing. The busy time problem assigns jobs to machines which can process an input-specified  $g$  number of jobs at once. It has the objective of minimizing the total busy time all the machines needed to process all the jobs. Since this problem is known to be NP-hard even when  $g = 2$ , it is unlikely that one can construct a polynomial-time algorithm which always produces the optimum. As a result, this paper focuses on finding approximate solutions using computationally tractable algorithms which run in polynomial time. We make two contributions to this busy time scheduling problem. First, we propose a new approximation algorithm, which we call GreedyParallelPursuit. Secondly, we conduct an experimental study comparing GreedyParallelPursuit to existing approximation algorithms for this problem. Our experimental results show that, relative to the alternative algorithms we consider, GreedyParallelPursuit performs well not only on average but also in terms of overall reliability.

### **The Effects of LED Light Exposure on Strawberry Quality in a Simulated Retail Setting**

*Kristi A. Kan*

*Centennial High School, Ellicott City, MD, Greater Washington, D.C. Area JSHS;*

*Teacher/Mentor/Sponsor: Yaguang Luo, US Department of Agriculture, Agricultural Research Service; Ellen Turner, US Department of Agriculture, Agricultural Research Service; Michelle Bagley, Centennial High School*

Light-emitting diodes (LEDs) are gaining popularity because of their high energy efficiency, but it is not known if LED light exposure affects strawberry quality. This study investigates the effects of LED light exposure on strawberry quality. Strawberries were exposed to either continuous LED, fluorescent, or no light at 1°C for ten days and were assessed for tissue electrolyte leakage, color, firmness, and sensory attributes (aroma, off-odor, overall visual quality, and purchase intent) on days 0, 2, 4, 7, and 9. When compared to strawberries from the fluorescent or no light treatment, strawberries exposed to LED light had the highest levels of electrolyte leakage and scored the highest for off-odor on day 9. The LED strawberries also had the lowest purchase intent, visual quality, and aroma scores, and they had the lowest chroma values and were the least firm on the last evaluation day. These results suggest that LED light exposure accelerates spoilage and reduces marketability, leading to increased food and financial loss for grocers.

### **Fungi with previously uncharacterized enzymatic activity can digest polyurethane in soluble and insoluble form**

*Caden W. Petersmeyer*

*The Potomac School, McLean, VA, Greater Washington, D.C. Area JSHS;*

*Teacher/Mentor/Sponsor: Dr. Isabelle Cohen, The Potomac School*

The discovery of microorganisms that can efficiently degrade polyester polyurethane (PUR) has become a pivotal goal in promoting bioremediation as an applicable solution to plastic waste. This report reveals members of the *Glomerella* and *Cladosporium* genera that display previously uncharacterized enzymatic activity for PUR degradation. The degradation was measured using a halo assay, in which a clear ring appears around the fungal growth as the fungus degrades the plastic. Fungi were also tested in a liquid medium and effectively degraded insoluble PUR under minimal conditions. This is a particular point of interest due to the high proportion of insoluble plastic waste present in the environment. Taken together, the isolation of these fungi has the potential to advance the development of the sustainable disposal of plastics.

## **Effect of Microbially Fermented *Morinda Citrifolia* on Ovarian Cancer**

*Kealyssa M. Castillo-Martin*

*Kamehameha Schools, Honolulu, HI, Hawaii JSHS;*

*Teacher/Mentor/Sponsor: Gail Ishimoto, Kamehameha Schools*

*Morinda citrifolia* (noni) is a folk medicine in many cultures. One traditional Hawaiian preparation is fermentation. This study explored the effect of traditionally prepared noni on ovarian cancer in varying concentrations and bacterial diversity of noni throughout fermentation. SKOV-3 cells were treated with fresh and fermented noni, and growth was measured over three days. It was found that when fermented noni is concentrated by evaporation, the cytotoxic compound also becomes more concentrated, indicating that it is not volatile; however, the cytotoxic compound of fresh noni is volatile. The study also examined the bacterial diversity of noni at different stages of fermentation. Bacterial DNA was isolated from fermented samples of noni and the 16S gene was amplified using PCR. Cyanobacteria (aerobic respirators) were identified in fresh noni samples. Sequences related to *Aeromonas*, *Enterobacteriaceae*, *Novosphingobium*, *Klebsiella*, and *Acinetobacter* (anaerobic bacteria that utilize fermentation) were found in fermented noni samples. In conclusion, the cytotoxic compound of fermented noni is most likely a product of the bacteria driving fermentation. It is possible these bacteria are fermenting preexisting compounds of noni to create the cytotoxic effect. And based on small sample size, bacterial diversity increases with time spent in fermentation.

## **The Role of *Homalanthus nutans* (G. Forst.) Guill., A Samoan Medicinal Plant, As an Insect Growth Regulator**

*Charu Joserose*

*Tafuna High School, Pago Pago, Hawaii JSHS;*

*Teacher/Mentor/Sponsor: Dr.J.Jyothibhavan, Tafuna High School*

The extract from the bark of Samoan medicinal plant '*mamala*' (*Homalanthus nutans*), is used to treat hepatitis in Samoan Islands. Its active component is prostratin, a non-tumor promoting phorbol ester and protein kinase C (PKC) activator, which has been shown to flush the HIV-AIDS latent viral reservoirs in humans. The development of insects is regulated by insect growth hormones, such as the juvenile hormone, which acts by activation of PKC-dependent signaling. Given the role of prostratin in PKC activation and its abundance in *mamala*, our research explores the putative roles of the *mamala* bark extract in regulating the development of the mosquito *Aedes polynesiensis*, the main vector of the dengue virus in the Pacific. The *Ae. polynesiensis* larvae were treated with different concentrations of *mamala* bark extract and compared with two commercial Juvenile hormone analogs (JHAs), Nyguard® and Gentrol®. Both JHA's and *mamala* bark extract, inhibited the successful adult emergence, induced mortality in larvae, and pupae in varying concentrations and time periods compared to untreated control. We determine that the *mamala* bark extract is a highly potent regulator of *Ae. polynesiensis* growth and assume that the developmental abnormalities are caused by the prostratin present in the *mamala* extract, needs to be confirmed.

## **Microwire Biosensor: A Novel Detection of Escherichia coli**

*Ariana Kim*

*St. Andrew's Priory, Honolulu, HI, Hawaii JSHS*

Microwire Biosensor: A Novel Detection of Escherichia coli Ariana Kim St. Andrew's Priory, Honolulu, Hawaii Dr. Soojin Jun, University of Hawai'i at Manoa Outbreaks of foodborne illness linked to pathogenic bacteria such as Escherichia coli have attracted increasing public attention. Traditional culture-based methods for pathogens identification are time-consuming and labor-intensive, raising the need for fast and sensitive detection techniques. A novel, rapid detection method for E. coli performed by a functionalized microwire sensor was developed and evaluated. A gold-tungsten microwire immobilized with anti- E. coli -antibodies was used to capture E. coli bacterial cells. Cell suspension with dielectrophoretic force generated by an alternating current with an electric field was used. Immobilization of antibodies using conventional methods is non-compatible with the DEP driven electric field, challenging the surface functionalization. Therefore, this study was aimed to develop a microwire sensor based on DEP and antigen-antibody reaction for pathogen detection and evaluate the sensor's performance to detect Escherichia coli K-12 from a liquid sample. The microwire was manipulated by an automated xyz stage and the sensing process included antibodies immobilization, bacteria detection and cells quantification. Field Emission Scanning Electron Microscope figures and fluorescence intensities of bacteria on the wire validated the sensing mechanism. The developed sensor demonstrated high sensitivity and specificity with fast detection rate, which shows a strong potential for the application in food industry.

## **Helicotoroidal Topology of Leptons, Quarks, and Hadrons**

*Viola Mocz*

*Mililani High School, Mililani, HI, Hawaii JSHS;*

*Teacher/Mentor/Sponsor: Nel Venzon, Mililani High School; Andre S. Bachmann, University of Hawaii at Hilo*

The internal structure of elementary particles is not yet fully understood. I formulate a semi-classical wave-particle model to describe some fundamental properties of leptons, quarks, and hadrons within the framework of mathematical knots. In the model, the particle is confined in periodic boundary conditions and the material wave propagates on closed toroidal paths corresponding to the streamlines of energy flow over the toroidal surface. The wave may also be viewed as a series of helical tubular surfaces, the trajectory of which is the torus of the proposed model. The particle-wave topology depends on the number of radial oscillations through the torus-hole and azimuthal revolutions around the torus. Each path is specified by a torus knot which is also associated with the mass, spin, path angular momentum, and quivering motion named the Zitterbewegung of the particle. The computed path angular momentum suggests that leptons may be described by double-looped unknots, pseudoscalar mesons by circular loops, vector mesons by figure-eight unknots, and baryons by overhand trefoil knots. Quarks are not sufficient in themselves to complete a closed loop, but when combined they can form the closed loops of hadrons. The results warrant further investigation of the internal topological structure of elementary matter.

## **MERG1a K<sup>+</sup> Channel Decreases NF-κB Activity in Skeletal Muscle**

*Chase D. Latour*

*Carbondale Community High School, Carbondale, IL, Illinois JSHS;*

*Teacher/Mentor/Sponsor: Mrs. Stacey Massie, Carbondale Community High School; Stacey Massie, Carbondale Community High School*

ERG1 encodes a K<sup>+</sup> channel. The Pond laboratory has shown that the ERG1 channel participates in the onset of skeletal muscle atrophy by increasing ubiquitin proteasome proteolysis (UPP) activity and that ERG1 up-regulation induces expression of MuRF1, a UPP ligase. We know that MuRF1 expression is linked to activation of NF-κB transcription factor family members by upstream IKK-B activation. We hypothesized, therefore, that ERG1 expression may induce NF-κB activity. Thus, we ectopically co-expressed mouse ERG1 (MERG1) and an NF-κB activity luciferase reporter in left gastrocnemius muscles of mice while co-expressing the NF-κB reporter and a control empty plasmid in the right gastrocnemius muscles (n=40). We killed 5 mice daily and harvested all gastrocnemius muscles for 7 days. The data show that MERG1 expression decreases NF-κB activity. NF-κB activity decreased 40.6% after the first day and dropped by 65% on day 3 after which the activity increased. This is surprising because NF-κB factors are known to induce expression of atrophy-related genes. We conclude that, because MERG1a expression causes a significant decrease in NF-κB transcription factor activity, the MERG1a K<sup>+</sup> does not modulate expression of the MuRF1 E3 ligase through NF-κB transcription factors.

## **Cloning Ezh1: First Steps Toward an Analysis of Ezh1 Function**

*Natalie A. Nickrent*

*Carbondale Community High School, Carbondale, IL, Illinois JSHS;*

*Teacher/Mentor/Sponsor: Mrs. Stacy Massie*

Ezh1, a protein involved in the regulation of skeletal muscle differentiation, was cloned into a vector and analyzed. As a member of the polycomb repressive complex 2 (PRC2), Ezh1 has been shown to be an early catalyst in recruiting the complex to cells. Cancer cells, however, exhibit an overexpression of PRC2, so an excess of the protein in a cell can ultimately lead to complications and uncontrollable proliferation. After ligating and transforming the E. coli cells with the desired vector and insert, the plasmids were extracted. Western gel electrophoresis later proved that the protein was successfully expressed in the cell, which enables further experimentation on the protein to be performed.

## **A New General Method of Relational Heuristics Utilizing Agent-Based Collective Intelligence**

*Conner T. Ruhl*

*The Governor French Academy, Belleville, IL, Illinois JSHS;*

*Teacher/Mentor/Sponsor: Mrs. Christine Stewart, The Governor French Academy*

A method of identifying and utilizing relationships within data was created. This system was implemented using a collection of agents that have individualized goals and are capable of self-determination. These agents are assigned to fulfill various requirements of an algorithm. Each agent possesses traits that modify the queries they perform on their initial breadth-first search for solutions pertaining the algorithm's goals. These attributes are subject to modification, and range from the depth the agent will search, to its willingness to select solutions that have already been explored by other agents. The results of each of these queries are then aggregated and examined by the algorithm using a scoring system that takes agent attributes into consideration. All of these aspects result in a system that provides highly unique, yet structured solutions to a broad range of problems. The system is applicable in any scenario where a variety of distinct, heuristic answers are favored. Examples of these applications include recommendation systems, curriculum development for individuals or schools, or even medical diagnoses. The agent management algorithm is highly customizable, allowing the system to be adapted for a wide range of purposes with varying complexity and size.

## CycloAlkyl Fluorophores: A Synthesis and Analysis

*Brian J. Suarez*

*Carbondale Community High School, Carbondale, IL, Illinois JSHS*

Six fluorescence based probes for the optical detection of pH were synthesized, purified, and tested. To make these fluorescent probes I used rhodamine 6G and rhodamine B. The probes contain a cycloalkyl-amine molecule, which reacts to different pH levels. The probes provide a sensitive measurement of pH by undergoing a colorimetric and fluorescent change as an aqueous environment changes from basic to acidic. At high pH, the methylamino group interacts with the fluorophore by forming a colorless, non-fluorescent, spiro-cyclic structure. As the pH is lowered, near the pKa of the methylamino group, the spiro-amine is protonated and the ring opens resulting in a brightly colored, highly fluorescent species. This series of rhodamine derivatives differ by the type of alkyl substitution on the methylamino nitrogen atom. Specifically the cyclic alkyl systems were compared and characterized the effect those systems have on the pKa of the spiro-amine ring opening process. It was found that the series of cyclic amines pH response correlated well with the Baeyer strain theory on how ring structure affects the basicity of amines by showing that an increase in the size of the ring structure directly increases the basicity.

## Radio Static Random Number Generation

*Andrew L. Woodruff*

*Macomb Highschool, Macomb, IL; Michael Dofing, Macomb Highschool, Macomb, IL, Illinois JSHS;*

*Teacher/Mentor/Sponsor: Mr. Thomas Johnson, Macomb Highschool*

Most modern computers rely on software based pseudo-random number generators, which are generally accepted to be less secure than those based on physical phenomena. In this proposed solution, an arduino uno was used to control and gather stereo data from a radio receiver, in order to gather and analyse the resulting data. This test was meant as a proof of concept for using radio static to generate random numbers, not as a cryptographically secure random number generator. The arduino combined both signals and indirectly converted the data into binary information and performed a mean value test on one kilobit of data. If the mean value was close enough to .5, the frequency was used to further generate 80 32-bit hexadecimal integers and print them to the serial console. This process was repeated until over 2 MB were generated for use in several more rigorous statistical analyses. The information gathered from these tests was then compared against the test random numbers generated based on atmospheric data and data from Fortran's rand function. From these tests it can be concluded that while generating pseudo-random numbers from radio static is viable, the software used screen frequencies and filter the data require further refinement.

### **Lithium-Induced Neuroprotection is Associated with Epigenetic Modification of Specific BDNF Gene Promoter and Altered Expression of Apoptotic-Regulatory Proteins**

*Tushar Dwivedi*

*Neuqua Valley High School, Naperville, IL, Illinois (Chicago) JSHS;*

*Teacher/Mentor/Sponsor: Hui Zhang, University of Illinois at Chicago*

Lithium-Induced Neuroprotection is Associated with Epigenetic Modification of Specific BDNF Gene Promoter and Altered Expression of Apoptotic-Regulatory Proteins

Tushar Dwivedi, Neuqua Valley High School, Naperville, Illinois Mentor: Dr. Hui Zhang, University of Illinois at Chicago Bipolar disorder (BD), one of the most debilitating mental disorders, is associated with increased morbidity and mortality. Lithium is the first line of treatment option for BD and is often used for maintenance therapy. Recently, the neuroprotective action of lithium has gained tremendous attention, given that BD is associated with imbalance in cellular signaling that leads to neurotoxicity and consequent structural and functional abnormalities of the brain. However, the precise molecular mechanism by which lithium exerts its neuroprotective action is not clearly understood. The present study aims to investigate such mechanisms. In rat hippocampal neurons, lithium not only increased dendritic length and number, but also neuronal viability against glutamate-induced cytotoxicity. While lithium increased the expression of BDNF, a gene involved in neuronal survival and plasticity, as well as genes associated with neuroprotection such as Bcl2 and Bcl-XL, it decreased the expression of pro-apoptotic genes Bax, Bad, and caspases 3. Interestingly, lithium activated transcription of specific exon IV to induce BDNF gene expression. This was accompanied by hypomethylation of BDNF exon IV promoter, suggesting that epigenetic modifications play a key role in inducing BDNF expression by lithium. This study delineates novel mechanism by which lithium mediates its effects in protecting neurons.

### **Creation of Novel Absorbent Antimicrobial Bandages and Ointment from the Slime of the Pacific Hagfish, *Eptatretus stoutii*, for Use on Burns and Wounds**

*Grace M. Niewijk*

*Oak Park and River Forest High School, Oak Park, IL, Illinois (Chicago) JSHS;*

*Teacher/Mentor/Sponsor: Allison Hennings, R.N., B.S.N., M.A.T., Oak Park and River Forest High School; Douglas Fudge, Ph.D., University of Guelph*

Current burn treatments are deficient with respect to antimicrobial effects and absorption of exudate. Three new materials were developed from hagfish slime components. All were tested for absorbency and antimicrobial activity in order to determine the suitability for production of a bandage or ointment. The experimental hypothesis proposed that extracted slime components would be exceptionally absorbent due to the ability of hagfish slime to capture liquids, and that the lysozymal antimicrobial properties would be preserved in processed slime. Absorbency was tested by saturating 1x1 cm samples of different bandages and measuring percent change in mass and volume absorbed. Absorbency was tested with water, to mimic plasma found in wound exudate, and with blood. Slime-based bandages were significantly ( $p \leq 0.000279$ ) more absorbent than their respective controls. It was also determined, through bacterial proximity tests and wound replica testing, that there was significant bactericidal and bacteriostatic activity against *Micrococcus luteus*. It was concluded, based on the absorbency and antimicrobial properties, that slime-derived materials are ideal biomaterials to be used to make the wound environment less hospitable to bacterial infection. Future research based on this study should refine slime-derived materials, develop methods of mass production, and investigate activity against other bacteria. Keywords : biomaterial bandage, *Eptatretus stoutii*, slime, *Micrococcus luteus*, absorbency

## **Morphological Identification of Wide-Separation Gravitationally Lensed Quasars**

*Pranav Sivakumar*

*Barrington High School, Barrington, IL, Illinois (Chicago) JSHS;*

*Teacher/Mentor/Sponsor: Teacher: James A Hawrysko, Barrington High School; Mentor: Sivakumar Muthuswamy, Motorola Solutions, Inc.*

A novel method was developed to identify gravitationally lensed quasars from the Sloan Digital Sky Survey (SDSS). Understanding gravitational lensing helps decipher the properties of dark matter and dark energy. It is hypothesized that if multiple objects in an SDSS image meet both photometric and spectral criteria, then these objects are lensed quasar candidates. The first phase of this project used data from the SDSS Data Release 9. In the follow-up study, a new identification algorithm was implemented using the SDSS Data Release 10, which included data for over 300,000 quasars. The data was retrieved and processed using Structured Query Language (SQL) queries. Using this information, the algorithm compared quasars to their neighbors to determine if the neighbors were images of the same quasar. The results were validated against a control group of lensed quasars from the literature. Statistical analyses were performed to ensure consistency of validation criteria across the data set. A comparison of the project's results with published lists of lensed quasars showed that the hypothesis was well supported. In addition to identifying a majority of the quasars in the control group, the algorithm also identified additional high-probability lens candidates not reported in the literature.

## **Environment and Variability of High Redshift X-Ray Bright Optically Normal Galaxies**

*Talia E. Weiss*

*Evanston Township High School, Evanston, IL, Illinois (Chicago) JSHS;*

*Teacher/Mentor/Sponsor: Dr. Daryl Haggard, Northwestern University*

This study examines a sample of 48 X-Ray Bright Optically Normal Galaxies (XBONGs) to investigate two explanations for their abnormal characteristics: variability of Active Galactic Nuclei (AGN) and X-ray emissions produced by extended hot gas halos within galactic clusters and fossil groups. XBONG characteristics are most commonly attributed to accreting supermassive black holes that have radiatively inefficient flows or are diluted by starlight from their host galaxies. Using a sample of sources identified as XBONGs by Trump et al. (2009), this study examines the viability of multiple explanations for XBONGs' X-ray brightness and lack of optical emission lines. Unlike previous studies that assumed that XBONGs are AGN and attributed their unique properties to low-luminosity accretion disk phenomena, this study focuses on the likelihood that XBONG characteristics are caused by changes in AGN luminosity overtime (variability), as well as the possibility that XBONGs are galaxies with inactive galactic centers surrounded by halos of hot gas. Using data from the Chandra X-Ray Telescope, I determined that 18% of my sample showed evidence of variability, and approximately 22% showed signs of extension. These results indicate that AGN variability and extended hot gas emissions are viable explanations for XBONGs.



## **“Utilizing the Isolated Components, Variation in Mammals, and Treatment Processes of Milk for Grain Yield Enhancement”**

*Jordan R. Cadle*

*Paoli Junior/Senior High School, Paoli, IN, Indiana JSHS;*

*Teacher/Mentor/Sponsor: Laurie Jo Andry, Paoli High School; Kerry Wyatt, Paoli FFA*

This project explores an organically friendly and globally accessible product of milk to increase grain yields. The supreme concepts behind the idea to use milk are to apply carbohydrate energy and create a canvas with fat to increase the greenhouse effect. By applying sugar, fat, and protein to wheat in a Latin square design, the fat and sugars showed an increase over the control at the 90% confidence interval. In another part, camel milk was found to express the highest yields in wheat compared to goat, sheep, and cow. Also, sour, pasteurized, and fresh milks were tested on wheat but only the fresh milk saw a yield increase. For the milk being applied to the wheat, yields varied from no change up to 15.5% for a plant average yield with a sugar application. A 33% increase in corn yields was found but likely too high for continual expected results. Based on these results, farmers can apply milk to grains and see a yield increase but the value of their milk and labor must be taken into consideration for economical profitability.

## **Factors that Influence Energies of Simple Hydrocarbons**

*Tingyue Cui*

*Terre Haute South Vigo High School, Terre Haute, IN, Indiana JSHS;*

*Teacher/Mentor/Sponsor: Prof. Eric Glendening; Mrs. Melanie Huber*

The computational chemistry research presented here focuses on evaluating the factors that are most consequential to hydrocarbons' relative stabilities. The energy parameters for each model were fitted to best represent the atomization enthalpies (AE) of the C1-C6 alkanes, calculated by the Gaussian electronic structure program. In contrast to older models that generally lack theoretical support, the vicinal interactions model (VIM) proposed here is justified by natural bond orbital (NBO) analysis confirming that vicinal, antiperiplanar bond-bond and bond-antibond interactions are most consequential. As a fairly simple additivity scheme based on bond enthalpies and vicinal, antiperiplanar bond pair interactions, the VIM model was compared to the localized bond model (LBM) and geminal interactions model (GIM). Parameter fittings yielded chi squared values for the LBM, GIM, and VIM of 15.26, 12.04, 7.68 respectively. As anticipated, the LBM failed to account for differing AEs as it was only a two-parameter fit. The GIM, although exhibiting an improvement over the LBM, failed to describe the AEs of alkane conformers. The proposed VIM, on the other hand, generated unique AEs for each C1-C6 alkanes. Although preliminary, the results of this study strongly support the VIM as a new model for understanding the differing alkane stabilities.

## **Elimination Of Positional Discontinuity In Regenerating Limbs**

*Kamna Gupta*

*Carmel High School, Carmel, IN, Indiana JSHS;*

*Teacher/Mentor/Sponsor: Dr. David L. Stocum, IUPUI; Anita Gupta, Carmel High School*

The salamander *Ambystoma mexicanum* (axolotl) regenerates amputated limbs by reprogramming limb cells to form an undifferentiated blastema that grows and redifferentiates into the missing limb parts. The base of the blastema carries a positional identity of its origin on the proximodistal (PD), anteroposterior (AP) and dorsoventral (DV) axes and fills in all the distal missing positional identities during regeneration. Reversal of the AP or DV axes of the blastema with respect to the limb stump creates discontinuities in positional identity on either side of the limb that stimulate regeneration of supernumerary limbs from the PD level of amputation. I hypothesized that the PD positional identities of the reversed blastema and limb stump must not be discontinuous in order for such supernumeraries to form. To test this hypothesis, I grafted distal zeugopodial blastemas to mid-stylopodial limb stumps while simultaneously reversing their AP or DV axis, thus making both PD and AP or DV discontinuities. The result was that supernumeraries could not form from the mid-stylopodial level. Instead, the PD discontinuity first had to be eliminated by intercalation to the level of origin of the grafted blastema, whereupon supernumerary digits were now able to form. This result indicates that every PD positional identity has corresponding AP and DV identities that must be 'matched' in order for supernumerary formation to occur. The necessity for matching helps us to understand the cellular interactions necessary for limb regeneration. In the next phase of research I would like to re-conduct this experiment by grafting proximal blastema.

## **Identification of the Oxygen Sensing Mechanism in Hypoxic Vasodilation of Porcine Coronary Arteries**

*Kevin T. Hunckler*

*Marian High School, Mishawaka, IN, Indiana JSHS;*

*Teacher/Mentor/Sponsor: Mr. Ken Andrzejewski, Marian High School; Dr. Douglas Sisk, Marian High School; Dr. Kenneth Olson, Indiana University School of Medicine*

Oxygen dependency is a universal characteristic of almost all living animals. To maintain adequate oxygen flow throughout their bodies, a decrease or increase in oxygen must first be detected. Throughout the body, there are oxygen sensing mechanisms that regulate blood flow so that an adequate amount is delivered. These mechanisms allow vasodilation in hypoxic (low oxygen) conditions in return for increased blood flow. However, the scientific community has not conclusively decided on a definite sensing mechanism. It is hypothesized that the metabolism of endogenously produced hydrogen sulfide (H<sub>2</sub>S) is involved as the oxygen sensing mechanism of porcine coronary arteries. This was tested using a myograph to measure vasodilation of pig coronary arteries in response to the addition of the drug tempol and other various conditions. H<sub>2</sub>S was found to effectively dilate coronary arteries in every situation. The responses to tempol showed the critical oxidizing affects it and enzymes like it have on H<sub>2</sub>S. Further knowledge of these mechanisms could lead to the advancement of many treatments for low oxygen conditions within the body. Cardiovascular disease, sleep apnea, and cancer cells are only a few of the many conditions that could directly be affected by further advancements in this field.

## Mapping the Discrete Lambert and finding its trace

*Krishan S. Kumar*

*South Vigo High School, Terre Haute, IN, Indiana JSHS;*

*Teacher/Mentor/Sponsor: Dr. Joshua Holden, Rose-Hulman Institute of Technology; Mrs. Melanie Huber, South Vigo High School*

Given a number  $x$ , we consider the dynamic system  $x$  goes to  $x \cdot g \pmod{pn}$ , also known as the Discrete Lambert equation. In this equation, all variables are known other than  $x$ . The Discrete Lambert ( $x$ ) is so difficult to solve for because the variable  $p$ , which is a prime number, may be hundreds of digits long, meaning that even with a computer it might take many years to solve. To visualize a specific cycle, an accompanying map and matrix may be illustrated. The map shows which inputs go to which outputs. The goal was to extract an algorithm to allow any such map to be drawn with accuracy without having to plug in every number  $x$  into the generator  $g$  until a pattern is distinguished. When the map is actually drawn out, certain numbers,  $x$ , will form contained sets. By noticing a pattern in the arrangement of numbers in these sets and using the properties of logs, proofs were deciphered and an algorithm was distinguished. The Discrete Lambert problem and similar exponentiations are used to verify the authenticity of legal documents, financial transactions, and other important communications and are a vital component of today's society.

# Intermountain (Colorado, Montana, Idaho, Nevada)

---

## **Efficacy of Five Methods of Purifying Water and Their Possible Uses in Third-world Countries**

*Ryan Barney*

*Wasatch Jr. High, Salt Lake City, UT, Intermountain (Colorado, Montana, Idaho, Nevada) JSHS;*

*Teacher/Mentor/Sponsor: Kim Stucki, Wasatch Jr. High; Jordan Farr, Jordan Applied Technology Center*

Every year, 3.4 million people--mostly children--die worldwide due to waterborne illness. Though there are many facets of this problem, I decided to study which methods are most effective at purifying infected water. To test this, I used a gravity filter, a UV purifier, Iodine tablets, bleach, and boiling to treat water infected with *Escherichia coli*, *Serratia liquefaciens*, and *Bacillus megaterium*. My bacterial testing showed that boiling was the most effective method, followed by the filter and bleach. The UV lamp and Iodine were less effective. I then used a Cost-effectiveness Analysis (CEA) to analyze the overall value of each method compared to its cost, indexed against average income in Ghana. My CEA showed that boiling was still best, closely followed by bleach. These were also the only methods that met all of the United Nations' cost and availability guidelines for water purification. Boiling, however, has risks and costs stemming from the fact that the cooking fires used to boil the water produce much smoke that can cause premature death over time. Firewood is also needed, adding time and effort. Due to this, I concluded that bleach is the best choice for water purification in third-world countries.

## **Analysis of Montane Rainforest Dwellings using Computer Vision**

*Anthony Cheng*

*Hillcrest High School, Midvale, UT, Intermountain (Colorado, Montana, Idaho, Nevada) JSHS;*

*Teacher/Mentor/Sponsor: Philip Dennison, University of Utah; Tolga Tasdizen, University of Utah*

This paper describes the use of Computer Vision algorithms to analyze satellite imagery of dwelling locations in a rainforest setting. Researchers are currently trying to determine the impact of population movements on the environment in areas such as the Gishwati Rainforest of Rwanda. The movement of populations can be tracked by looking at the location of dwellings. Considering that the current method of analyzing the location of dwellings is by hand, this paper describes the approaches developed in regards to this problem using the methods of Computer Vision, specifically Connected Components labeling. The prototype initially used a simple binary threshold and contour detector to detect the objects, while the final code used HSV thresholding and several other algorithms with experimentally determined parameter values. Combinations of many algorithms were tested for optimal results. The code, written in Java, used methods from the open-source OpenCV (Open Computer Vision) library. The source images were from Google Earth. The design was largely successful; the program was able to detect nearly all white-roofed houses, a first step towards a fully automated program. This code can potentially be applied to many other settings, such as traffic, vegetation, and wildfire analysis in the geographic field.

## **Networking Nuances: Creating Hardware and Software Solutions Using UDP/IP Datagrams**

*Melissa S. Ivie*

*Copper Hills High School, West Jordan, UT, Intermountain (Colorado, Montana, Idaho, Nevada) JSHS;  
Teacher/Mentor/Sponsor: Mary Meyer, Copper Hills High School; Brian Ivie, University of Utah; Dalton Horscroft, Entheos Academy*

The primary purpose of this research and engineering project was to develop a system of products to be used to easily connect devices to an ethernet network, including functions for handling the TCP/IP protocols for Internet connectivity. This project has taken place over the last 2-1/2 years. I began by developing an ethernet shield for use with the Arduino microcontroller platform using the Microchip ENC28J60 IC. I developed a PCB layout and had the design professionally etched. I then developed a similar shield for use with the Texas Instruments Launchpad using the Energia platform to convert Arduino code for use with the Launchpad hardware. I also developed test applications, including implementing a RGB LED that had the brightness of the red, green and blue elements controlled by pulse width modulation, so that the amount of red, green or blue light could be adjusted from an iPod Touch using the standard Open Sound Control (OSC) protocol to send UDP/IP datagram packets to the microcontroller through the ethernet module. I am currently implementing my work in the development of several devices to monitor environmental conditions over a network, including devices to monitor temperature, soil moisture, humidity, air pollution, noise pollution and other environmental factors.

## **Recovering the Effective Thermal Conductivity of SIMBA Sea Ice with a Composite Material Model**

*Daniel W. Liu*

*West High School, Salt Lake City, UT, Intermountain (Colorado, Montana, Idaho, Nevada) JSHS;  
Teacher/Mentor/Sponsor: Todd Kassner, West High School; Kenneth Golden, University of Utah; Jingyi Zhu, University of Utah*

This study aims to find a composite material model that best describes the heat transfer within the medium of sea ice by solving an inverse problem. Sea ice temperature data from the “Sea Ice Mass Balance in the Antarctic” (SIMBA) project are divided into two sets and used for model training/validation. This study proposes several layered diffusivity models. For each proposed model, an estimated temperature profile is recovered from the sea ice heat equation and is compared with the training data to calculate a root mean squared error (RMSE). The Nelder-Mead method is used to find the optimal model by minimizing the RMSE. The optimal model is verified by calculating its validation RMSE using the validation data. It is found that a five-layer model is the most effective. The extreme diffusivity value discovered in the bottom layer of the model indicates that there might be convective properties in the ice. To account for this, the sea ice heat equation is modified to include a brine movement velocity item and the five-layer model is refined.

## **Speed of Phytochrome Activation in Lactuca Sativa (Lettuce) Seeds**

*Emma J. Mackey*

*Wasatch Jr. High School, Salt Lake City, UT, Intermountain (Colorado, Montana, Idaho, Nevada) JSHS;  
Teacher/Mentor/Sponsor: Ms. Stucki, Wasatch Jr. High School; Prof. Leslie Sieburth, University of Utah*

Germination is the process of a seed giving rise to a free-living plant. My question was how long must a Lactuca Sativa (lettuce) seed imbibe in water before phytochromes can detect light so that the seed can become metabolically active. I hypothesized that a seed would only need to imbibe in water for five minutes before phytochromes are activated. I tested the seeds by applying red or far-red light after the specific imbibition period. Both red and far-red light occur in nature. Phytochromes detect these qualities of lights to know whether the outside conditions are favorable enough to survive. Far-red light stops germination because in nature far-red light indicates that the seed is in the shade and has a small chance of survival. My hypothesis was partially correct. I found that the phytochromes became active between five and ten minutes. This is a biological advantage for plants because when conditions are favorable a seed needs to be able to germinate as quickly as possible.

## **Isolation Of Escherichia Coli O157 Proteins That Interact With The Bovine Recto-anal Junction Squamous Epithelial (rse) Cells**

*Aparna S. Ajjarapu*

*Ames High School, Ames, IA, Iowa JSHS;*

*Teacher/Mentor/Sponsor: Indira Kudva, National Animal Disease Center; Uma Vithala, Ames High School*

The enterohemorrhagic strain Escherichia coli O157:H7 ranks fourth among the agents causing gastrointestinal illnesses in North America. Cattle are the main reservoirs for this human pathogen with the recto-anal junction (RAJ) serving as the primary colonization site. The objective of this study is to examine the mechanism by which E. coli O157 adheres to the squamous epithelial (RSE) cells at the bovine recto-anal junction. An adapted protocol was developed to isolate the E. coli O157 bacterial proteins that interact with the RSE cell membrane proteins. After checking the RSE cells for good morphology, the RSE cell surface proteins were extracted and labeled using the Thermo Scientific Pierce cell surface protein isolation kit. The E.coli O157 proteins were harvested and interacted with the RSE cell surface proteins in a biotin cell protein column. The interacting bacterial proteins were eluted and then quantitated using NanoDrop. These proteins are currently sent for bottom-up proteomics analysis. A follow up experiment, an adherence-inhibition assay, was conducted and the results clearly showed that the interacting bacterial proteins isolated in this experiment play a role in E. coli O157 adherence to the RSE cells at the RAJ.

## **The Effects of Cheese Sludge on Field Corn**

*Christopher Grebner*

*Beckman Catholic High School, Dyersville, IA, Iowa JSHS*

The wastewater from the cheese making process is filled with many vital nutrients that can be used to help grow crops but is oftentimes left to pollute rivers and lakes. My initial idea was to determine whether or not that the waste left over from cheese, also known as sludge, would affect the growth of corn in a positive way. From prior knowledge and research, sludge was known to contain Nitrogen, Phosphorus, and Potassium that is needed by corn and most other crops to grow. As a result, sludge was added to soil to fertilize corn. After a preliminary investigation, a correlation between the amount of sludge and growth of the corn arose. Upon further examination, an increased amount of growth was noticed in the fertilized corn.

## **Silver Nitrate's Effect on Natural vs. Induced Antibiotic Resistance in Escherichia coli**

*Breanna Kramer*

*Central Lee High School, Donnellson, IA, Iowa JSHS;*

*Teacher/Mentor/Sponsor: Alicia Schiller, Central Lee High School*

Using the Kirby Bauer Protocol, my recent findings show silver ions can override antibiotic resistance in E. coli. Control trials were cultured E. coli on Mueller-Hinton agar with the addition of two ampicillin magazines. After 24 hours incubation, diameters were compared to standardized charts. I repeated this protocol with the addition of 30ul silver nitrate on top of the magazines. Resulting diameters were compared to previous experiments. This same method was used with induced plasmid resistance, and natural resistance developed through gradient ampicillin agar. Diameters increased almost two-fold in all trials, suggesting silver ions affect cells differently than common antibiotics. Natural and induced plasmid resistance both began with 10-11mm resistant diameters; however, after silver exposure natural resistance increased 12mm, while induced plasmid increased 9mm. I propose these differences are due to plasmid insertion that prepares E. coli for relatively more extreme antimicrobial conditions enabling less permeable membranes due to morphological changes in proteins; more protected enzymes; and DNA more capable to handle antimicrobial properties. Controls increased 14mm, as DNA wasn't modified against antibacterial properties. Silver ions demonstrate abilities to destroy E. coli antibiotic resistance. Perhaps it's time to rediscover silver's remarkable applications to the medical community's patients with antibiotic resistance.

## **The Effects of Urbanization on Water Quality of Streams in Linn County, Iowa**

*Karleigh Schilling*

*Prairie High School, Cedar Rapids, IA, Iowa JSHS;*

*Teacher/Mentor/Sponsor: Keith Schilling, University of Iowa; Lori Danker, Prairie High School*

Urbanization is increasing in many areas around the United States, and it can have serious effects on water quality. The purpose of this study was to test the amount of total dissolved solids (TDS) in various streams within Linn County to determine whether or not urbanization in Cedar Rapids is increasing TDS levels. Three methods were used to test this: 1) comparing two different populations of urban and rural streams, 2) testing one stream as it flows from the country into the city, and 3) testing a larger river to see if the effect was still observed. Water samples were collected using a specific conductance meter, since specific conductance is proportional to total dissolved solids and it is easy to measure. Study results indicated that urbanization can affect water quality. All three methods showed a definite increase in total dissolved solids as the stream flowed through a city. The greatest effect was observed when two populations were tested, and less effect was evident in the Cedar River. Further testing is needed to confirm the cause of this, but road salts, fertilizers, and wastewater may be contributing factors.

## **Waste No More: A Study of the Net Energy Gain of Cellulosic Ethanol from Recycled Matter**

*Abby L. Walling*

*Iowa City West High School, Iowa City, IA, Iowa JSHS;*

*Teacher/Mentor/Sponsor: Carolyn Walling, Iowa City West High School*

The need for alternative fuel sources is becoming increasingly evident due to the climate changing effects of gasoline. One popular alternative, corn, may not be better due to the energy required producing it. However, in this experiment, grass, newspaper, and paper towels were fermented into ethanol. The energy content of the solid byproducts was then tested to determine if the biomass could be burned to distill the ethanol created. Thus, the net energy gain of the cellulosic ethanol was found. After fermenting the samples, paper towels created the highest yield of ethanol (0.084 %), compared to grass (0.021 %) and newspaper (0.024 %). By using a calorimeter, it was also determined that paper towels have the most chemical potential energy with 20,258 kJ per kg. Lastly, the net energy gain of the cellulosic ethanol was calculated by adding the energy in the ethanol to the leftover energy in the byproduct (after part of the biomass hypothetically distilled the ethanol). Paper towels have the greatest energy gain with 435.437 kJ per kg of cellulose fermented. Overall, paper towels can be fermented and the byproducts burned for distillation to result in over 400 % more energy than needed to create the ethanol.

## **A Novel Idea: the Development of a Photobioelectric Cell Utilizing an Agar Gel - Electrolyte Matrix**

*Hayden J. Allen*

*Cascia Hall Preparatory School, Tulsa, OK, Kansas-Nebraska-Oklahoma JSHS;*

*Teacher/Mentor/Sponsor: Sally Fenska, Cascia Hall Preparatory School*

An insurgence of concern for the climate has accelerated the rate at which research and development occurs around the world. The purpose of this project is to design a fuel cell, using biological processes that will create a usable form of electricity that will retain the energy that it has created. An electrolyte agar was created using 1.5% agar and a 5M NaCl solution. A chloroplast extract was created using spinach, and 0.5M sucrose solution. An energy rate test was conducted over 15 seconds immediately following the introduction of the chloroplasts to the cell. Data was collected under three different lighting conditions, individually, two in series, and three in series. The data suggests that the created cell is behaving much like an alkaline battery, in the fact that as more cells are added in series, the voltage increases (Graph I, II, III). Under tested conditions, the three LWCs had a peak average output of 507 mV under direct lighting. Another test was run to determine how long the fuel cell would hold the created charge in the absence of light. The voltage continued to increase steadily in excess of 5 hours before peaking and held this charge for 24 hours.

## **3PO and P301L Mutations of Tau Protein Cause Synaptic Aberrations in Cholinergic and GABAergic Neurons: A 2nd year study of Alzheimer's disease pathology using C. elegans worms**

*Disha Dasgupta*

*Olathe North High School, Olathe, KS, Kansas-Nebraska-Oklahoma JSHS;*

*Teacher/Mentor/Sponsor: Dr. Brian Ackley, University of Kansas (KU)*

This project investigated whether the 3PO/P301L mutations of the tau protein cause aberrations in the synaptic vesicles of cholinergic/GABAergic neurons. Cholinergic and GABAergic neurons contain neurotransmitters that are associated with memory and cognition, functions which are impaired in Alzheimer's patients. The 3PO/P301L tau mutations are also known to cause memory disorders. Hypothesis: If the genes that code for the 3PO/P301L mutations of tau are expressed in *C. elegans* worms, then the cholinergic/GABAergic synaptic vesicles will display aberrations. Microscopic *C. elegans* worms were used for this study. Two strains of control worms without any tau, two strains of *C. elegans* with 3PO tau, and two strains of *C. elegans* with P301L tau, all with cholinergic (Ihls13) or GABAergic (juls1) cell-specific Green Fluorescent Protein (GFP) markers, were selected. GFP Microscopy was used to screen the worms in which with 3PO/P301L tau genes were expressed. Confocal microscopy was used to obtain detailed images of synaptic vesicles of those worms. Image J software was used to measure the area, perimeter, and circularity of the synaptic vesicles. Image analysis from 2890 synaptic vesicles supported the hypothesis - that 3PO/P301L mutations of tau change the area, perimeter, and circularity of the synaptic vesicles of cholinergic/GABAergic neurons.



## **A Fluid Idea A comparison of fluidized sand filters verses drip sand filters in the removal of dirt, bacteria, heavy metals, phosphates, and nitrates.**

*Sarah L. Riley*

*Grove High School, Grove, OK, Kansas-Nebraska-Oklahoma JSHS;*

*Teacher/Mentor/Sponsor: Keli Steen, Grove High School*

The purpose of this project is to determine whether fluidized sand filters are more efficient than drip sand filters. I created two fluidized sand filters and one drip sand filter. I then compared the clarity, bacteria, phosphates, nitrates, and lead levels before and after every procedure. By creating fluidized sand filters it is hypothesized that it can clean water quicker and more efficiently than drip sand filters. The results were taken from spectrophotometer readings, petri dishes, and colorimeter readings. The drip sand filter was used as the control to compare the two different styles of fluidized sand filters. I tested clarity first with just dirt in the water, then bacteria (both before and after), and then lead, nitrates, and phosphates all together. The results varied in my testing. Overall the second fluidized sand filter came up on top confirming my hypothesis. The only problem was that it didn't take out any nitrates.

## **Chemokine Expression in 3-LL vs. p-3LL Lung Cancer Cells**

*Lekha P. Devara*

*duPont Manual High School, Louisville, KY, Kentucky JSHS;*

*Teacher/Mentor/Sponsor: Glenn Zwanzig, duPont Manual High School; Robert Baar, duPont Manual High School; Dr. Rajesh Sharma, University of Louisville*

Lung Cancer is the leading cause of cancerous death in the United States. Kentucky in turn has the highest lung cancer incidence in the country. 90% of lung cancer related deaths occur due to metastasis of the tumor to other vital organs in the human body. Chemokines, which are a sub-group of cytokine proteins, have recently been found to play an important role in cancer translocation through the process of chemotaxis. This project explores the differences in various chemokine expressions between 3-LL and p-3LL cancer cells from both cultures and tumor samples from murine models. These two cell lines are the same, though the p-3LL is a passaged version. To obtain results, RTPCRs were conducted. The results are reported and fold change in the expression of chemokines was used as a method of comparison. Experimentation showed trends in differences between the expression of the CCL-2, CCL-3, CCL-4, CCL-5, CCL-7, CCL-8, CCL-17, and CCL-19 chemokines. Results from this project could be used to target specific chemokines and/or chemokine receptors to reduce tumor burden and prevent lung cancer metastasis.

## **Magnetic Nanoparticles for Targeted Hyperthermia**

*Seohyun Im*

*duPont Manual High School, Louisville, KY, Kentucky JSHS;*

*Teacher/Mentor/Sponsor: Mr. Robert Baar, duPont Manual High School; Mr. Glenn Zwanzig, duPont Manual High School; Dr. Kyung A. Kang, Chemical Engineering Department, University of Louisville*

Traditional cancer treatment methods, e.g., chemotherapy, radiation therapy, immunotherapy have unhealthy side-effects (nausea, vomiting, hair loss, etc.) and are invasive, therefore, being unhealthy for patients. Low-heat hyperthermia, a safer alternative cancer treatment, heats the cancerous tumor to a temperature between 40-45 °C. Iron oxide (Fe<sub>3</sub>O<sub>4</sub>) nanoparticles (IONPs) have low toxicity and are used in hyperthermia to heat tumors. A hyperthermic cancer treatment method was designed using IONPs with an alternating electromagnetic generator (AEM) for tumor-specific heating. A hyperthermia study was conducted, observing the heating performance of IONPs (10nm, 20nm, 30nm, 40nm) of concentrations (0.01%, 0.03%, 0.05%, 0.08%, 0.10% w/v%). Each solution of IONP and water was placed in a glass vial and heated in the solenoid probe of the AEM for 5min. at 287 KHz with insulation. Water was used as the baseline to observe how much the glass vial heated by itself and to ensure consistency of the heating performance of all samples. A linear trend was observed in the temperature increase of IONPs; as concentration increased, temperature increased. IONPs 20nm heated the best for all concentrations. This minimally invasive and safe hyperthermic cancer treatment method has great potential in administering successful cancer treatment.

## **Bioethanol Production from Encapsulated Active Dry Yeast**

*Ellen K. Kendall*

*Notre Dame Academy, Park Hills, KY, Kentucky JSHS;*

*Teacher/Mentor/Sponsor: Sr. Mary Ethel Parrott, Notre Dame Academy*

Calcium alginate beads were created to immobilize active dry yeast commonly used in yeast dough in a growth medium. After initial pipet-dripping, a device was designed to make beads of uniform size automatically with an old fashioned IV drip and tubing. A sodium alginate and yeast solution dripped into a 0.05M calcium chloride solution, forming beads with yeast encapsulated inside. These beads were combined with a 15% glucose solution in a closed container with an ethanol sensor to detect the production of ethanol, a biofuel. The beads were removed, dried, and tested again to see if they could successfully produce ethanol going through the fermentation process multiple times. The beads continually produced ethanol but at reduced rates as they were reused six times, showing that this research is promising for future controlled, systematic production of this important biofuel.

## **The Effect of Concentration Gradient, Membrane Surface Area, and Temperature on Peak Osmotic Power in a Pressure Retarded Osmosis System**

*Szofia E. Komaromy-Hiller*

*Notre Dame Academy, Park Hills, KY, Kentucky JSHS;*

*Teacher/Mentor/Sponsor: Sister Mary Ethel Parrott, Notre Dame Academy*

Pressure retarded osmosis (PRO) provides renewable energy with no greenhouse gas emissions. The efficiency of an osmotic power plant is dependent upon the semipermeable membrane and the osmotic pressure gradient. The purpose of this experiment was to study the effect of salt concentration gradient, membrane surface area, and temperature on the osmotic pressure gradient using a simple osmosis system. A three-level full factorial design with response surface analysis was used to optimize the independent variables. A U-shaped osmosis apparatus was utilized with tap water as the feed solution and a saline solution as the draw solution. The rate of water rise in the draw solution was measured to determine water flux. ANOVA calculations and response surface analyses showed that all three independent variables were statistically significant and that no interaction terms between the variables were statistically significant. An increase of the three independent variables leads to increased water flux. The effect of the variables needs to be taken into consideration when building osmotic plants as colder temperatures at higher latitudes and low salt concentration gradients will decrease the efficiency of an osmotic plant. High membrane surface area and associated cost also need to be carefully balanced.

## **Effects of the Environmental Pollutant Acrylic Aldehyde on Renal Fibrosis**

*Sanjana J. Rane*

*duPont Manual High School, Louisville, KY, Kentucky JSHS*

Cigarette smoke has been shown to promote renal fibrosis but the direct effects of acrolein (acrylic aldehyde), a constituent of cigarette smoke had not been determined. Heat shock protein 27 (Hsp27) is known to regulate renal fibrosis and Nuclear Factor Erythroid derived Protein-2 (NF-E2) is a novel Hsp27 binding protein. Therefore, I hypothesized that acrolein will induce renal fibrosis by altering pro-fibrotic CTGF expression and HK-11 cell apoptosis in a NF-E2 dependent manner. HK-11 cells were exposed to varying concentrations of acrolein (10  $\mu$ M, 25  $\mu$ M, 50  $\mu$ M) for 24 hours and cell lysates were immunoblotted with anti-CTGF, anti-NF-E2, and anti-cleaved-caspase-3 antisera. Exposure of HK-11 cells to acrolein significantly induced CTGF expression in a dose dependent manner with a concurrent decrease in NF-E2 expression. Increased NF-E2 expression was detected in acrolein treated HK-11 supernatants. Acrolein also induced caspase-3 cleavage and nuclear condensation indicative of apoptosis. Increasing acrolein concentration decreased HK-11 cell viability as documented by MTT reduction. Over-expression of NF-E2 inhibited CTGF expression and prevented HK-11 apoptosis by inhibiting caspase-3 cleavage. Thus, my studies identified NF-E2 as novel regulator of acrolein-induced CTGF expression and HK-11 apoptosis. Therefore, inducers of NF-E2 expression may serve a therapeutic role in treating renal fibrosis.

## **The Effect of HPV16 on Host Cell Interactions with the Stromal Microenvironment**

*Cole H. Evensky*

*Caddo Parish Magnet High School, Shreveport, LA, Louisiana JSHS;*

*Teacher/Mentor/Sponsor: Kris Clements, Caddo Parish Magnet High School*

Interactions between tumors and the surrounding stromal microenvironment are now known to be important in cancer progression, though little is known about them and they have never been studied systematically in human papillomavirus-infected cells. HPV is similar to cancer in that it forms lesions and evades immune detection. Stromal cells, like host cells, can mediate levels of signaling proteins that carry out functions important to viral survival. To observe these interactions, experiments were conducted to measure changes in signaling proteins in non-infected and infected keratinocytes, with and without fibroblasts, which simulated a stromal microenvironment. The broad approach provides answers and knowledge about these important interactions for future work. Interesting patterns establish a substantial knowledge base about how stromal cells influence production of signaling proteins in HPV important for things like growth, immune evasion, and angiogenesis. Protein levels led to observation of the NF- $\kappa$ B pathway, a major immune regulator.  $\kappa$ B, its primary inhibitor, was used in qPCR to study how pathway activity related to levels of signaling proteins. Where  $\kappa$ B increased, pro-inflammatory downstream targets of NF- $\kappa$ B were inhibited. In the future, the inhibition of the NF- $\kappa$ B pathway, implicated by this research, will be investigated in relation to the pathogenesis of HPV16.

## **Exit Velocity of a Sphere Falling in Narrow Tubes**

*Nicholas A. Larsen*

*Caddo Parish Magnet High School, Shreveport, LA, Louisiana JSHS;*

*Teacher/Mentor/Sponsor: Dr. Julian Simeonov, Naval Research Laboratory*

Understanding the hydrodynamic forces occurring during particle-particle collisions in viscous fluids furthers knowledge in areas such as industrial fluidized beds and bedload sediment transportation. A fluidized bed reactor can convert solid fuels such as biomass or coal into gas or other liquid fuels, providing a better environment for processes such as combustion, and resulting in less pollution and waste. Modeling the hydrodynamics of bedload sediment transport has applications in dredging shipping channels, building harbors, and predicting erosion. The particle-laden flows of commercial and geophysical significance are generally turbulent. A Direct Numerical Simulation collision model can account for the hydrodynamic forces in a turbulent particle-laden flow, but it is very expensive, exceeding the capacity of super-computers. One method to reduce the computational cost is to use theoretical equations for the forces occurring when the gap between two colliding particles is very small. To determine the best laboratory setup for experiments to validate these theoretical equations, a method for controlling particle trajectories and minimizing particle rotation was tested. Water, a fluid with low viscosity, was found to be unsuitable for collision experiments. It is recommended that a fluid with a higher viscosity, such as glycerol, be used for future particle collision experiments.

## **Factors Influencing Canine Mammary Neoplasia**

*Morni A. Modi*

*Caddo Magnet High School, Shreveport, LA, Louisiana JSHS;*

*Teacher/Mentor/Sponsor: Kris Clements, Caddo Magnet High School*

The purpose of this retrospective study was to determine specific host factors influencing the prognosis of canine mammary tumors. This research is being conducted as current literature is inconclusive regarding the association between spaying and mammary tumors in dogs. It was hypothesized that intact females would have increased risk of developing malignant mammary tumor compared to spayed females. Data on 709 dogs with mammary tumors from 18 different sites were collected and analyzed. Information pertaining to: breed, date of birth, age at the time of diagnosis, weight, ovarian hysterectomy status (spay status), surgery date, length of stay in clinic, tumor type (benign/malignant), histopathology results, and survival status were collected on the dogs. A statistical analysis was performed to assess the significance of ovarian hysterectomies on the development of tumor type, mortality and survival rates. The findings suggest that no breed is more prone to a certain histopathological subtype of tumor. Spaying female dogs has a protective effect from both malignancy of tumor and mortality. Significantly lowered mortality rates were observed among spayed dogs regardless of type tumor, malignant or benign. Results also suggest that spaying dogs can lead to a better post surgical survival.

## **A Prospective Study of Logarithmic Spirals and Hurricanes**

*Neil F. Nathan*

*Caddo Magnet High School, Shreveport, LA, Louisiana JSHS;*

*Teacher/Mentor/Sponsor: Kris Clements, Caddo Magnet High School*

The purpose of this project is to determine if the pitch angles of logarithmic spirals in hurricanes can be used to predict hurricane intensity prospectively and to determine if the external pitch angles are more accurate than the internal pitch angles. The hypothesis is that this is possible using the pitch angle scale devised in a previous retrospective study that showed a significant negative correlation. Logarithmic spirals were traced in all hurricanes from the 2012 Atlantic hurricane season. Pitch angles were drawn on each hurricane using both the external and internal logarithmic spirals. Two predictions of ultimate hurricane intensity were made for each hurricane using the pitch angle scale. Data was tabulated and compared to actual hurricane intensity. Statistical analysis was performed using Spearman Rank Correlation Analysis and Wilcoxon Signed Rank Test. Both of these tests yielded highly significant results. The p value was  $<.01$  which is extremely significant. It is concluded that hurricane intensity can be predicted by using the pitch angle scale. External logarithmic spirals prove to be more accurate than the internal spirals. This method is very reliable and simple and can lead to significant savings in terms of life and property by improving hurricane preparedness.

## **SNAP: A Novel Algorithm for Fast Global Sequence Alignment and Database Search**

*Venkatesh S. Sivaraman*

*Caddo Parish Magnet High School, Shreveport, LA, Louisiana JSHS;*

*Teacher/Mentor/Sponsor: Kris Clements, Caddo Parish Magnet High School; Dr. Marjan Trutschl, Louisiana State University at Shreveport*

There has been an explosion in the amount of genetic data (DNA and protein sequences) available to biologists in the past two decades. Here, a new sequence alignment algorithm is presented that compares genetic sequences faster than existing algorithms while maintaining accuracy. The new algorithm, called Segmented Numerical Alignment Preprocessing (SNAP), divides amino acid sequences into small segments, then converts the segments into numbers using a novel approximation method. This approach simplifies the alignment process, allowing much faster analysis at a lower "resolution" than other methods. SNAP was tested alongside four other algorithms: Needleman-Wunsch (the gold standard for accuracy), simulated annealing, a genetic machine learning algorithm, and BLAST. For two test datasets, one containing 189 sequences and the other with 6,724 sequences, ten query sequences were processed by each algorithm to find the highest-scoring alignments in the dataset. In terms of accuracy, SNAP was superior to simulated annealing and the genetic algorithm and comparable to BLAST. It also performed on average 70 times faster than BLAST. Based on these findings, it is proposed that SNAP is a viable alternative to BLAST for searching today's vast sequence databases.

## **Implementing a Novel Approach for Inferring Haplotypes from Genotype Data while Modeling their Evolution in Populations**

*Ayush Goyal*

*Poolesville High School, Poolesville, MD, Maryland JSHS*

The ability to accurately and efficiently infer haplotypes, strings of single-nucleotide-polymorphisms, given genotype data opens doors for a multitude of cures for genetically inherited disease. Knowledge of the exact haplotypes of the individuals in a disease carrying population gives light to the specific mutations that have caused the diseases to originate. Distinguishing these mutations would allow scientists to analyze their biological mechanisms and more efficiently and effectively resolve treatments and cures. However, haplotype inference has been a continuing effort in optimizing efficiency and accuracy. Previous algorithms such as the Expectation Maximization algorithm and Clark's algorithm have used purely mathematical approaches to the combat the inference issue, finding great efficiency but faltering in terms of accuracy. This research proposes a new method of inference which introduces a genetic calculation of coalescence with a Gibbs-Sampler statistical and combinatoric basis to improve the overall process. The coalescence calculation is essentially a process in each iteration of the algorithm that checks whether or not a given haplotype can exist by reconstructing the evolutionary tree of all of the known haplotypes. After testing the algorithm through modeled haplotype data and statistical tests, the new approach proved to be promising in its ability to excise rare and nonexistent haplotypes. It was able to narrow down the amount of extraneous haplotypes inferred in each test. These properties revealed that this new direction is effective in making the inference more accurate, but it must continue to be explored and expanded upon.

## **Microglial shape postnatal reward circuits through phagocytosis of presynaptic terminals**

*Isobel A. Hawes*

*Science and Mathematics Academy at Aberdeen High School, Aberdeen, MD, Maryland JSHS;*

*Teacher/Mentor/Sponsor: Lindsay De Biase, National Institute on Drug Abuse; Antonello Bonci, National Institute on Drug Abuse*

Microglia are glial cells that were long thought to function mainly in clearing cellular debris from the CNS. During development, excess synapses are removed through a process called pruning, but mechanisms underlying this process are poorly defined. Recent studies indicate that microglia in the hippocampus (Paolicelli, 2011) and visual system (Schafer, 2012) contribute to synaptic pruning through phagocytosis of synapses. I investigated whether microglia participate in pruning in the developing reward circuitry, which regulates goal-directed behaviors. In contrast to the visual system, microglia in the nucleus accumbens (NAc) phagocytose VGlut2+ terminals through adolescence. In the ventral tegmental area (VTA), pruning takes place over a shorter period of time than the NAc, but at a much later time point than the visual system. Pruning of inhibitory presynaptic inputs takes place in a different way than excitatory inputs. In the NAc, VGAT pruning takes peaks at P22. These data suggest a unique time course across brain regions and populations of terminals, which is a novel finding. When microglia are ablated in mice at P22, they show a strong trend towards anxiety-like behaviors and dysfunctional addictive behaviors. Together, these findings provide the first evidence of microglial involvement in maturation of the reward circuitry.

## **Creating a Synthetic Mitochondrial Genome: Validation of a Lithium Acetate Transformation Technique to Integrate Foreign DNA into Yeast Mitochondria**

*John Mountain*

*Baltimore Polytechnic Institute, Baltimore, MD, Maryland JSHS;*

*Teacher/Mentor/Sponsor: Pamela Meluh, Johns Hopkins Medical Institute; David Nelson, Baltimore Polytechnic Ingenuity Project; Jef Boeke, Johns Hopkins Medical Institute*

The genome of an organism, all of its DNA, is the director of the cell's synthesis. By modifying the specific nitrogenous base sequences in the DNA, cell parts can be redesigned, eliminated, or created, allowing for cell and organism specialization for societal functions. A significant problem that scientists deal with involving gene sequence research is the difficulty of getting external DNA into cells to test the functionality of the DNA. This project focuses on a chemical transformation procedure that could enter foreign DNA into the mitochondria of yeast cells. A selectable marker ARG8m was ligated to a carrier plasmid. The parental strain of yeast, JMY001-C, lacks the ARG8 gene that is necessary to break down carbon sources. The chemical transformations were completed to insert the ARG8m marker into the ARG8-deficient cells. These transformants were plated on plates that lacked arginine, so that ARG8 deficient cells would die and ARG8 positive cells would grow. Each plate grew hundreds of ARG8 positive cells, supporting that the chemical transformation technique was successful and effective in inserting external DNA into the yeast cells.

## **Control of the Massively Parallel Reliability System**

*Jerry L. Zhang*

*Poolesville High School, Poolesville, MD, Maryland JSHS;*

*Teacher/Mentor/Sponsor: Zakarie Chbili, National Institute of Standards and Technology*

The gate dielectric reliability is a key parameter in the viability of metal-oxide-semiconductor field effect transistors (MOSFETs). The current methods for testing gate dielectrics are expensive and require a large space. This projects involves working on the implementation of a new system that would allow for the reliability testing of a large number of gate stacks simultaneously in a parallel fashion. In addition to the large savings in cost and space, the system would allow for customization in test settings and data processing.

### **Reflection Functions as Approximants of Chebyshev Polynomials**

*Ella M. Freudenburg*

*Kalamazoo Area Mathematics and Science Center, Kalamazoo, MI, Michigan (Southeastern) JSHS;  
Teacher/Mentor/Sponsor: Dr. Gene Freudenburg, Western Michigan University*

This project explored the connection between reflection functions and Chebyshev polynomials. Reflection functions describe the law of reflection from physics, and their definition was a significant project outcome. Another important result was the proof that, like Chebyshev polynomials, these functions commute under composition. Other properties, such as even and odd properties and parametrization, paralleled Chebyshev polynomials as well; essentially, it was determined that reflection functions are “straight-line versions” of these important polynomials. In addition, following the work of Cherrault and Mora, the project showed that the plane curves defined by reflection functions are extremely efficient densifying curves. By using Maple 16 software and a physical model, the researcher was able to visualize and gain insights into reflection functions. For example, in three-dimensional space, the curves they parametrize are piecewise linear knots, and the knot type is the same as that defined by the corresponding Chebyshev polynomials. Reflection functions have many physical and potential applications, most notably in computer science.

### **The Effect of Seed Quality on the Foraging Behavior and Communication in the Black-Capped Chickadee Population.**

*Bethel A. Mwenze*

*Kalamazoo Area Math and Science Center, Kalamazoo, MI, Michigan (Southeastern) JSHS;  
Teacher/Mentor/Sponsor: Dr. John Goudie, Kalamazoo Area Math and Science Center; Dr. Sharon Gill, Department of Biological Sciences, Western Michigan University*

The “chick-a-dee” call of many Paridae species these include the chickadees is structurally complex and functions in social cohesiveness and interactions. Literature suggests that vocalizations relate to a wide variety of contexts. The Black-capped chickadee bird species vocalizes complex calls when they discover food sources. These calls function to contact, recruit and or alert flock members about a newly found food source. This study tested the effect of food source quality on the foraging calls and how that affected the foraging behavior of the Black-capped Chickadee population. By observing the initial calls made and observing the foraging behavior exhibited. Regarding the communication of the chickadee population this observational field study found the tseet contact call to be the most produced call despite change in seed quality. The foraging behavior of the chickadees did not change as the seed quality varied which makes this study contrast the studies in literature. Since this is a preliminary study, the results are not conclusive.



## **The Knocking Down of Histone Acetyltransferase MOF is Insufficient to Suppress CGG Repeat-Induced Toxicity in the Fly Model of FXTAS**

*Sam Natla*

*Okemos High School, Okemos, MI, Michigan (Southeastern) JSHS;*

*Teacher/Mentor/Sponsor: Fang He, University of Michigan; Peter Todd, University of Michigan; Andrew Moore, Okemos High School*

In fragile X-associated tremor/ataxia syndrome (FXTAS), moderate CGG repeat expansion in the 5' UTR of FMR1 leads to neurodegeneration in humans. The isolated CGG expansion is capable of eliciting toxicity in *Drosophila*. FXTAS is caused by elevated CGG repeat-containing FMR1 transcription. Studies show that elevated histone acetylation by histone acetyltransferases (HATs) is responsible for increased FMR1 mRNA levels. Acetylation of histone proteins opens chromatin structure and makes genes more accessible to RNA polymerase II to start transcription. Overexpression of expanded CGG repeats is suppressed by high level of histone deacetylases (HDACs), shown in *Drosophila*, indicating that similar high levels of acetylation appear in *Drosophila*. We utilized the fly model of FXTAS to explore an HAT potentially responsible for CGG repeat toxicity. We found that a decrease of one *Drosophila* HAT, MOF, by RNA knockdown (RNAi) was insufficient to reduce CGG repeat toxicity. Using qRT-PCR, we confirmed the decrease of MOF gene expression in RNAi lines and noticed such a decrease was not able to decrease CGG repeat-containing RNA expression. Moreover, decreased MOF expression could not suppress CGG repeat toxicity. Thus, we are led to believe that other HATs may be responsible for the increased acetylation and expression present in FXTAS.

## **The Toxin in Rice- Arsenic in Our Food: Developing a Novel Testing Method and Analyzing Arsenic Levels in Rice**

*Anuush K. Vejalla*

*Detroit Country Day Upper School, Beverly Hills, MI, Michigan (Southeastern) JSHS;*

*Teacher/Mentor/Sponsor: Dr.Hanlan, Detroit Country Day Upper School; John Dougherty, Detroit Country Day Upper School*

The aim of the project is to understand the content of arsenic in rice and to furnish recommendations based on statistical and experimental results to both governments and users all over the world. Arsenic is a deadly toxin that leads to cancer, heart problems, and death. Since there is not any published method to quantify the levels of inorganic arsenic in rice, a novel testing method was developed through experimental and theoretical means. The formation of the rice grain depends on the soil, fertilizer, water, pesticide, and the location of cultivation, which all need to be considered to understand arsenic levels in rice. Thus to verify one hypothesis, that rice grown domestically would contain higher levels of arsenic than rice grown in foreign countries, rice from different parts of the world was tested. Another hypothesis, that brown rice would have higher levels of arsenic than white rice, was verified by testing brown, black, and white rice. The rice had four to nine times the EPA limit on arsenic in water, 10ppb. The results show that brown rice has higher levels of arsenic than white rice, but the correlation between where the rice is grown and the level of arsenic varies.

## **Functional Network Connectivity and Evoked Responses to Gaze Cueing: Possible Biomarkers to Autism**

*Frank Wang*

*Troy High School, Troy, MI, Michigan (Southeastern) JSHS;*

*Teacher/Mentor/Sponsor: Mentor - Susan Bowyer, Henry Ford Hospital*

Autism is a complex neurodevelopmental disorder that affects social interaction and communication, often impairing individuals for a lifetime. In the study, I used Magnetoencephalography (MEG), a non-invasive brain imaging technique, to identify possible biomarkers. In the resting state test, patients looked at an image while brain activity was recorded. In the evoked state test, responses to visual eye gaze cues were recorded. For the resting state, patients with autism had an abnormal concentration of activity in the frontal lobe while controls had activity concentrated in the occipital lobe. Controls also had significantly higher coherence levels. A high coherence indicates that the brain is well connected and communicating with many other areas of the brain. In patients with autism, the frontal lobe was unusually active. This area is typically used in higher-level cognition. For the evoked study, autistics had noticeably higher amplitudes in all regions used in the gaze cueing process. These results suggest that the autistics were more focused on an unknown task, and used more brain power to complete a decision in the evoked tasks. These regions of abnormal brain activity indicate possible biomarkers for autism.

## **Determining the Effects of Oxidizing Graphene on the Efficiency of Dye Sensitized Solar Cells**

*Daniel M. Hall*

*Camdenton High School, Camdenton, MO, Missouri JSHS;*

*Teacher/Mentor/Sponsor: Mr. Reeves, Camdenton High School*

Around the world, the need for new forms of energy is growing. As hydrocarbon based forms of energy are becoming more expensive for the average consumer to be able to afford purchase, a need for alternative energy sources has risen. One such alternative form of energy that is being proposed is that of Dye Sensitized Solar Cells (DSSC). Much research has been done to increase the efficiency of these cells; however research pertaining to oxidizing graphene in DSSCs has not been extensively explored. The purpose of this paper is to experiment and investigate the effects of oxidizing graphene and its efficiency compared to platinum and non-oxidized graphene. The oxidized solar cells contained graphene that had been oxidized at several time intervals. This was to examine the differences of efficiency as the graphene was slowly oxidized. The control groups that were used to compare the oxidized graphene to were three sets of regular non-oxidized graphene cells, and three platinum based cells. Results from this experiment indicate that oxidizing graphene using heat did not improve efficiency of the cell. This is shown by the drop in voltage as the graphene was oxidized at the ten, twenty, and thirty minute marks.

## **The Impact of Inclusion Programs for High School Students with and without Special Needs**

*Katherine E. Hufker*

*Lindbergh High School, St. Louis, MO, Missouri JSHS;*

*Teacher/Mentor/Sponsor: Kimberley Dailey, Lindbergh High School; Megan Roegner, Lindbergh High School*

This project sought to investigate the impact of an inclusion program where students with and without developmental disabilities eat lunch together twice a week on the social skills and mental well-being of the students with developmental disabilities and the typically developing students' attitudes towards special needs. Scores were obtained at the beginning of the school year and after six weeks of participation or no intervention. As measured using the Autism Spectrum Quotient Questionnaire, there was little improvement in social skills, although the control group showed a greater improvement on the communication subscale ( $p=.016$ ). As measured using Goodman's Strengths and Difficulties Questionnaire, the control group improved more on the emotional subscale ( $p=.029$ ). The intervention group did show a greater decrease in peer problems, but it was not statistically significant ( $p>.05$ ). Finally, the non-disabled peers improved more than the control group on three of four factors of the Attitudes Toward Intellectual Disability Questionnaire, with a significant difference ( $p=.007$ ) for knowledge of capacity and rights. Future research should utilize a longer intervention period. This research supports that inclusion programs increase the non-disabled students' knowledge of the capacity of those with special needs and may decrease peer problems for those with special needs.

## **Investigation of Enantioselective Solvation of Chiral $\alpha$ -hydroxyphosphonates by Cinchona Alkaloids by Nuclear Magnetic Resolution Spectroscopy**

*John L. O'Keefe*

*Maplewood Richmond Heights, St. Louis, MO, Missouri JSHS;*

*Teacher/Mentor/Sponsor: Dr. Bruce Hamper, University of Missouri St. Louis; Kathleen Dwyer, Maplewood Richmond Heights*

Nuclear Magnetic Resonance (NMR) spectroscopy was used to observe the molecular interactions between chiral  $\alpha$ -hydroxyphosphonate esters and cinchona alkaloids (quinine and quinidine). Evaluation of cinchona alkaloids as selective chiral solvating agents (CSAs) for enantiomeric  $\alpha$ -hydroxyphosphonates was determined by measurement of the chemical shift of the phosphorus in the  $^{31}\text{P}$ -NMR spectra. Changes in chemical shift of the enantiomeric phosphonate esters were measured relative to the concentration of the cinchona alkaloids. Determination of the binding constants  $K$  for each phosphonate enantiomer with the CSA was determined by evaluation of NMR titration data using a double inversion plot. Differences in binding energy of the two diastereomeric solvates were determined directly from the binding constants.

## **The Effect of Aging on the Differentiation Potentials of Bone Marrow Mesenchymal Progenitors**

*Olivia Long*

*John Burroughs School, Saint Louis, MO, Missouri JSHS*

A main cause for age-dependent osteoporosis is decreased osteoblast number and function. However, it is not clear whether the deficiency arises from intrinsic defects in progenitors or changes in the bone marrow microenvironment. The present study utilizes bone marrow progenitors from mice to investigate osteoblast differentiation. Furthermore, since more fat is observed in the marrow of older people, I hypothesize that cells from older mice differentiate less efficiently into osteoblasts and more efficiently into adipocytes. Bone marrow progenitor cells from mice aged 2, 5, 12 and 24 months were cultured in specific media to differentiate them into either adipocytes or osteoblasts. Staining for alkaline phosphatase activity, a marker for osteoblasts, revealed that cells from the 24-old-month mice showed the greatest extent of differentiation. qPCR for other osteoblast markers confirmed this finding. Moreover, qPCR analyses for adipocyte markers did not detect an obvious increase in adipocyte differentiation with age. Therefore, bone marrow progenitors from the oldest mice were not intrinsically deficient in osteoblast differentiation, nor were they more prone to adipocyte differentiation. Thus, extrinsic factors may be a main determinant for age-dependent osteoporosis.

## **Generating And Computing Perfect Phylogenies Using Saturated Chains**

*Ezra Umen and Yang Liu*

*Ladue Horton Watkins High School, Ladue, MO, Missouri JSHS;*

*Teacher/Mentor/Sponsor: John Pais, Ladue Horton Watkins Highschool; James Umen, Danforth Plant Science Center*

A phylogenetic tree is a rooted tree in which each character labels exactly one edge (or one vertex) of the tree and each taxon is represented by a unique path to exactly one leaf of the tree. Given a collection of characters and taxa, the Perfect Phylogeny Problem is to determine whether or not there is a phylogenetic tree that faithfully represents this data. Instead of the standard approach using 0-1 matrices, this paper recasts the problem in terms of partial orders of sets of attributes (characters). Using saturated chains of sets of attributes, a Phylogeny Representation Theorem is proved for perfect phylogenies, and a Phylogeny Equivalence Theorem is proved demonstrating the equivalence between the saturated chain approach and the standard representation. Furthermore, several interesting combinatorial results using Stirling Numbers and generating functions are proved in an attempt to enumerate the number of possible (extended) perfect phylogenies. Another goal of this work is the computational testing and visualization of phylogenetic trees. Using LSD radix sort, versions of Gusfield's algorithms are implemented in the Java programming language in order to computationally determine whether a set of attributes/traits can form a perfect phylogeny, and if they can, how to construct this perfect phylogeny.

## **Determining the Behavioral Response of *Drosophila melanogaster* to Blue Light (470nm) as a Wake Enhancing Stimulus**

*Sydney L. Zuraski*

*Camdenton High School, Camdenton, MO, Missouri JSHS*

Finding time to sleep is becoming strenuous. A photo pigment in the eye was discovered to be responsible for reacting to light (Benowitz, 2001). Technology outputs large amounts of blue wavelengths through screens. (Cajochen, 2011). With blue wavelengths hypothesized to affect our circadian patterns, use of technology is potentially initiating longer wakefulness periods with a lower amount of melatonin produced. Blue wavelengths could play a vital role in the future in providing wakefulness. This experiment attempted to determine the behavioral effects of blue wavelengths as wake enhancing stimuli. A testing unit was created where blue light and visible light were exposed to fruit flies. Fruit flies were chosen due to their similarities in mammalian sleep (Cirelli, 2006). The separated chambers disallowed light to escape from individual units. Photos were taken at timed intervals of the fruit flies documenting their effects to the wavelengths. Blue light had a significant ( $p < 0.05$ ) effect on fruit flies when providing increased activity. Results indicate that exposure to blue light could possibly play an important role in our lives when incorporated in situations where wakefulness is crucial. Blue lights could revolutionize night shifts, and collected results could inform people of the possible effects of blue light.

### **Creating an Accurate Analytical Tool for the Efficiencies of Various Fuel Cells**

*Adedayo R. Gbadamosi*

*Marine Academy of Technology and Environmental Science, Manahawkin, NJ, New Jersey (Monmouth) JSHS;  
Teacher/Mentor/Sponsor: Dr. John Wnek, Marine Academy of Technology and Environmental Science*

Fuel cells are electrochemical devices that convert chemical energy into electricity through a chemical reaction with oxygen or another oxidizing agent. However, because of the drastic variety in fuel use, analytical tools used to determine fuel cell efficiencies are often generalized across all fuel cells, thus rendering them inaccurate. This project details the fabrication of an analytical tool used to accurately determine the efficiencies of a variety of fuels cells. In addition, the project describes the assessment and comparison of the efficiencies of various fuel cells. Subsequently, efficiency was calculated by the ratio of output reaction energy to input reaction energy. Furthermore, this study compared the efficiencies of the two different fuel cells as well as found a correlation between methanol fuel concentration and fuel cell efficiency for the direct methanol fuel cell(DMFC). The results of this research indicate that the DMFC is significantly more efficient than a proton exchange membrane fuel cell (PEMFC), and efficiencies of various fuel cells can be more accurately determined in the energy industry through the fabrication of a more precise analytical tool. The results of this project will help reform the energy industry in creating more efficient sources of energy both nationally and globally.

### **Investigating the Therapeutic Mechanism of Angiogenin in Alzheimer's Disease**

*Sang Hyun Kim*

*Bergen County Academies, Hackensack, NJ, New Jersey (Monmouth) JSHS;  
Teacher/Mentor/Sponsor: Donna Leonardi, Bergen County Academies*

Investigating the Therapeutic Mechanism of Angiogenin in Alzheimer's Disease Sang Hyun Kim Bergen County Academies, Hackensack, New Jersey Mentor: Mrs. Donna Leonardi, Bergen County Academies Angiogenin, a potent agonist of neovascularization, has been implicated in the pathogenesis of various neurodegenerative disorders, including Parkinson's disease (PD) and amyotrophic lateral sclerosis (ALS). A recent study has shown that the serum level of angiogenin is directly correlated with the cognitive functions of patients with Alzheimer's disease (AD), suggesting that angiogenin may play a role in AD as well. However, its mechanism of action, independent of its regulatory effects on neovascularization, is unknown. Using an *in vitro* model system of AD, this study identified a possible mechanism of action of angiogenin involving both the level of phosphorylated tau and beta-amyloid (A $\beta$ ) production, each of which play a critical role in the progression of the disease. Exogenous angiogenin reduced tau phosphorylation and A $\beta$  production with statistical significance ( $p < 0.05$ ), by regulating the activities of AKT and glycogen synthase kinase 3 $\beta$  (GSK3 $\beta$ ). These results provide new insight to angiogenin's potential as a viable multi-targeted therapeutic agent for AD.

## **The Cellular Pathways Mediating the Anti-Tumor Effects of *Paeonia suffruticosa* on Human Breast Cancer Cells**

*Dongyeon Kim*

*Bergen County Academies, Hackensack, NJ, New Jersey (Monmouth) JSHS;*

*Teacher/Mentor/Sponsor: Donna Leonardi, Bergen County Academies*

Extracts of *Paeonia suffruticosa*, traditionally used in Chinese herbal medicine, have demonstrated anti-tumor, anti-inflammatory and analgesic effects of unknown mechanisms. The present investigation studied and elucidated potential apoptotic mechanisms of aqueous extract of *P. suffruticosa* (0.3-8mg/mL) on triple negative breast cancer cells (MDA-MB-231). Analysis of cell viability revealed a biphasic dose-response with proliferation at low concentrations (<0.6mg/mL) and decreased viability at high concentrations ( $p < 0.01$ ). IL-6, IL-2, and TNF- $\alpha$  secretion levels were inversely related to viability ( $p < 0.05$ ). Cell cycle arrest at G0/G1 was demonstrated. IL-24, a tumor suppressor protein, increased at high concentrations ( $p < 0.05$ ), indicating a significant cellular mechanism. The decrease in Bcl-2:Bax ratio ( $p < 0.01$ ) indicated the induction of apoptosis. Fas Ligand production and caspase 9 secretion levels demonstrated an intrinsic mechanism of action ( $p < 0.05$ ). The reduction of pAKT ( $p < 0.05$ ) suggested the mechanism of cell death through JNK1/2 pathway. When evaluated by HPLC, results revealed penta-O-galloyl-beta-D-glucose (PGG), benzoic acid and paeonol as the active constituents. Their effects on viability showed that PGG and paeonol may be the active ingredients prompting apoptosis. *P. suffruticosa* and PGG has a selective effect on cancer cells demonstrated through its effect on viability in keratinocytes. *P. suffruticosa* might be a promising agent for triple negative breast cancer treatment or as an adjunct to conventional therapies.

## **An Analysis of Tweets for the Presidential Debates**

*Kunal V. Singh*

*High Technology High School, Lincroft, NJ, New Jersey (Monmouth) JSHS;*

*Teacher/Mentor/Sponsor: Michael T. Roche, High Technology High School*

The 2012 U.S. presidential election, people used Twitter to respond to the presidential debates. Given Twitter's 140-character limit, were people able to respond in any meaningful way? My null hypothesis was that there was no correlation between the number of times a candidate mentioned a topic during a debate and the number of tweets he received about that topic. I collected over 2 million tweets and the transcripts for the three presidential debates held in October 2012. I constructed a set of topics based on the content discussed in the debates. An analysis of the number of mentions of a topic in the first two debates by a candidate and the number of mentions of that topic in the tweets for that candidate shows that they are positively correlated (Spearman's coefficient: .8177) with a  $p$ -value  $< 0.0001$ , rejecting the null hypothesis. Further, using the first two debates as the training set and the third debate as a test set, I designed predictors that will predict the number of tweets for a topic given the number of mentions of that topic. My work helps to understand people's response to the 2012 presidential debates and has applications in predicting irregular activity on Twitter.

## **Development and Analysis of a Double Displacement Method to Detect Nitrates, Sulfates, and Phosphates.**

*Tony Zheng*

*Marine Academy of Technology and Environmental Science, Manahawkin, NJ, New Jersey (Monmouth) JSHS;*

*Teacher/Mentor/Sponsor: John Wnek, MATES Academy; Datta Naik, Monmouth University*

Water is vital for life, therefore, maintaining the health of our water is essential. Nutrients are considered a major threat to the health of water bodies worldwide. There are numerous methods established to detect for nutrients; however, many of them are extremely costly per test, qualitative, take a 2 hour period or longer, and/or are difficult to fund for long periods of time. This study includes the development and evaluation of a novel method to detect nutrients. To assess the novel method,  $SO_2$ ,  $NO_3$ , and  $PO_4$  ions were tested and compared. Forty-six water samples were gathered from the Metedeconk River, NJ and a Brick MUA, NJ tap water source. Samples were tested using the novel method against a LaMotte SMART 2 Colorimeter. Results were then compared to the Brick MUA's state lab test methods. Results suggest that the novel method was six times more accurate and over 3,000 times more cost efficient compared to the Colorimeter. The results were also significantly similar as the Brick state laboratory results with less cost (\$0.005/test vs \$50.00/test). Overall, results suggest that the novel method could be a possible method to detect nutrients present in water bodies.

### **Characterization of Nitrogen Plasma Treated and Amide Functionalized Multi-Walled Carbon Nanotubes for Enhanced Photothermal Applications**

*Aditya Balaji*

*Bergen County Academies, Hackensack, NJ, New Jersey (Northern) JSHS;*

*Teacher/Mentor/Sponsor: Jean Patrick Antoine, Rutgers University*

Multi-walled carbon nanotubes (MWCNTs) can photothermally kill cancer cells owing to their strong absorption in the near-infrared (NIR) region, thus averting some of the side effects of current cancer treatments. Nitrogen-doped MWCNTs via chemical vapor deposition have been suggested as good candidates for high NIR absorption, but mass production of these could be cost-prohibitive. In this study, alternative methods of incorporating nitrogen into MWCNTs were attempted using nitrogen plasma and amide functionalization. NIR spectroscopy of nitrogen plasma MWCNTs showed a pronounced absorption peak at 959 nm, which can be attributed as a third overtone C≡N stretch, while amide functionalized MWCNTs revealed their characteristic N-H stretching overtone from 900 nm to the visible range. In order to investigate the correlation between NIR absorption and temperature increase, three different MWCNTs (nitrogen plasma treated, amide functionalized, and plain; all dispersed in water and surfactant at 1 mg/mL concentration) were exposed to broadband NIR radiation while their temperatures were monitored over 15 minutes. The nitrogen plasma MWCNTs generated a statistically significant increase in temperature compared to others. The results suggest that nitrogen plasma treated MWCNTs can couple energy more efficiently, and warrant more future investigation. Nitrogen plasma treated MWCNTs may prove to be key factor in making photothermal therapy a more cost-effective and viable option for cancer patients.

### **Development of a Novel, Safe Method for In Vitro Re-creation of the Tooth Enamel Layer**

*Laura Beth Fulton*

*Egg Harbor Township High School, Egg Harbor Township, NJ, New Jersey (Northern) JSHS*

Centering on the innovative concept of providing a re-created enamel layer, I established a viable, enamel solution with a biologically compatible bonding agent. Tooth enamel protects underlying dentin against dental caries and erosion which permanently expose teeth to deterioration. Ameloblasts, cells that make tooth enamel, are inert after mature enamel formation; no current methods have proven successful, safe or cost effective to re-form the enamel layer once damaged. Replicating enamel's structure and bond proves difficult; enamel's composition- hydroxyapatite (HA), easily synthesized, is a chalky white powder without bonding ability. Hypothesis: through development of a novel enamel solution using a biologically compatible bonding agent, artificial enamel can be created and applied in simulated in vitro conditions and assessed to determine efficacy. Chemical characterization and adherence to teeth was determined: X-ray diffraction identified chemical composition; Microleakage tests revealed enamel bond durability equivalent to natural enamel's; Vickers Hardness concluded enamel and dentin bond structure rivals true, natural enamel; SEM analysis revealed rod-bonded structures identical to natural enamel's. Adherence of 30 seconds when photoionized: decreases bacterial infection risk, increases microleakage resistance. The hypothesis was supported. Re-created enamel shields teeth against cavities, provides insulation to temperature, protects teeth in daily use, and improves overall health.



## Visible Hertz-level optical beats

Jiyoun J. Ha

Tenafly High School, Tenafly, NJ, New Jersey (Northern) JSHS;

Teacher/Mentor/Sponsor: Mrs. Helen Coyle, Tenafly High School; Professor Tanya Zelevinsky, Columbia University

To illustrate the wave nature of light, physics instructors are often limited to static demonstrations of a light interference pattern. This novel project presents a lecture hall demonstration of the wavelike nature of light creating a visible beats effect. While the demonstration of visible Hertz-level optical beats has been written about before, this study presents a new design where the demonstration was built simply, compactly, and relatively inexpensively by using optical components commonly found in many laser physics labs without the use and expense of a photodetector. An interferometer in the Mach-Zehnder configuration was constructed and modified to incorporate an acousto-optic modulator in each of the legs. The acousto-optic modulator Doppler-shifts the frequency of incoming light by scattering photons from moving diffraction grating formed by radio frequency (RF)-induced traveling pressure waves in a crystal, causing a frequency shift exactly equal to a chosen RF drive frequency which was around the visible 1Hz. This interferometer also provides a striking illustration of light's wave nature as its two projections are exactly out of phase. This demonstration was constructed, tested, and shown to be a convenient classroom demonstration of optical beat frequency, which is rarely seen outside a specialized physics lab.

## Resistance of Long-Term Survival Phase Cells to Oxidative Stress

Paige Hammell

Montville Township High School, Montville, NJ, New Jersey (Northern) JSHS;

Teacher/Mentor/Sponsor: Mrs. Salazar, Montville Township High School

Recent studies have shown that *Listeria* bacteria enter into a long-term survival (LTS) phase when nutrients in their environment are depleted. It has also been shown that in this LTS phase, *Listeria* are resistant to many environmental stresses, such as temperature and pressure stresses. The objective of my research was to determine if LTS phase cells of *Listeria innocua* (LI) are more resistant to oxidative stress than log and stationary phase cells. LI cells were incubated at 35 degrees Celsius until the cells had reached log, stationary, and LTS phase, then were treated with various concentrations of hydrogen peroxide (0.5% and 1%) for 30 minutes. Contrary to expectations, LTS phase cells were not more resistant to the hydrogen peroxide; both LTS and log phase cells were highly susceptible to the hydrogen peroxide. Interestingly, these results indicate that stationary, not LTS, phase cells were the most resistant to oxidative stress.

## A New Fibonacci-Like Sequence Of Composite Numbers

Jaesung Son

Ridgewood High School, Ridgewood, NJ, New Jersey (Northern) JSHS;

Teacher/Mentor/Sponsor: Dan Ismailescu, Hofstra University

An integer sequence  $(x_n)_{n \geq 0}$  is said to be Fibonacci-like if it satisfies the binary recurrence relation

$$x_n = x_{n-1} + x_{n-2}; n \geq 2.$$

In 1960, Graham proved that there exist relatively prime positive integers  $x_0$  and  $x_1$  such that the sequence  $(x_n)_{n \geq 0}$  defined by the recurrence above contains no prime numbers:  $x_0$  and  $x_1$  have 33 and 34 digits, respectively. Graham's construction was gradually refined by Knuth, Wilf, Nicol and Vsemirnov; the current record is  $x_0 = 106276436867$ ,  $x_1 = 35256392432$ , and was found by Vsemirnov in 2004.

The common feature of all the above constructions is the existence of a finite set of primes  $\{p_1; p_2, \dots, p_t\}$  such that for every positive integer  $n$ , there exists an  $i \in \{1, 2, \dots, t\}$  with  $x_n \equiv 0 \pmod{p_i}$ . We say that  $\{p_1, p_2, \dots, p_t\}$  is a covering set for the sequence  $(x_n)_{n \geq 0}$ .

In this paper we construct a Fibonacci-like sequence of composite numbers for which such a finite covering set does not appear to exist.

## New Mexico (Southwest)

---

### Phase IV: Revisiting Quorum Sensing and Investigating Bioluminescent Fluctuation in Marine Dinoflagellates

*Sarah R. Dallo*

*Albuquerque School of Excellence, Albuquerque, NM, New Mexico (Southwest) JSHS;*

*Teacher/Mentor/Sponsor: Fahri Arik, Albuquerque School of Excellence*

#### Problem Statement

Part A.) Is it possible for isolated groups of dinoflagellates to respond to flashes from other dinoflagellates in close proximity?

Part B.) Does limiting light exposure to a narrow bandwidth impact the luminosity of marine dinoflagellates?

#### Hypothesis

Part A.) Dinoflagellates will respond to each other's glow because of observations in previous experimentation.

Part B.) Changes to the bandwidth of light will affect the normal glow function in dinoflagellates. The light with a shorter wavelength will make the dinoflagellates glow with a greater intensity because blue light is the frequency that they naturally produce.

#### Results

Part A.) *P. lunula* reacted to both *P. fusiformis* and *P. noctiluca*. However, *P. fusiformis* and *P. noctiluca* did not react with each other.

Part B.) Longer wavelengths produce brighter glow in dinoflagellates. Both red and green LED's produced greater intensity.

#### Conclusion

Part A.) My data concluded that dinoflagellates respond to flashing from other species.

Part B.) Dinoflagellates exposed to longer wavelengths increased luminosity. Green LED's produced a higher luminosity, which may be due to chlorophyll in dinoflagellates.

### New Generation of Hydrogen Storage Materials: From Synthesis to System Integration

*Kathryn M. Harris*

*Rio Rancho High School, Rio Rancho, NM, New Mexico (Southwest) JSHS;*

*Teacher/Mentor/Sponsor: Robert Keeney*

New Generation of Hydrogen Storage Materials: From Synthesis to System Integration The purpose of this project is to see if a MOF (Metal Organic Framework) and CNT (Carbon-nano Tube) hybrid material found in scientific literature can be replicated in order to store hydrogen. I worked alongside Dr. Alexey Serov for more than 48 hours in the lab. UNM provided knowledge of synthesis of CNTs which gave parameters to compare my product to (40-70nm). Synthesis began with a process of grinding silica and carbon. Producing MOFs was more complicated in that iron and silica were combined as powder. Then DMF was added, but evaporation occurred so a condenser was utilized. CNT and MOF materials were then ground together. I captured detailed pictures (using a Scanning Electron Microscope) demonstrating shape and size of each sample; MOF and CNTs separately and combined. According to Sigma-Aldrich, my MOFs (110.8855 sq. m/g) was a little lower, but was expected, then their findings (~150 sq. m/g). My CNTs were in between UNM parameters at 50nm. These data suggest the theoretical storage of hydrogen. If both products can separately store hydrogen at those measurements, then the hybrid material could absorb and release hydrogen efficiently as a fuel.

## Humidity vs. Radiation Detection

*Sean P. Palmer*

*Santa Teresa High School, Santa Teresa, NM, New Mexico (Southwest) JSHS;  
Teacher/Mentor/Sponsor: Alicia Stevens, Santa Teresa High School*

An ionization chamber indirectly detects radiation via the measurement of ions present in the air by collecting ion pairs and registering voltage. The problem with ion chambers is the tendency for inaccuracy when exposed to humidity. The purpose of this project is to test the effectiveness of the ion chamber under varying degrees of relative humidity in an effort to find the true reading on a humid day. Accuracy in the device is fundamentally crucial to maintain safety precautions. My hypothesis was that the greater the humidity, the lower the measurement would register on the multimeter. The taken procedures included making the ion chamber, making the hygrometer to read humidity levels, and taking readings under different conditions. Two trials utilized the radioactive isotope Americium-241, and another two trials utilized natural background radiation. My hypothesis was supported in each trial, namely trial 1 in which the relative humidity rises from 23% to 51% and the voltages drop from 0.1 to .044 volts. In environmental sciences, this project provides a way to find the true voltage measurement on a humid day and maintain the accuracy after making use of percent error calculations and experimental voltage measurements.

## Sound as Energy: pluggedIN

*Melanie B. Schneider*

*V. Sue Cleveland High School, Rio Rancho, NM, New Mexico (Southwest) JSHS;  
Teacher/Mentor/Sponsor: Angelica Lopez, V. Sue Cleveland High School*

Due to the world's increasing power demand, alternative sources need to be developed. This project was engineered with the hopes of obtaining a usable electrical charge from sound with the intentions of establishing another alternative energy. Microphones, which transduce acoustic energy to an electric signal, were used to capture this power. Piezo elements, used in contact microphones to convert pressure to electricity, were connected in series and placed at a focal point of an elliptical structure to naturally amplify the sound available and transduce this sound based pressure. Dynamic microphones, which produce a charge when a diaphragm moves a coil through a magnetic field, were also used in an attempt to transduce sound. The intention of this project was met, in that voltages were produced from sound; however, the amount generated is currently indicative of an inefficient source of power. In order to produce a usable charge, sound must be further amplified, as well as the current it produces. On a larger scale, with greater resources, the energy of sound could be amplified, utilized, and electrified. It remains hopeful that we could one day plug in to din.

## Measuring the Wave Function of a Quantum System

*Katherine A. Schneider*

*V. Sue Cleveland High School, Rio Rancho, NM, New Mexico (Southwest) JSHS;  
Teacher/Mentor/Sponsor: Ms. Angelica Lopez, V. Sue Cleveland High School*

Measuring the Wave Function of a Quantum System, Katherine A. Schneider, V. Sue Cleveland High School, Rio Rancho, NM; Sponsor: Ms. Angelica Lopez The time-independent Schrödinger equation, when solved, produces a wave function offering information about a particle's position values. By applying this wave function to the finite square well concept, it's possible to predict values after a single particle is localized. As results of other studies made me question the predictability of wave behaviors under the well, the goals of this project are to develop a wave simulation under set conditions, analyzing how changing conditions affect wave patterns. To do this, I used a Microsoft Excel spreadsheet creating three different finite square well models. Each scenario produced a wave function in one dimension with the energy, differential distance step value, and depth of each well manipulated. Numerical and graphical representations show the wave behaviors correlating with the energy difference of the system producing position probabilities for the wave functions. This yields that waves tended to exist close to their ground states and could be found outside of finite barriers as they reached the well wall ( $\pi$ ) with very low probabilities. This validates consistent waves under specific constraints within a well, and the ability to predict discrete values based on it. Future research will include the study of quantum tunneling.

## **Air-Baked Glass for Ultra-High Vacuum**

*Mary C. Spanjers*

*East Mountain High School, Sandia Park, NM, New Mexico (Southwest) JSHS;*

*Teacher/Mentor/Sponsor: Dr. Matthew Squires, Air Force Research Laboratories*

Before glass can be used in a vacuum, the molecules must be removed from the surface of the glass through the process of outgassing. However, when molecules, most of which are water, are deeply embedded in the glass they take much longer to diffuse from the glass. By air baking glass before outgassing it more of these embedded molecules may be removed. This experiment involved air-baking glass at higher temperatures before entering the glass into an outgassing procedure within a vacuum chamber. Data collected demonstrated a decrease in the levels of water molecules in the glass which had been air baked over the glass which had not been air baked. In addition air baking periods of 1 to 2 days will produce the improved results during pump down.

## **Art, Personality, and the Mind: The Effect of Personality Type on the Liking of Art**

*Sierra Venegas*

*Rio Rancho High School, Rio Rancho, NM, New Mexico (Southwest) JSHS;*

*Teacher/Mentor/Sponsor: Miyashiro*

The purpose of this experiment was to determine if personality type affects the liking of representational art. Using the NEO five-factor personality test, I was able to test 35 right-handed females between the ages of 15-17. I hypothesized that the subjects with Openness to Experience, Agreeableness, and Conscientiousness would have the highest average ratings. I then did a controlled survey to find their average rating of 25 figurative/representational images. The data showed that the subjects with O-types of personality rated the images higher (7.147). The other personality types are as follows: A (6.713), N (6.18), C (5.7), and E (5.36). The ANOVA p-value was 0.039, making these averages differ with personality types. I concluded that the subjects with the O-type personality had a higher rating of the representational art because they enjoy things that lead to creative/intellectual advancement. Those with the C-type did not have the highest rating as expected, due to the age range. It can be assumed using results of past studies that subjects with the O-type personality have higher activity in the left cingulate sulcus, bilateral occipital gyri, fusiform gyrus, and cerebellum. E-type personalities have lower activity in the caudate nucleus and putamen. Possible research applications include implementing more efficient therapy for patients with disorders in the above listed areas of the brain. By showing patients different types of artwork, you can potentially strengthen certain parts of their brain. In the future, I would like to do a similar experiment with MRI scans and more subjects.

### **A Practical Notification System to Identify Incoming Sudden Ionospheric Disturbances**

*Anthony R. Bisulco*

*Commack High School, Commack, NY, New York (Long Island) JSHS;*

*Teacher/Mentor/Sponsor: Richard Kurtz, Commack High School; Lorraine Solomon, Commack High School; Fred Kruger, Kruger Inc.*

Solar flares, which are the sudden release of high-energy particles from the sun, are a threat to our vital communication and power networks because they have the ability to disable these systems. In this investigation a method to minimize this threat was developed and evaluated. The central aspect of this method was creating a solar flare early detection system based on identifying the characteristics of a solar flare through its effect on Very Low Frequency (VLF) radio signal propagation. When a solar flare hits the ionosphere it increases the reflectivity of the D layer of the ionosphere. This causes the Very Low Frequency (VLF) waves that propagate through the atmosphere to reflect with attenuation. Therefore, a high amplitude VLF signal could indicate a solar flare. The detection and warning system consisted of constructing and using a loop antenna that detects the VLF waves, a preamplifier and sound card, and MATLABR a software program used for writing the code that processes the signal and identifies the potential solar flare. A smart phone application has been written and implemented to deliver the information about a potentially disruptive solar flare to various communication devices.

### **The Effects of PLGA and Titanium Dioxide Nanoparticles on Endothelial Cell Proliferation. Implications for Angiogenesis.**

*Leandra Meraglia-Garcia and Daphne Chen*

*St. Anthony's High School, South Huntington, NY, New York (Long Island) JSHS;*

*Teacher/Mentor/Sponsor: Dr. Miriam Rafailovich, Stony Brook University; Mr. Paul Paino, St. Anthony's High School*

Angiogenesis is the growth of blood vessels from preexisting vasculature. It is vital to wound healing, causing improved blood flow and oxygen/nutrient delivery to injured tissue. Successful angiogenesis requires cell traction and regulation of endothelial cell interaction with the extracellular matrix. This study examined the effect of PLGA (poly[lactic-co-glycolic acid) and Titanium Dioxide (TiO<sub>2</sub>) nanoparticles on endothelial cell cytotoxicity and angiogenesis. PLGA was synthesized with a surfactant stabilizer PF68 (Pluronic-68). The emulsion was centrifuged, the isolated pellet lyophilized, and nanoparticle size determined by Transmission Electron Microscopy. PLGA concentrations of 0.1 mg/mL, 0.4 mg/mL, and 1.0 mg/mL were used for the cytotoxicity tests; 0.1 mg/mL and 0.4 mg/mL were used for the angiogenesis assay. Anatase and Rutile TiO<sub>2</sub> were at 0.1 mg/ml. Cell counting was conducted at twenty four and forty eight hours. PLGA was cytotoxic and not angiogenic to endothelial cells. Rutile TiO<sub>2</sub> had no notable effect. Anatase TiO<sub>2</sub> had no cytotoxicity but had a positive angiogenic effect, exhibiting the greatest magnitude of large lattice formation. Anatase TiO<sub>2</sub> can be utilized in angiogenic substances onto scaffolding materials and for frameworks in which angiogenesis is applied to aid wound healing.

## **Development of a Multi-Sensory System to Better Relay Pharmacotherapy Information**

*Matthew M. O'Connell*

*Commack High School, Commack, NY, New York (Long Island) JSHS;*

*Teacher/Mentor/Sponsor: Mr. Richard Kurtz, Commack High School*

The purpose of this project was to develop an interactive computer-based system for medication prescribers to better convey, through multi-media, pharmaceutical instructions to their patients.

Patients worldwide continually face the dangers of dosing errors resulting from poor understanding of medical instructions. Retention of medication information given verbally is minimal and low literacy skills can further impede understanding and recall. Pictograms, translations, and orations of medical instructions were provided by the International Pharmaceutical Federation (FIP) and compiled into databases. A software program titled The Prescription Architect (TPA) was developed for prescribing medical professionals to create pictogram handouts and generate spoken instruction for patient prescriptions. TPA is downloadable online for free and does not require internet access to use. Additionally, new data (translations, pictograms, & orations) can be appended to the program's databases. TPA was presented at the FIP's 2013 world conference in Ireland and has since been downloaded by over 500 individuals worldwide. TPA will be in full use after FIP validation. Studies are currently being developed and/or conducted to evaluate usability of the software.

## **An in vitro assessment of Nitric Oxide-Releasing Nanoparticles as a Potential Drug Delivery Vehicle for Treating Hypoxia-Induced Pulmonary Vascular Inflammation**

*Ankoor Talwar*

*Herricks High School, New Hyde Park, NY, New York (Long Island) JSHS*

Purpose: Pulmonary vascular remodeling associated with hypoxia leads to elevation in pulmonary vascular resistance, right heart failure, and death. Macrophage Migration Inhibitory Factor (MIF) as a critical molecule in hypoxia-induced vascular remodeling, and thyroxine (T4) as a natural inhibitor of MIF inflammatory activity. De-iodinase2 (DIO2) catalyzes breakdown of T4. Thus, DIO2 expression may be considered a proinflammatory marker under these conditions. Studies also suggest the involvement of ubiquitin-proteasome system in remodeling. I evaluated the efficacy of novel Nitric Oxide-releasing nanoparticles (NONps) in limiting hypoxia-induced inflammation in cell cultures through changes in these inflammatory markers. Methods: NONps used were based on a hybrid particle combining hydrogel properties with a strong hydrogen bonding network that limits NO release until the particles are exposed to water. Both NONp and nitrite-free nanoparticles (control nanoparticles) were added to cultures of human lung fibroblasts (CCL210) under normoxic or hypoxic conditions (1% O<sub>2</sub> concentration). MIF accumulation was assessed using ELISA, intracellular DIO2 expression by Western blot, and proteasome activity by fluorometric small peptide cleavage assay. Results: NONp significantly ( $p < 0.05$ ) reduced MIF accumulation compared to control particles in both normoxia (253 vs 582 pg/ml) and hypoxia (360 vs 668 pg/ml). DIO2 expression was also significantly decreased in a similar fashion. In addition, proteasome activity under hypoxic conditions was significantly increased ( $p < 0.05$ ) in presence of NONp (21.4 vs 19.2). Conclusions: This study reveals the effect of NONp (a novel NO delivery system) in attenuating relevant pro-inflammatory markers in hypoxia-induced pulmonary vascular inflammation, which may have significant clinical implications.

## **Design, Synthesis, and Testing of Novel Inhibitors Against InhA in Mycobacterium tuberculosis**

*Neil M. Thivalapill*

*Great Neck South High School, Great Neck, NY, New York (Long Island) JSHS;*

*Teacher/Mentor/Sponsor: Dr. Carol Hersh, Great Neck South High School; Lauren Spagnuolo, Institute of Chemical Biology and Drug Discovery: Stony Brook University; Dr. Peter Tonge, Institute of Chemical Biology and Drug Discovery: Stony Brook University*

Tuberculosis claims 2 million lives each year. Emerging multi-drug resistant strains highlights the need for new drugs to be developed. The currently exploited target is the fatty acid biosynthesis pathway that produces vital components of the cell wall. In this study, four novel inhibitors of InhA were synthesized whose structures varied to determine structure activity relationships between these drugs and the active site of InhA. On the A-ring of the drugs, an ethyl group, a cyclopentyl group and a cyclohexyl group were substituted in and a methyl or cyano group was added to the B-ring. Kinetic studies and thermodynamic constants were measured to determine in vitro efficacy. Drug-like characteristics of the inhibitors were also calculated to predict the compounds' efficacy in vivo. The structure activity relationships showed that there was a size limit to the A-ring substituent and that a less polar group on the B-ring was preferable. Molecular docking studies were subsequently executed to validate in vitro findings and MIC data was used to translate in vitro efficacy into in vivo efficacy and determine the overall effectiveness of the drugs. These drugs present themselves as advancements to understanding the structure activity relationships between inhibitors and InhA in Mycobacterium tuberculosis.

### **A Novel Device for Crowd-Sourced Road Quality Monitoring**

*Maxim S. Diamond*

*Croton Harmon High School, Croton on Hudson, NY, New York (Upstate) JSHS;*

*Teacher/Mentor/Sponsor: Donna Light-Donovan, Croton Harmon High School; Anthony Rowe, Carnegie Mellon University*

Whether by car, truck, or bus, road transport of people and goods is an integral aspect of modern life. In urban environments, roads wear out quickly and cause damage, often at a rate that is higher than civil engineers can compensate. In rural environments, roads can deteriorate as a result of weather factors, cutting off remote areas from supply routes. To enable efficient road maintenance, civil engineers must be supplied with data that reflects current road quality conditions. To facilitate this, road quality must be monitored frequently in an efficient manner. Previous research has indicated that this can be done by utilizing a participatory sensing network. To evaluate such a system, an originally-designed participatory road quality sensing system was designed and built. This system is termed PRAD - Participatory Road Anomaly Detection. PRAD uses a GPS module and 3-axis accelerometer to record vehicle vibrations resultant from the road surface in correspondence to vehicle's location. Statistical processes are used to calculate road quality from this data. Testing results show that PRAD is effective at monitoring road quality when GPS signal strength permits. Future work involves algorithm creation to correct for vehicle tilt and behavioral analysis of driver actions.

### **Relative vs. absolute orientation judgments: a re-evaluation of some neural decoding models**

*Stephanie Ding*

*Byram Hills High School, Armonk, NY, New York (Upstate) JSHS;*

*Teacher/Mentor/Sponsor: Dr. Ning Qian, Columbia University*

Neurons in area V1 of the occipital lobe are tuned to orientation in external stimuli. A certain orientation will lead to a specific degree of response of a cell in the form of action potentials. The brain is thus able to determine the visual orientation of a line by 'listening' to a population of cell responses. Researchers have attempted to model how the brain decodes the electrical responses using several decoding theories such as Maximum Likelihood Theory, Bayesian Theory, and Population Vector. One common assumption among all these theories is that our relative judgments (i.e., comparison of two stimuli) are referenced upon absolute judgments (i.e., perception of each stimulus alone). According to this assumption, our relative judgments are slightly less accurate than absolute judgments. However, intuition implies the contrary since judgment based on comparison is easier to evaluate than judgment of a single item. Results from this study indicate that actual relative judgment performance is significantly better than performance predicted by the assumption of these three theories. The result of this demonstrates that the assumption of these theories is incorrect and thus draws attention to the need for an adjustment to the theories for future studies and applications.



## **The MAPT H1 haplotype is Associated with Increased Clinical and Neuropathological Severity of Chronic Traumatic Encephalopathy**

*Adam Z. Illowsky, Sr.*

*Ossining High School, Ossining, NY, New York (Upstate) JSHS;*

*Teacher/Mentor/Sponsor: Angelo Piccirillo, Ossining High School; Valerie Holmes, Ossining High School*

Post-mortem examination of brains from patients with chronic traumatic encephalopathy (CTE) reveals massive accumulation of neurofibrillary tangles (NFTs) throughout the brain theorized to be a manifestation of repetitive head trauma. Extensive exploration of the role of MAPT in the onset or severity of CTE has yet to be conducted. This study examined the possible association between the MAPT gene and the severity of clinical and neuropathological features of CTE. MAPT genotyping was conducted on 39 CTE brain samples from professional football players, professional hockey players, professional wrestlers, Military Veterans patients, and 52 controls. The MAPT H2 haplotype was found to be associated with increased disease duration amongst CTE patients in this study ( $p=0.015$ ). Age of death of the CTE patients in this study was found to be lower amongst MAPT H1 homozygotes than MAPT H2 carriers by approximately 9.2 years, but this was not a statistically significant difference ( $p=0.137$ ). The stage/-age ratio of MAPT H2 carriers was found to be significantly lower than that of the homozygous H1 carriers, indicating a much slower progression of neurodegeneration amongst MAPT H2 carriers ( $p=0.0184$ ). Thus, the MAPT H12 haplotype seems to lead to a more sevmay serve and fasteras a protective factor in the progression of CTE and highlights a potential role for genetic factors in the development of CTE.

## **An In Silico Model to Describe the Localized Dendritic Transport of $\beta$ -Actin mRNA**

*Jason S. Rosenberg*

*Blind Brook High School, Rye Brook, NY, New York (Upstate) JSHS;*

*Teacher/Mentor/Sponsor: Dr. Michele Sugantino (teacher), Blind Brook High School; Dr. Robert Singer (mentor), Albert Einstein College of Medicine*

mRNA trafficking and local translation are physiologically important processes in the functioning of many cells, including neurons. However, observations of the isolated contributions of the complex mechanisms involved in mRNA localization have proven difficult experimentally. Here, single molecule experimental and in silico techniques are used to create a model of the dendritic trafficking of  $\beta$ -actin mRNA. In this model, created using the Virtual Cell, the individual effects of the factors influencing mRNA transport can be quantified. Additionally, the local transport of  $\beta$ -actin mRNA in the absence of one of its regulatory proteins is modeled. The models suggest that the degree of somatodendritic tapering greatly affects mRNA distribution. The models also reveal that in the absence of a regulatory protein, diffusive processes and increased transcription rates can largely compensate for decreased active transport of mRNA in maintaining proper dendritic mRNA distributions. Comparisons of these models to experimental data suggest the utility of in silico models of neuronal mRNA localization. Furthermore, the models can be readily adapted to investigate the trafficking of mRNA species other than  $\beta$ -actin mRNA, including those for which defects in their neuronal trafficking have been implicated in diseases such as amyotrophic lateral sclerosis and fragile X syndrome.

## **An Investigation Comparing the Flight Orientation of Lab-raised & Wild-caught Migrating Monarch Butterflies**

*Alexis A. Scott, Jr.*

*Burnt Hills - Ballston Lake High School, Burnt Hills, NY, New York (Upstate) JSHS;*

*Teacher/Mentor/Sponsor: Regina Reals, Burnt Hills - Ballston Lake High School*

Every fall, the Monarch butterfly makes its annual migration from northern North America to the mountains of Central Mexico where they hibernate during the winter. This migration has been made for countless years, but is now threatened as the species undergoes a dramatic population decline. The species is struggling to survive because the habitat in their wintering sites has decreased, global climate change is affecting the timing of their migration, and their food source, milkweed, is threatened by expanding agricultural development. Efforts to reduce the impact of these factors might come too late if the butterfly population reaches a critically low level. It might be necessary to conserve the North American migrating Monarchs by boosting their population with lab-raised individuals. A flight simulator, with some modifications from the basic design by Mouritsen and Frost (2002), was constructed to record the flight-orientation of Monarch butterflies. The simulator will be used to investigate the potential differences and similarities of the flight-orientation of wild and lab-raised Monarch butterflies. If any similarities of orientation between wild and lab-raised Monarchs are observed, then there is potential that the migrating North American Monarch butterfly population can be revived by the release of lab-raised Monarchs.

### **Electrically Characterizing NbSe<sub>2</sub> through Soft Micro-Stencil Lithography and Atomic Force Microscopy**

*Waqarul B. Islam*

*Stuyvesant High School, New York, NY, New York City (Metro) JSHS;*

*Teacher/Mentor/Sponsor: Dr. Chul Ho Lee, Columbia University*

The electrical characterization of newly discovered nanomaterials allows researchers to discover properties that may provide several new applications of nanomaterials in electronics. However, a large subset of nanomaterials cannot be conventionally characterized due to their incompatibility with organic compounds that are traditionally required for such electrical testing. To alleviate this issue, I worked on developing a novel microfabrication procedure aptly named Soft Micro Stencil (SMS) lithography, which employs a polymer based stencil mask that is patterned using electron beam lithography. This SMS procedure provides for high resolution construction of nanodevices on both planar and non-planar surfaces of nanomaterials a feat that expands the toolset of researchers in nanoscience. Tailoring SMS lithography to NbSe<sub>2</sub> provides a chemical-free procedure to fabricate nanostructures for electrical testing on the surface of a 20-30nm piece of NbSe<sub>2</sub> without surface contamination or other damage. This study further details the deterioration of NbSe<sub>2</sub> in both air and organic compounds such as acetone using atomic force microscopy (AFM). Running a current through layers of NbSe<sub>2</sub> results in properties similar to those of graphene (a single layer of carbon in a hexagonal pattern) in terms of superconductivity thereby enabling the potential usage of NbSe<sub>2</sub> in future electronics or experiments.

### **Using Ligands to Control the Growth Kinetics of Cadmium Selenide Clusters**

*Alexandra L. LaGrassa*

*The Bronx High School of Science, Bronx, NY, New York City (Metro) JSHS;*

*Teacher/Mentor/Sponsor: Dr. Karen Fien, The Bronx High School of Science; Alexander Beecher, Columbia University; Dr. Jonathan Owen, Columbia University*

Although researchers have intensely studied colloidal semiconducting quantum dots for the past twenty years recognizing that their optoelectronic properties, especially their narrow, size-dependent emission, make them ideal for applications in the fields of lighting, solar energy, and biolabeling, fundamental studies have been limited by their inherent polydispersity. In particular, kinetics of their growth processes is difficult to study without a consistent, atomically defined structure. In this study, cadmium selenide quantized growth clusters are employed as molecularly defined models of quantum dots that grow into discrete uniform sizes. The data shows that the most important step in the growth mechanism is highly sensitive to the interaction between the ligand and the surface of the nanocrystal. A high concentration of both ligands during synthesis from the precursors slows down the rate of the reaction. Kinetic studies varying the strength of the charged ligand-surface bond demonstrates that the reaction is significantly influenced by electronics. A Hammett sigma plot shows that the key step in the reaction has a build-up of negative charge, indicating a charged ligand dissociation step. This kinetics study using molecularly defined clusters with a high surface area to volume ratio rigorously demonstrates control over cluster growth using surface chemistry.

## **Epithelial Mesenchymal Transition is a Key Factor of Perineural Invasion in Pancreatic Adenocarcinoma**

*Erica Lin*

*Hunter College High School, New York, NY, New York City (Metro) JSHS;*

*Teacher/Mentor/Sponsor: Dr. Chun-hao Chen, Memorial Sloan Kettering Cancer Center; Dr. Richard Wong, Memorial Sloan Kettering Cancer Center; Ms. Gilana Reiss, Hunter College High School*

Pancreatic adenocarcinoma is one of the most common causes of cancer-related death. Perineural invasion (PNI) occurs frequently in pancreatic adenocarcinoma and correlates with poor prognosis. Epithelial Mesenchymal Transition (EMT) of carcinoma cells is associated with increased motility and invasiveness. The relationship between these two processes has not been established. The study hypothesis was that EMT contributes to PNI. In order to test the hypothesis, PANC-1 cells were transfected with human Twist1 gene to induce EMT. Boyden chamber motility assays using dorsal root ganglion (DRG) as substrate were performed to evaluate for cell motility. In vitro DRG models of nerve invasion were also performed to evaluate cell invasion. The study results showed that EMT leads to increase in motility and invasiveness of pancreatic carcinoma. Cells with EMT phenotype moved through the membrane in the Boyden chamber assay in greater number and, similarly, invaded DRG in higher number in the in vitro DRG model of nerve invasion model. These findings indicate that cells with EMT phenotype have greater motility and invasiveness potential for PNI. Therefore, inhibition of the EMT mechanism represents a potential therapeutic target that can be used to decrease PNI, and thus, improve the prognosis of pancreatic adenocarcinoma.

## **The Effect of Solvents on the Photorelease of a Model Drug from a New Phototrigger**

*Rasidha Rahman*

*Queens High School for the Sciences at York College, Jamaica, NY, New York City (Metro) JSHS;*

*Teacher/Mentor/Sponsor: Dr. Jong Ill Lee, York College CUNY; Shanaz Baksh, Queens High School for the Sciences*

The purpose of this research is to test the photorelease efficiency of the phototrigger, t- Boc GABA Triphenyl Ethane which can be used to treat cancer more targeted and effectively. Acetonitrile-D3 and Chloroform-D were the solvents that were used for each photoreaction in a 300 nm Rayonet Photoreactor. The experiment shows that phototrigger successfully delivers drug and is efficient during photorelease in an environment that closely mimics the human body. The phototrigger had higher photorelease efficiency in Acetonitrile-D3 than in Chloroform-D. 48.8% of t-Boc GABA was released in Chloroform-D whereas 91.5% of t-Boc GABA was released in Acetonitrile-D3. t-Boc GABA Triphenyl Ethane has a high photorelease efficiency and solubility which makes it a reliable drug delivery system. In the long run, the drug t-Boc GABA could be replaced with other cancer treatment drugs in order to treat cancer more efficiently.

## **The Role of Serotonin in Impulsivity in Mice**

*Praveen Rammohan*

*Bronx High School of Science, Bronx, NY, New York City (Metro) JSHS;*

*Teacher/Mentor/Sponsor: Dr. Adam Kepecs, Cold Spring Harbor Laboratory; Dr. Hyun Pi, Cold Spring Harbor Laboratory; Mr. Richard Lee, Bronx High School of Science*

Problems in patience and impulsivity can lead to several disorders, including suicidal behavior, attention deficit disorder, drug addiction and criminal behavior. This project investigates the mechanisms behind patience and impulsivity based on the previously suggested idea that serotonin has a controlling role in impulsive behavior. Four transgenic black-6 mice were trained to perform a task in which they poke a port for a set amount of time to get a water reward. The waiting time was programmed to automatically increase in small intervals after every successful trial so that the mice wouldn't perform poorly as a result of a large difference in waiting time. After the mice were able to wait for at least a second and complete the task successfully, an optic fiber was implanted at the serotonin-neuron-dense dorsal raphe nucleus of the brain so that when a blue-light laser was shone through it the serotonergic neurons were activated. The mouse's performance in stimulation and nonstimulation trials was compared. The incremental task helped the mice increase their waiting time greatly in a short training period. As for the stimulation and non-stimulation distinction, further experimentation needs to be done before concluding whether patience can be induced optically.

## The Radio Number of Grid Graphs

*Tian-Shun A. Jiang*

*North Carolina School of Science and Mathematics, Durham, NC, North Carolina JSHS;*

*Teacher/Mentor/Sponsor: Dr. Dan Teague, North Carolina School of Science and Mathematics*

The radio number problem uses a graph-theoretical model to simulate optimal frequency assignments on wireless networks. A radio labeling of a connected graph is a function such that for every pair of vertices  $u, v$ , we have  $|f(u) - f(v)| \geq d(u, v)$  where  $d(u, v)$  denotes the diameter of  $G$  and the distance between vertices  $u$  and  $v$ . Let  $\Delta$  be the difference between the greatest label and least label assigned to  $G$ . Then, the radio number of a graph is defined as the minimum value of  $\Delta$  over all radio labelings of  $G$ . So far, there have been few results on the radio number of the grid graph: In 2009 Calles and Gomez gave an upper and lower bound for square grids, and in 2008 Flores and Lewis were unable to completely determine the radio number of the ladder graph (a 2 by  $n$  grid). In this paper, we completely determine the radio number of the grid graph for  $n \times n$ , characterizing three subcases of the problem and providing a closed-form solution to each. These results have implications in the optimization of radio frequency assignment in wireless networks such as cell towers and environmental sensors.

## Fuel Efficient Passive Flow Control for Class 8 Tractor Trailers

*Megan E. Miller*

*Western Alamance High School, Elon, NC, North Carolina JSHS;*

*Teacher/Mentor/Sponsor: David Vernon, Western Alamance High School*

Tractor-trailers use 13% of the annual US petroleum. Drag behind the rear of the trailer or trailer base drag constitutes the greatest portion of aerodynamic drag at highway speeds. To perform drag testing, a 10meter long backyard wind tunnel was optimized and validated. Using general physics principles and computational fluid dynamic (CFD) modeling, an open circuit, pull fan tunnel was optimized by adding two fans in sequence with flow straightener vanes, a rounded inlet and a lengthened diffuser. The optimum tunnel demonstrated a 32% increase in airflow with improved laminar flow. Trailer base drag reduction testing involved rear mounted vortex devices on a 1:16 tractor trailer scale model at  $1.8 \times 10^5$  Reynolds flow. Testing occurred at steady state conditions, air density range 1.14-1.16 kg/m<sup>3</sup> with 5000 data points per test. The optimum devices were two 5mm spheres on each side of the trailer base, placed at 5cm and 10cm from the trailer bottom. This configuration underwent reproducibility testing and an average of 7% total drag reduction was found. The 5,10 spherical configuration represents a simple vortex device with a potentially significant, cost effective solution to trailer base drag on a full-scale class 8 tractor trailer.

## Tracking Electron Density Change in a Photocatalyst and Exploring Replacement Central Atoms

*Pranay Orugunta*

*Teacher/Mentor/Sponsor: Dr. Jonathan Bennett, North Carolina School of Science and Mathematics*

Photocatalytic water oxidation is an area of study that has gained recent attention due to interest in hydrogen fuel cells. We use computational chemistry in order to model the electron density fluctuations as a copper photocatalyst reduces water. We hope this will provide some insight into how the photocatalyst can be optimized for reaction rates. We also use Gaussian software to replace the central atom of the catalyst to find different activation energies, which affects the rate of the reaction. From our results, we find that we can model electron density change this reaction, and that the location of greatest electron density moves first from the photocatalyst into the water molecule. Then, density slowly flows into the more polar bonds and then back into the photocatalyst. Since Au and Cu photocatalysts exhibit similar electron density behavior, we run energy calculations using copper and gold as the central atom. The activation energy for the transition states, on average, for Au is 25% lower than that of Cu. We can conclude that the reaction rate for Au is ~23% faster than that of the copper photocatalyst. This study suggests that the efficiency of photocatalysts can be improved by substituting different central atoms and ligands.

## **Screening for endophytes that produce volatile organic compounds (VOCs) that can be used as biofuels**

*Joseph H. Roberts*

*Brevard High School, Brevard, NC, North Carolina JSHS;*

*Teacher/Mentor/Sponsor: Jennifer Williams, Brevard High School*

Biofuels (fuels derived from plant or animal material) have been researched lately because of the emphasis on renewable energy. Recently, a new focus for biofuel production has been on fungi that produce volatile organic compounds (VOCs). Some fungi that produce VOCs are endophytes. Endophytes have mutualistic relationships with their host plant and live within and around the cells of their host. The hypothesis for this study is that some tree species that emit abundant VOCs harbor endophytes that produce VOCs. Thirty-eight endophytes isolated from the leaves and barks of eastern white pine, tulip poplar, magnolia, black walnut, and black gum, were cultured and identified. These trees were chosen because they emit VOCs and are found in western North Carolina. The endophytes were tested for the production of volatile alcohols using a colorimetric dichromate reduction assay. An isolate identified as *Diaporthe* sp. or *Phomopsis* sp. from black gum bark, an isolate identified as *Entonaema* sp. or *Xylaria* sp. from black walnut leaf, and an isolate identified as *Diaporthe* sp. from magnolia bark produced alcohols when cultured on rice. These results support the hypothesis stated above and suggest that these three fungal species could potentially be used for biofuel production.

## **Mitigating the Neurodegenerative and Teratogenic Effects of Ziram with UVC Waves**

*Joshua Zhou*

*East Chapel Hill High School, Chapel Hill, NC, North Carolina JSHS;*

*Teacher/Mentor/Sponsor: Dr. Wu Dong, Duke University Nicholas School of the Environment*

Ziram is a common pesticide and chemical, being applied on most produce, used to make many products for home construction, yards, papers, and plastics, and present in animals, water, and sometimes air. America alone uses 2 million pounds annually. Ziram, however, is acutely and chronically toxic to vital organs of certain vertebrate animals. Ziram's harm is magnified by its ready absorption upon dermal contact with skin oil. Aquatic organisms can accumulate up to 90 times as much ziram as the amount present in surrounding water. Using embryos of a model vertebrate animal, medakafish, this study investigated (1) if ziram poses risks to vertebrate animals, in general, and (2) if UVC waves can quickly, cheaply, and significantly reduce ziram's harm. Observations of medakafish during development and after fixed tissue underwent Alcian Blue cartilage staining and TUNEL staining showed that ziram was extremely impairing in 8 significant aspects. In fact, 3 mg of accumulated ziram could kill 2000 medakafish. After relatively short exposures of ziram to UVC waves, however, there was significant, and often complete, elimination of ziram's effects. Through a similar mechanism of decomposition, UVC waves can effectively eliminate the harm of other potent chemicals in a practical manner for real-world application.

## North Central (Minnesota, N. & S. Dakota)

---

### **Determination of Factors that Impact Clearance of Suspended Particulate Matter (Dust) in Air**

*Alanna M. Bram*

*John Marshall, Rochester, MN, North Central (Minnesota, N. & S. Dakota) JSHS;*

*Teacher/Mentor/Sponsor: Richard Bram, John Marshall*

Environmental dust is deleterious to human health, machinery, and agriculture. Multiple interventions have been used to reduce dust levels, including filtering the air, and altering local atmospheric conditions. I hypothesized that filtering would provide the most effective decrease in atmospheric dust, while changes in local humidity, temperature, or ionic charges would be less effective. To test this hypothesis, I designed and built a microprocessor controlled dust meter, with sensors to also measure temperature, humidity, time, and location. Dust levels in Rochester, MN were determined to identify areas with higher dust concentrations. To analyze effects of atmospheric conditions, dust from smoke was monitored in a controlled environment. Rates of dust decay over time were determined under conditions of varying humidity, temperature, and ionic charge potential. I found that dust levels decayed at reproducible exponential rates. I also tested the abilities of several materials to filter out dust. Surprisingly, the most effective condition that removed suspended particulate matter was the generation of negative ions. Finally, a compact personal dust detector was designed and built, and demonstrated to detect dust levels. This methodology may be useful for detecting harmful atmospheric dust at low cost to improve health and prevent damage to machinery.

### **Improved Efficiency of Seawater Steam Generation Using Carbon Nanoparticles**

*Carolyn K. Jons*

*Eden Prairie High School, Eden Prairie, MN, North Central (Minnesota, N. & S. Dakota) JSHS;*

*Teacher/Mentor/Sponsor: Dr. Christopher Hogan, University of Minnesota*

Water scarcity is a world problem. Although essential for life, almost one billion people lack safe drinking water. Rice University's scientists recently discovered focused sun light shone on nanoparticles, in pure water, generates steam without substantially raising the surrounding water temperature. My research aims to determine if nanoparticles can be used to generate steam, with similar efficiency, from seawater. Prior to testing, a high intensity, focused light source and testing apparatus were constructed, artificial seawater solutions were made, and carbon nanoparticles were dispersed. Preliminary studies demonstrated nanoparticles were necessary for efficient steam generation. This study particularly focused on comparing energy efficiencies of steam generation for pure water, 3.5% NaCl, and 3.5% seawater, where "energy efficiency" is the fraction of energy vaporizing water compared to energy heating the bulk fluid. At 95% confidence, a two-tailed t-test demonstrated statistically greater steam generation efficiency for water containing NaCl or seawater, as compared to pure water. The steam generation efficiencies for seawater and salt water (NaCl) were not statistically different at 95% confidence. Later extensions found top-surface illumination achieved substantially (3X) greater steam generation efficiency than bulk solution illumination. An application of this research includes water purification in sun rich, water poor regions.

## **Biofeedback Controller: Virtual Training for Myoelectric Transradial Prosthesis**

*Matthew T. Lerdahl*

*Coon Rapids High School, Coon Rapids, MN, North Central (Minnesota, N. & S. Dakota) JSHS;  
Teacher/Mentor/Sponsor: Gary Alexander, Coon Rapids High School*

Robotic Prosthetics of the modern day often utilize myoelectric control. Myoelectric control uses electromyography, a system of detecting and quantifying the electrical activity of contracting muscles as a way to actuate dexterous movement. The electrical signal quantified by EMG sensors can be trained and strengthened by repeated contraction. Using the extensor and flexor muscle groups as isolated myoelectric sites, I created a device that incorporates modern gaming to increase the electric threshold of muscles commonly used for myoelectric control. With collaborative efforts from both Advanced Arm Dynamics and Advancer Technologies, the system created makes use of Advancer Technologies' v3 EMG sensor and employs a sensor orientation that is capable of training four muscle groups at once. Using the Arduino Uno and the corresponding software as a microcontroller, an interface was created that allows the user to play multiple scrolling games such as Mario using only muscle contractions as controls. The current developed prototype would cost the user under two hundred dollars while current training devices range from upper hundreds to thousands of dollars. This device is capable of increasing the electromyogram signal exponentially and therefore allows clinical prosthetists to obtain more information from the patient's muscles.

## **Hand Hygiene Gone Viral? A Study of Student Involvement in a Social Media Campaign as a Method of Bringing Hand Hygiene to the Masses**

*Timothy J. Renier*

*Duluth East High School, Duluth, MN, North Central (Minnesota, N. & S. Dakota) JSHS;  
Teacher/Mentor/Sponsor: Robin Churchill, Holy Rosary School; Dr. James Boulger Ph.D, University of Minnesota Medical School Duluth*

**Aim:** This study aimed to promote hand hygiene behavior throughout a high school population through student development and sharing of a social media campaign (SMC) (Facebook and Twitter). **Methods:** 114 consented high school students participated in an intervention (INT), receiving education and creating a SMC. 308 control students (CON) were surveyed. Assessments included anonymous surveys about hand hygiene behavior, social media, and SMC reception for INT (weeks 1 (baseline), 7, and 12 (follow-up)) and CON (baseline and follow-up). School-wide, lunchroom hand sanitizer use (LHS) was covertly observed (baseline, 7, follow-up) and illness-related absenteeism change was compared with a control high school. Facebook Insights measured viewership. **Results:** INT had significant improvement ( $p < 0.05$ ) in hand washing before eating (Linear Regression), knowledge of hand washing time, and desire to improve hand hygiene behavior (Logistic Regression). 30% of CON viewed the SMC. CON who viewed the SMC improved hand washing at school more than CON who did not, with INT reporting greater improvement than CON. Significant pre-post SMC improvement in LHS occurred school-wide (t-test). The Facebook campaign was viewed 13,292 times, reaching 2806 people. **Conclusion:** The SMC significantly impacted student hand hygiene and may effectively communicate with and change health behaviors among adolescents.

## **Creating a Cavity-Dumped Helium Neon Laser**

*Kevin Zheng*

*Wayzata High School, Plymouth, MN, North Central (Minnesota, N. & S. Dakota) JSHS;  
Teacher/Mentor/Sponsor: Martin Cohen, Stony Brook University; John Noé, Stony Brook University*

An acousto-optic modulator is used to quickly extract circulating optical power from a home-built 1.4m open-cavity helium neon laser. 100 ns pulses with a maximum peak power of approximately 2 mW are extracted from the laser cavity at a repetition rate of 100 kHz. Repetition rates of over 1MHz are attained with decreased peak power. A theoretical model for the shape of the extracted pulses is presented. The unique home-built and adjustable nature of the laser suggests its pedagogical potential for introductory laser science students at the undergraduate or graduate level. The author would like to acknowledge Sam Goldwasser for providing key equipment. This work was supported by the Laser Teaching Center at Stony Brook University and the Simons Foundation.



## **Northern New England (Maine, New Hampshire, Vermont)**

---

### **Nanofibrous Collagen Scaffold Production via Ice Templating**

*Evan T. Brewer*

*Bangor High School, Bangor, ME, Northern New England (Maine, New Hampshire, Vermont) JSHS;  
Teacher/Mentor/Sponsor: Mr. Cary James, Bangor High School*

Type I collagen is an extra cellular matrix structural protein found in a variety of tissues. Biomedical collagen scaffolds have been formed in vitro via freezing techniques for tissue regeneration. Current methods of creating collagen scaffolds produce a porous monolithic morphology, but no method of producing nanofibrous collagen scaffolds exists. The aim of the present work is to adapt one such technique, previously utilized to generate nanofiber matrices of water soluble polymers, and employ it to produce similarly structured collagen scaffolds. The rapid freezing method directs a stream of solution containing the target material onto a rotating metal drum cooled with liquid nitrogen. As the solution contacts the drum, a continuous frozen ribbon of material is formed; the ribbon is subsequently freeze dried. The rapid freezing of the aqueous solution creates dendritic ice crystals with nanoscale dimensions, and phase separates the dissolved polymer around them, thereby creating nanofibers of polymer. Collagen is water insoluble at ambient pH and as such must be solubilized in order to be employed in the rapid freezing technique. Acetic acid is a known pH modifier, and as such has the potential to aid in collagen dissolution at decreased pH. Additionally, acetic acid is volatile and would be removed in the freeze drying processing step-leaving a pure collagen scaffold. The present work has proven the feasibility of dissolving collagen in acetic acid modified aqueous solutions, and employing the resulting solution for collagen nanofiber formation via rapid freezing.

### **Novel Silver Doped Photocatalytic Composites for Inactivation of Bacteria in Wastewater**

*Deepika S. Kurup*

*Nashua High School South, Nashua, NH, Northern New England (Maine, New Hampshire, Vermont) JSHS;  
Teacher/Mentor/Sponsor: Linda Polewarczyk, Nashua High School South; Ramaswamy Nagarajan, University of Massachusetts Lowell*

Due to the increasing scarcity of fresh water resources, wastewater treatment for reuse is gaining considerable attention. The goal of this research was to develop a safe, cost-effective, and eco-friendly method to harness ultraviolet (UV) radiation and visible light from the sun for wastewater remediation. Simple methodologies were developed to synthesize robust and lightweight TiO<sub>2</sub>-ZnO and Ag-TiO<sub>2</sub>-ZnO photocatalytic composites using titanium dioxide (TiO<sub>2</sub>), zinc oxide (ZnO), silver nitrate (AgNO<sub>3</sub>), hollow glass microspheres, and a hydraulic cementing binder. The composites were tested to evaluate bacterial inactivation in wastewater under different light exposure conditions (sunlight, visible light, and dark). The bacterial inactivation by the TiO<sub>2</sub>-ZnO photocatalytic composite was primarily due to UV-A activated photocatalysis, as shown by its efficacy in destroying bacteria when exposed to sunlight. On the other hand, the Ag-TiO<sub>2</sub>-ZnO photocatalytic composite exhibited bactericidal properties in sunlight, visible light, and in the dark. The rate of bacterial inactivation was greatest when exposed to sunlight, followed by visible light and finally in the dark. This project opens numerous possibilities for sustainable, economically viable, and effective water purification that requires minimal resources.

## **Water Conservation and Climate Change in Northern Peru**

*Andrew D. Sandweiss*

*Bangor High School, Bangor, ME, Northern New England (Maine, New Hampshire, Vermont) JSHS;*

*Teacher/Mentor/Sponsor: Mr. Cary James, Bangor High School; Professor Shaleen Jain, University of Maine*

El Niño (ENSO) has long been a concern for farmers in the extreme desert of northern coastal Peru. Climate change is predicted to increase ENSO frequency and associated floods, and to melt Andean glaciers, causing a 40% reduction in average annual streamflow in this region. ENSO could help mitigate flood damage to irrigation systems via construction of microdams to retain and distribute ENSO's rainfall for agriculture and to provide relief from permanent loss of streamflow due to glacial melting. Looking at ENSO's effects on streamflow (data from UCLA and Peru's National Water Authority), precipitation (data from the World Meteorological Association), and crop production (data from Peru's Ministry of Agriculture) in this Environmental Science project I used MATLAB and Excel to create a model that calculates potential damage from increased ENSO frequency. A newly identified type of El Niño, El Niño Modoki (EMI), is becoming more frequent. EMI raises Sea Surface Temperatures (SST's) in the Central Pacific Ocean, rather than the Eastern Pacific, where normal ENSOs raise SST's. I concluded that ENSO increases streamflow and precipitation while decreasing crop production, but that EMI causes a significantly lower streamflow than normal years, increasing the need for water conservation via the proposed microdams.

## **Design of an Apparatus for the Efficient Radiation of Light within a Specified Wavelength Range**

*Keenan G. Wood*

*Berlin High School, Berlin, NH, Northern New England (Maine, New Hampshire, Vermont) JSHS;*

*Teacher/Mentor/Sponsor: Mr. Kevin Carpenter, Berlin High School*

The goal of this engineering project was to design, build, and test an apparatus that could efficiently emit electromagnetic radiation of wavelengths within a specified range. The light source was designed to be an iron cylinder, repelled above and away from the walls of its cylindrical chamber via electric forces. The theory was developed for the conversion of power from a surrounding solenoid at its resonant frequency to the filament through eddy current and hysteresis losses, and methods of chamber charging and rarefaction were considered. Finally, using the critical angles and chromatic aberrations of various dielectric materials (in this case glasses), a bulb geometry was designed to reflect all radiation not in the desired wavelength range back to the filament, and to emit all radiation of the desired wavelengths at a power equal to the rate of energy transferred to the filament from the solenoid. A shortage of time and resources prevented the construction and empirical evaluation of the apparatus, thereby making the production of a prototype the next step in research.

## **Developing a Sustainable Water Cleaning System for use in Rural Areas of Low Income Countries**

*Bluyé DeMessie*

*William Mason High School, Mason, OH, Ohio JSHS;*

*Teacher/Mentor/Sponsor: Dr. George Sorial, University of Cincinnati*

Adsorption of heavy metal ions from polluted water was studied using dried powdered banana peels and pyrolyzed banana peels (PBP). Tests included equilibrium adsorption, kinetics of adsorption, and column studies. The results were compared with adsorption using commercial activated carbon. The morphology, physical, and chemical properties of the adsorbents were characterized using thermo-gravimetric analysis, Fourier transfer infrared spectroscopy, pH electrophoresis, surface area analysis, scanning electron microscopic imaging, and X-ray diffraction analysis. PBP is a porous, large surface area adsorbent ( $50 - 60 \text{ m}^2/\text{g}$ ), with negative surface charges resulting in increased adsorption capacity. The adsorption capacity of Cu(II) and Pb(II) ions were 347.78 and 180.92 mg/g for PBP, and 28.24 and 3.22 mg/g for clay. The equilibrium adsorption data was modeled with the Freundlich and Langmuir isotherms. Adsorption kinetics followed pseudo-second order model. Fixed bed column studies were conducted to determine the flow effects and breakthrough points for different Cu(II) and Pb(II) concentrations in the feed. The Thomas model was employed to determine the influence of process parameters on adsorption rate and adsorption capacity. Ion exchange and electrostatic complexation of metal ions with PBP were proposed as possible adsorption mechanisms. The effectiveness of sand-clay-PBP in reducing total suspended solids was also tested.

## **Human Glioblastoma Cells**

*Shaleen Goel*

*Sylvania Southview High School, Toledo, OH, Ohio JSHS;*

*Teacher/Mentor/Sponsor: Mrs. Blythe Tipping, Sylvania Southview High School*

Effects of Alkylation and Poly-ADP Ribose Polymerase (PARP) Inhibition on the Survivability of Glioblastoma patients have less than a 3% five year survival rate. Current treatments include using alkylation through temozolomide (TMZ), to which the cancer eventually becomes resistant. The alkylation initially kills cancerous cells because it initiates mismatch repair (MMR), causing apoptosis. It does not kill human cells because they have MGMT, which repairs the alkylation. Glioblastoma cells become resistant is by "losing" MMR, and thus not having apoptosis following alkylations. PARP is a protein integral to the DNA repair pathway of base excision repair (BER). BER is a repair pathway which also repairs DNA alkylations. The purpose was to find out if a synthetic lethal approach using alkylation and PARP inhibition will kill glioblastoma cells both short and long term. The rationale was due to the extreme volume of mutations in the TMZ resistant glioblastoma. The results showed that the synthetic lethal approach worked to cause cell death in TMZ resistant glioblastoma cells both short and long term. There was only a 0.5% cell survival for the synthetic lethal approach, over five times less than using an alkylating agent. Theoretically, this provides a new approach to treat glioblastoma tumors in patients, but future studies are required to extrapolate the results.

## **An Investigation of Electrowetting for Variable Focus Liquid Lenses**

*Aditya Jog*

*William Mason High School, Mason, OH, Ohio JSHS;*

*Teacher/Mentor/Sponsor: Karen Young, William Mason High School*

The feasibility of electrowetting for creating variable focus liquid lenses was investigated. It was hypothesized that voltage applied to a conductive drop placed on a dielectric substrate would experience change in shape sufficient to cover the range of focal lengths typically required for vision correction. To test the hypothesis, a small droplet (diameter less than capillary length) was placed on a glass substrate consisting of an Indium-Tin-Oxide conductive layer with 300-nm-thick Parylene-HT dielectric coating. The droplet was photographed at different applied voltages and the contact angle was determined by image processing. The experiment was repeated with an added surfactant and a water droplet immersed in silicone oil. The change in the radius of curvature of the oil-water interface and corresponding focal length of the liquid lens was calculated. By changing the applied voltage from 0 to 45 V the contact angle changed from 65 to 48 degrees for water, 35 to 22 degrees with the surfactant, and 109 to 70 degrees with oil. Based on the contact angle measurements, a 25-mm-diameter water-oil lens can cover -4.5 to 4.5 diopters with vertical sides. This range can be expanded to -6.5 to 6.5 diopters by changing side angles by +/- 20 degrees.

## **The Synthesis Of 6-deoxy Gulal Derivatives for the Stereoselective Synthesis of S-Linked Digitoxin**

*Ragavi Lanka*

*Sylvania Southview High School, Sylvania, OH, Ohio JSHS*

Heart diseases are the leading cause of death in the United States of America; however, the number of cases has declined significantly due to pharmacological advancements in the study of cardiac glycosides, therapeutic agents derived from naturally occurring materials. The most commonly used cardiac glycoside is digitoxin, which is utilized to treat cardiac arrhythmia. Despite its usage as a treatment, digitoxin has various negative side effects that have led to renal kidney failure. In order to remove these symptoms, digitoxin has been formed through the synthesis of analogs, synthetic molecules; however, most of these analogs continue to have a detrimental effect on certain human cell lines. It was, therefore, hypothesized that S-Linked digitoxin, an analogue of digitoxin, can be prepared by glycosylating a simple thiol acceptor with 6-deoxy gulal donor through the catalysis of metals such as Tin to form thioglycosidic linkage. The formation of gulal occurred through a seven-step reaction using galactose pentaacetate as the starting material, and three trials were completed, resulting with 92 percent yield. This process included various reaction methods such as reduction, thioglycosylation, deacetylation, and Ferrier rearrangement. Thus, this implies that 6-deoxy gulal can be used to form the thioglycosidic linkages in S-linked digitoxin.

## **Novel Automated Next-Generation Multijunction Quantum Dot Solar Panel Designs Using Monte Carlo-Based Modeling**

*Valerie S. Ding*

*Catlin Gabel School, Portland, OR, Oregon JSHS;*

*Teacher/Mentor/Sponsor: Dr. Veronica Ledoux, Catlin Gabel School*

Multijunction quantum dot solar cells (MJQDSCs), especially those using lead sulfide (PbS), are rapidly gaining attention as a potential economical, highly-efficient solution for solar power, due to their ability to utilize same materials with bandgap tuning. However, work is primarily at the feasibility stage, as little theoretical or experimental work has been done to understand exactly how to design efficient systems. This work aimed to address this gap by systematically investigating interactions between quantum dots and photons in MJQDSCs and identifying fundamental limits of solar cell efficiency, utilizing computational quantum physics to design maximum-efficiency solar-harnessing technology. Automatically searching through PbS quantum dots ranging from 1 to 5 nm in diameter corresponding to ultraviolet through infrared regions of the solar spectrum, novel algorithms were programmed in JAVA to conduct stochastic Monte Carlo simulations to simulate 10 million incoming solar photons and sort through a grid of all possible quantum dot stacks combinations in 1 through 9-stack MJQDSC designs. Highest-efficiency configurations were identified for 1 through 9-stack MJQDSCs. The results of the investigation indicated that efficiency can be increased up to 2.23 times maximum 33.7% conventional single-junction silicon solar cell efficiency, to 75.0% in the best 9-stack MJQDSCs design.

## **Hybridized Characteristic 3 Galois Field Arithmetic for Elliptic Curve Cryptography**

*Vinay S. Iyengar*

*Oregon Episcopal School, Portland, OR, Oregon JSHS;*

*Teacher/Mentor/Sponsor: Dr. Bevin Daglen, Oregon Episcopal School*

Hybridized Characteristic 3 Galois Field Arithmetic for Elliptic Curve Cryptography Vinay S. Iyengar Oregon Episcopal School, Portland, Oregon Sponsor: Dr. Bevin Daglen, Oregon Episcopal School Given a rapid rise in cyber security threats for Internet users, corporations, and governments, there is a dire need for safer cryptographic algorithms. Galois fields are mathematical groups that form the basis of today's cutting-edge public-key cryptography algorithms. The purpose of this 3rd year capstone project was to create a highly efficient and scalable characteristic 3 Galois field arithmetic algorithm for high-security elliptic curve cryptography applications. By using a novel combination of logarithm table and conventional arithmetic algorithms within Galois extension fields, a new algorithm was developed. When evaluated based on theoretical, computational, and statistical analyses, this algorithm proved to be more efficient than the best algorithms previously presented in literature in terms of pre-computation time and operation speed. This hybridized algorithm specifically increased the speed of elliptic curve scalar multiplication by factors of 7 to 26 while cutting pre-computation costs to just around a millisecond. Furthermore, this algorithm showed a distinct applicability to creating very high-level security elliptic curve cryptosystems and therefore has major implications for the field of cryptography.

## **Capacity Limits of Working Memory: The Impact of Multitasking on Cognitive Control and Emotion Recognition in the Adolescent Mind**

*Alexandra Ulmer and Sarayu Caulfield*

*Oregon Episcopal School, Portland, OR, Oregon JSHS*

Media multitasking is increasingly prevalent in our society, especially among the young. Processing multiple information streams simultaneously, however, challenges cognitive function and may reduce performance. Working memory is the brain function responsible for prioritizing tasks and limiting distraction. This study examined the effects of multitasking on the performance of working memory. 403 participants were randomly assigned to either a multitasking or non-multitasking room; both groups completed a Media Multitasking Index used to identify groups of High and Low Media Multitaskers, tests to assess the ability to juggle tasks and focus (AX-CPT) and to assess emotion recognition (DANVA2). Participants in the multitasking room completed these studies simultaneously with additional cognitive tasks. The results suggest that the pattern of media use is reflected in the performance of the individual's ability to switch between tasks and filter irrelevant information. High Media Multitaskers were better able to filter out distracting irrelevant tasks ( $p = 0.014$ ), but surprisingly performed worse when they were not pursuing multiple tasks. They were better at multitasking, but performed worse when made to focus. Low Media Multitaskers were less able to filter out interference from distracting tasks, but were best able to focus on single tasks ( $p < 0.0001$ ).

## Use of LED Lights as Photovoltaics

*Glen S. Gallik*

*Lewisburg Area High School, Lewisburg, PA, Pennsylvania JSHS*

*Teacher/Mentor/Sponsor: Wayne Latchford, Lewisburg Area High School*

Renewable energy is taking an increasingly important role in the energy grid. Solar energy is currently one of the most promising and widely used renewable energy sources. My research focused on the photovoltaic properties of common LED lights and their potential to be used to produce energy. My research focused on the potential for LED lights to generate power at usable, storable, levels. I conducted tests on an array of 150 LED lights that were attached to a rechargeable battery I could monitor. I found that the LED light array was capable of generating both amperage and voltage, and that this energy could be easily stored in batteries. The data clearly showed potential for LED lights to be used.

## The Effects of Caffeine on the Aggregation of Dictyostelium discoideum

*Hoang Anh T. Phan*

*Wyoming Seminary, Kingston, PA, Pennsylvania JSHS;*

*Teacher/Mentor/Sponsor: Dr. Andrea Nerozzi, Wyoming Seminary; Ms. Renee Casterline, Wyoming Seminary*

Dictyostelium discoideum is a cellular slime mold that can aggregate under special conditions such as starvation. In this experiment, the effect of caffeine on the aggregation of Dictyostelium discoideum was examined. The hypothesis is that the higher the concentration of caffeine, the greater the number of aggregates and smaller the size of the particles. Cultures were maintained at four different concentrations (0mM, 1mM, 3mM, 5mM) caffeine. A digital microscope and Motic Images Plus 2.0 software was used to collect data. A T-test: Two-Sample Assuming Equal Variances was performed between 6 possible pairs out of the 4 different concentrations. The T-test indicated a significant difference between the number of aggregates in all pairs ( $|t| > |2.1009|$ ), except for the 1mM - 3mM caffeine ( $t = |1.3606| < |2.1009|$ ). An ANOVA: Single Factor test indicated a significant difference in aggregate sizes at different caffeine concentrations (ANOVA  $p = 0.000329 < \text{Alpha}: 0.05$ ). These effects were likely the results of variation in cAMP, the most important signals individual amoeba sends out, which interferes with the activation of adenyl cyclase and with phosphodiesterase level. These results show that as the concentration increases from 0mM to 1mM, the number of aggregates increases. The number of aggregates is about the same in 1mM and 3mM of caffeine but if the concentration of caffeine goes up to high (5mM), little or no aggregation happens. Also, as the concentration increases, the area of aggregation decreases.

## Nano-Formulated Quercetin: A Novel Therapy for Neuroblastoma by the Re-expression of RIZ1

*Priyanga Selvakumar*

*Marple Newtown High School, Newtown Square, PA, Pennsylvania JSHS;*

*Teacher/Mentor/Sponsor: Dr. Ashakumary Lakshmikuttyamma, Thomas Jefferson University; Mrs. Elizabeth Landes, Marple Newtown High School*

Neuroblastoma is an aggressive pediatric cancer with a survival rate of less than 50%. Current drugs cause adverse side effects which greatly affect the developmental milestones in children. Therefore, a new therapeutic drug is needed to treat neuroblastoma effectively and reduce a patient's side effects. RIZ1, a tumor suppressor gene, is silenced in the aggressive forms of neuroblastoma due to promoter methylation. Quercetin, a natural flavonoid, re-expressed RIZ1 and inhibited the growth of neuroblastoma cells. Studies identified that Quercetin dose dependently inhibited the DNMT enzyme. This is the first report indicating Quercetin's ability to act as a DNMT inhibitor. Further, Quercetin was successfully encapsulated into a chitosan nanoparticle (Quercetin-CNP) which resulted in a size of 152 nm and an action potential of 43 mV. The Quercetin-CNP is more effective than Quercetin alone in decreasing the cell survival of neuroblastoma cells. Nano-formulation of Quercetin has a great potential to develop into a drug as mono- or in combination therapy with other chemotherapeutic drugs for the future treatment of neuroblastoma.

## **Investigation of Aquatic Plants & Bacterial Solutions as Efficient Bio-filters to Remove Ammonia from Water**

*David R. Shipe*

*Freeport Area Senior High School, Sarver, PA, Pennsylvania JSHS;*

*Teacher/Mentor/Sponsor: Donald Orlowski, Freeport Area Junior High School*

Purpose: The objective of this study was to determine the most efficient combination of aquatic plants and commercially available bacterial solutions to create a bio-filter to remove ammonia and its byproducts from water. Methods: 9 containers were filled with spring water and a 1 ppm solution of ammonia (NH<sub>4</sub>OH). Two types of plants, water lettuce and water hyacinth, and two bacterial solutions, Nite Out II and FritzZyme 7, were used to create four combinations of bio-filters. Water samples were tested for pH, ammonia, nitrite, and nitrate daily for 8 days. Results: The pH remained stable at 7.0-7.4. Based on progression of ammonia removal the bacterial solution Nite-Out II was more effective than the FritzZyme 7, and the water lettuce was more effective than the water hyacinth. Concentrations of nitrate and nitrite were negligible throughout the study. Conclusions: Both bacterial solutions and aquatic plants reduced ammonia in water at a concentration of 1 ppm. If scaled appropriately both aquatic plants and bacterial solutions could be used commercially to remove ammonia from water.

## **The Effect of Varying Light Frequencies on Plant Growth**

*Spencer Yacuboski*

*Berwick Area Senior High School, Berwick, PA, Pennsylvania JSHS;*

*Teacher/Mentor/Sponsor: Stephanie Rothery, Berwick Area Senior High School*

My experiment tested how differing light frequencies affected plant growth. During the light-dependent reaction of photosynthesis, plants absorb light energy to aid in the production of glucose, the molecule broken down for cellular energy. My hypothesis stated that the control (white) group of plants would grow the fastest, and the green group would grow the slowest. The original hypothesis was supported.



## **Earthquake Probability Based on the Position of the Moon**

*Angelic Arzola*

*CROEM, Mayaguez, PR, Puerto Rico JSHS;*

*Teacher/Mentor/Sponsor: Elba Sepúlveda; Gilberto Jimenez*

This research aims to find if earthquakes are influenced by the gravitational pull of the Moon, and how to calculate the probabilities of it to occur considering the effect the Moon has on the Earth. This research studied whether the position of the moon could be of influence in the eruption of these earthquakes. Earthquakes from 2010 to 2013, most with a magnitude of 8.0 ML or more, and smaller earthquakes that happened before and after, were selected. Their magnitudes were related to the phase of the Moon, the location of the Moon at the time of the earthquake. It required to consider how closer to perigee or apogee it was and the location of the earthquake at the time it happened. The results were laid down on a graph, where the relations could be seen. The expected results would then show an increase and/or decrease in earthquakes, related to the position of the Moon. After this, a conclusion and a possible, more accurate relation between the Moon and the effect it has on earthquakes are to be drawn.

## **Potential of Macroalgae for the Removal of Aluminium ion and Organic Pollutants from Natural Waters**

*Hennessy Bas*

*Pa' los Duros, Carolina, PR, Puerto Rico JSHS;*

*Teacher/Mentor/Sponsor: Yiria Muñiz; Dr. Liz M. Díaz*

Previous studies showed that the immobilized algae *Glacilaria* and *Sargassum* absorbs a percentage of the emergent semi-volatile pollutants found in the Puerto Nuevo River. This study aims to absorb a percentage of Aluminum, thought to be one of the causes of Alzheimer; found in the Rio Grande River, Carraizo Reservoir, Pithaya River and Maunabo River in Puerto Rico, through the algae. To carry out this research we used the algae: *Glacilaria* and *Sargassum*; these are not laboratory algae. Then it was proceeded to the identification of the aluminum in water samples and the immobilization of the algae with silica, for later to precede with the absorption of the aluminum, both as the aluminum substance and the river water samples. Finally the detection of aluminum in the samples was realized by a colorimetric method EDTA Complexometric. The algae which absorbed most the aluminum present in the solution was *Glacilaria*, but it did not differed by much from *Sargassum*. The algae absorbed 67 and 64 % of the aluminum present in the solution.

## **The behavioral changes in *Apis mellifera* when infected with *Nosema* spores**

*Waldemar Ortiz, III*

*Jose E. Aponte HS, Carolina, PR, Puerto Rico JSHS;*

*Teacher/Mentor/Sponsor: Yiria Muñiz; Dr. Zachery Huang*

The goal of this research is to identify the behavioral differences caused by *Nosema* infected bees to aid the recovery of declining honey bee populations worldwide. The *Nosema* parasite was recently discovered and its effects on the European honeybee (*Apis mellifera*) population are still unknown. We began testing with the two main *Nosema* parasites which were *Nosema apis* and *Nosema ceranae*. My hypothesis is that the *Apis mellifera* would have the capacity adapt to the parasite's presence and prefer other temperatures to reduce or suppress the effects on the honey bee. We began the experimentation process by creating a canal/apparatus that would have the capability to create a temperature gradient to observe the different temperature preferences that would be caused by the bee. The bees used in the experiment are one that have recently emerged from the brood. We then starve the bees for a period of 24 hours, divide the bees in 3 groups and infect 2 of them feeding them a certain quantity of *Nosema* spores and place them in an incubator. We then begin a the 6 day process of placing the bees in the temperature gradient canal and record their positions after a 15 minute acclimation period.

## **The effect of the runoff water in the population of Pyrodinium bahamense**

*Kenaly Ortiz*

*Colegio de Nuestra Señora del Perpetuo Socorro, Humacao, PR, Puerto Rico JSHS;*

*Teacher/Mentor/Sponsor: Lizbeth Delgado; Adolfo Rodriguez*

In Puerto Rico 's bioluminescent lagoons has been affected by the decline in populations of Pyrodinium bahamensis. This research will explore the effect of water runoff on populations of Pyrodinium bahamensis ( dinoflagellates ) . During the years 2012-13 in the Cabezas de San Juan in Fajardo , Puerto Mosquito in Vieques a visual inspection of the area was performed in order to identify possible channels formed by rain. In addition a qualitative analysis of pH were conducted including quality analysis. These yielded a higher concentration of nitrate, phosphate and sulfate , common in detergents , insecticides and pesticides. Thirty milliliters of water were filtered each sample to be analyzed under an electron microscope . During the current year (2014 ) the same procedure was conducted in La Parguera in Lajas in order to make comparisons between the three water bodies. It was found that samples collected on rainy days contained fewer organisms and possessed injury . The three samples with the highest number of damaged specimens became analyzed under a laser microscope . Changes in the covering of the organisms are described. Osmotic consideration related to population decline are discussed.

## **Synthesis Of Pd & Ni Catalytic Particles To Improve The Performance Of An Alkaline Media Fuel Cell**

*Jancel Taveras*

*University Gardens HS, San Juan, PR, Puerto Rico JSHS;*

*Teacher/Mentor/Sponsor: Pablo J. Hernandez*

Over the past years, fuel cells have emerged as a method of renewable energy. This research is about the synthesis of nano-particles catalysts of Palladium and Nickel to improve the performance of an alkaline media fuel cell. Several dyes were synthesized: Pt and Pd, PdNi (75:25), PdNi (50:50) (100); each was reduced using NaBH<sub>4</sub>. These dyes were then painted in a FAA-3 membrane and were prepared for tests in fuel cells. The catalysts were synthesized effectively. They were analyzed in the SEM, showing that the particles were of large size with an approximate difference of 6000-27000nm compared to Pt. Performance tests were conducted in a cell station and used hydrogen as fuel. Results in production of current were much lower compared to Pt and it was highly unlikely to work better with ammonia, possible fuel to be used. Pd (100) obtained 0-0.5 (mA/cm<sup>2</sup>), PdNi (75:25) 0-0.4 (mA/cm<sup>2</sup>) and PdNi (50:50) 3-6 (mA/cm<sup>2</sup>) current densities. Compared with commercial Pt, which is of 200-250 (mA/cm<sup>2</sup>) current densities, the performance of the cell is not enhanced which states that the hypothesis is rejected.

### **The effect of a n-type TiO<sub>2</sub> photocathode with a wide band gap on a *Shewanella oneidensis* MR-1 microbial fuel cell**

*Krishna T. Gorrepati*

*Spring Valley Highschool, Columbia, SC, South Carolina JSHS;*

*Teacher/Mentor/Sponsor: Dale Soblo, Spring Valley Highschool*

Microbial fuel cells (MFCs) show promise as a renewable energy source that can generate electricity through microbes. The purpose of this study was to compare n-type TiO<sub>2</sub> with 3.2-3.35 eV band gap cathodic electrodes with graphite cathodic electrodes in a MFC. It was hypothesized that the TiO<sub>2</sub> electrodes would increase voltage output due to photoirradiation. Twenty trials and fourteen trials were conducted for the graphite electrodes (Control MFC) and the TiO<sub>2</sub> electrodes (TiO<sub>2</sub> MFCs) respectively. In each trial, the voltage output was collected every minute for five days. Once the bacterium had stabilized, the mean for each trial was calculated. Using a two-sample t-Test with the means, the results showed that Control and TiO<sub>2</sub> MFCs were from the same population:  $t(32)=1.69$ ,  $p > .05$ . However, without the outliers, the results indicated that the two populations were significantly different:  $t(30)=1.70$ ,  $p < .05$ . The TiO<sub>2</sub> MFCs also had greater Q1, median, and Q3 values with and without outliers. Moreover, TiO<sub>2</sub> MFCs had a 10.3% increase in voltage outputs. This further supported that TiO<sub>2</sub> MFCs produced greater voltage outputs than the control MFCs. As the power density of MFCs continue to increase, they will continue to become a more reliable form of green energy.

### **The Influence of Social Networking on Teenage Decision-Making**

*Bushra B. Islam*

*Spring Valley High School, Columbia, SC, South Carolina JSHS;*

*Teacher/Mentor/Sponsor: Michelle Wyatt, Spring Valley High School; Michelle Spigner, Spring Valley High School*

As the usage of social networking websites increases dramatically, it is important to analyze the effects of social media. This experiment's purpose was to determine the influence of social networking websites, namely, Facebook and Twitter, on teenage decision-making regarding blood donation. It was hypothesized that teenage students exposed to Facebook/Twitter posts supporting blood donation would be more likely to donate blood. Participants completed a survey about their social networking usage and their opinions regarding the Internet's influence. They also provided their Twitter/Facebook usernames, although they were not informed about how this information would be utilized; the researcher utilized this information by "following" students on Twitter/"friending" them on Facebook. After participants were randomly placed into the experimental group, whose participants were exposed to posts that supported the blood drive, or the control group, whose participants were blocked from seeing such posts, social networking activity was monitored for one month. At the blood drive, the number of students from both groups who volunteered to donate blood was compared. Students were debriefed and informed that their Twitter/Facebook usernames were utilized to allow experimental-group students to see posts about the blood drive and block control-group students from seeing them. A Chi-squared test for independence was conducted at a confidence level of  $\alpha=0.05$ ,  $\chi^2(2, N=50)=9.93$ , and  $p<0.001$ ; a participant's decision to donate blood was dependent upon group placement, as hypothesized. Participants exposed to encouraging posts about the blood drive were more likely to succumb to social networking influence and choose to donate blood.

## **Effects of Azadiractin, from the Neem Tree, on Colonization and Mortality of the Sweet Potato Whitefly Biotype B on Collard**

*Dana Krzyzaniak*

*Academic Magnet, North Charleston, SC, South Carolina JSHS;*

*Teacher/Mentor/Sponsor: Merle Shepard, Clemson Extension; Alvin Simmons, USDA; Katy Metzner-Roop, Academic Magnet*

A study was conducted to determine the effects of foliar sprays of 1.25% Azadiractin on colonization and development by the B-biotype sweetpotato whitefly (*Bemisia tabaci*) on collards. Caged choice, caged no-choice, and y-tube olfactometer assays were conducted on oviposition, survival and adult behavior in response to azadiractin. Data was analyzed using a t-test ( $p = 0.05$ ). In the caged choice study, whiteflies most often chose to colonize and lay eggs on control plants. Decreased numbers of whiteflies were able to continue development in the treatment groups of the caged no choice studies, as compared to the control. Y-tube olfactometer tests indicated that azadiractin has a repellency effect on whiteflies. The findings may be useful in providing a more ecologically sound way to manage populations of the sweetpotato whitefly.

## **Effects of Genetically Engineered Maize and Glyphosate on *Eisenia fetida* Growth and Reproduction**

*Brett Winters*

*Dutch Fork High School, Irmo, SC, South Carolina JSHS;*

*Teacher/Mentor/Sponsor: Ms. Elizabeth McShane, Dutch Fork High School; Ms. Tamara Turner, Dutch Fork High School*

Biotechnology has provided approximately 144 genetically engineered (GE) crops. Because GE foods have only been consumed since 1994, the long-term effects are virtually unknown. Additionally, the increased use of glyphosate herbicide, applied to Roundup Ready® GE crops, may pose health risks upon ingestion. This project tested the growth and reproduction effects of GE maize and glyphosate on *Eisenia fetida*. GE and non-GE maize were grown. Glyphosate was sprayed on half the Roundup Ready® and Bt/Roundup Ready® plants. On days 50 and 183, there was an increased weight in those fed Roundup Ready®, Bt/Roundup Ready®, and glyphosate-sprayed variables and a decreased weight in those fed the Bt modification. On day 183, there was a greater weight increase in populations fed GE maize with glyphosate sprayed compared to those fed non-sprayed GE maize. No differences were noted in mortality or in the number of juveniles hatching from cocoons. A soil analysis on day 106 revealed that all samples contained 38-80% decreased bacterial count compared to the control. This experiment reveals that some varieties of GE maize vegetation and glyphosate may result in weight gain. Results suggest the potential for GE products and glyphosate to contribute to obesity by possibly altering gut flora.

## **Southern New England (Massachusetts, Rhode Island)**

---

### **Change Agent Attribution in the Pacific Northwest using LandTrendr Label Interface, Version 1.1**

*Easton J. Ehlers*

*Manchester Essex Regional High School, Manchester-by-the-Sea, MA, Southern New England (Massachusetts, Rhode Island) JSHS*

Remote sensing is becoming increasingly more important in the environmental sciences because any area can be accessed remotely via satellite. The LandTrendr Label Interface, Version 1.1, rooted in the concept of remote sensing, is aiming to develop an algorithm to detect universal land changes as in fire and or harvesting. The objective is for the interface to become dependent from human attribution, at the moment, this processes is still in progress. The question arises whether which change process is the most prevalent; it is conditionally dependent on Landtrendr's current focus location of the Pacific Northwest.

### **A Novel Bioinformatics System to Aid Researchers in Using Computational Biology to Guide Pharmacological Research for Different Disease Pathogens**

*Katie Hudek*

*Hudek Homeschool, Grafton, MA, Southern New England (Massachusetts, Rhode Island) JSHS;  
Teacher/Mentor/Sponsor: Gail Hudek, Hudek Homeschool*

In this paper, a method for using computational biology to help guide pharmacological research was developed and demonstrated. Additionally, a new bioinformatics system was designed, developed, and demonstrated which automates this overall method to aid researchers in finding new chemical compounds to treat disease. Computational biology is a relatively new field, which utilizes the discipline of bioinformatics. Bioinformatics is the use of computers, software, and mathematical models to process and integrate biological information. Proteins are the main agents of biological function, making them ideal subjects for study of diseased states; protein-protein interaction (PPI) maps, which can be utilized to analyze proteins and their interactions, are useful tools in understanding the molecular basis of disease. The bioinformatics system was written using the Java programming language. It uses natural language processing techniques for user input, and assists the user by automatically searching web-based, publicly available protein databases, creating PPI maps and aiding in their analysis, and searching publicly available drug database information for chemical compounds that target specific proteins of interest. This bioinformatics system automates a process that can be used for any disease pathogen, and was successfully tested and demonstrated using both the HIV-1 and H1N1 viruses.

### **Solving the Protein Structure of the Ultrasensitive Calcium Indicator Protein GCaMP6 and Designing New Calcium Indicators**

*Andrew F. Luo*

*Lexington High School, Lexington, MA; JingJin Ding, National Institute of Biological Sciences, Beijing, Southern New England (Massachusetts, Rhode Island) JSHS*

Calcium is important for numerous physiological processes and its cytoplasmic levels reflect the cellular activity levels. GCaMP is the most popularly used calcium indicator in cell biology and neuroscience. The newly developed GCaMP6 exhibits superior brightness and ultra-sensitivity to calcium at physiological concentrations (Chen et al. Nature, 2013). I worked in a biochemistry laboratory and proposed to determine the protein structure of GCaMP6 (Ding & Luo, et al., SCLS, 2014). I purified and crystalized GCaMP6m and determined the crystal structures of Ca<sup>2+</sup> bound GCaMP6 at the resolution of 2.8 Å. Along with my mentor, I presented detailed structural analyses and revealed the structural basis for the outperformance of GCaMP6. In comparison with its parent version, GCaMP6 has 3 substitution mutations that changes local structure and interaction to enhance Ca<sup>2+</sup> sensitivity and green fluorescence intensity. Specific substitutions in the three versions of GCaMP6 are also structurally consistent with their differential sensitivity and intensity. This study gives us insight on potential strategies for further structure-guided optimization and the design of novel calcium indicators.

## **Engineering Novel Nanoparticles for Drug Delivery to Treat Cryptococcal Infections**

*Vivek Subramaniam*

*Westborough High School, Westborough, MA, Southern New England (Massachusetts, Rhode Island) JSHS;  
Teacher/Mentor/Sponsor: Dr. Miriam Rafailovich, Stony Brook University; Mr. Mathew Desjardins, Westborough High School*

Cryptococcus is a leading cause of fungal meningoencephalitis worldwide, accounting for over half million deaths annually. Glucosylceramide, an important glycosphingolipid present in Cryptococcus, is essential for membrane integrity and pathogenicity. A unique characteristic of these fungi is their production of a negatively charged capsule that allows them to reside unharmed within pulmonary macrophages. Amphotericin B, the leading drug for treating Cryptococcal infections is expensive and nephrotoxic. The objective of this research was to engineer a cost effective, specific and safe drug-delivery mechanism to treat Cryptococcosis. Promising antifungal drug candidate N'-(3-bromo- 4- hydroxybenzylidene)-2-methylbenzo-hydrazide (BHBM) was encapsulated in poly(lactic-co-glycolic acid) (PLGA) nanoparticles to allow dispersion of the hydrophobic drug and for specificity of the nanoparticles. The PLGA nanoparticles were created with the positively charged surfactant chitosan chloride for targeted drug delivery by electrostatic attraction. The drug encapsulation was confirmed by nuclear magnetic resonance. Dynamic light scattering revealed the zeta potential of the particles and transmission electron microscopy revealed their spherical size and shape. The drug-loaded nanoparticles reduced intracellular Cryptococcus in macrophage-like cell line J774A.1 and reduced syncytia formation without affecting macrophage viability over 72 hours compared to drug-free nanoparticles. As future work, drug elution and nanoparticle drug release rates could be studied.

## **Developmental Effects of Correlated Color Temperature of Artificial Lights on Painted Lady Butterflies *Vanessa cardui***

*Simiao You*

*Holyoke Catholic High School, Chicopee, MA, Southern New England (Massachusetts, Rhode Island) JSHS;  
Teacher/Mentor/Sponsor: Mrs. L. LeTellier, Holyoke Catholic High School*

This experiment aimed to determine the effects of artificial night lighting on the life cycle of butterflies. Painted lady butterflies, *Vanessa cardui*, were exposed to various light sources with different correlated color temperature (CCT). Light intensity and temperature were monitored by data collection devices placed in each experimental unit. Butterfly development and life cycle stage length were observed and recorded regularly. The larvae that grew under artificial night light, which had high CCT (5000K and 6500K), were wider and longer than the larvae that grew under low CCT lights (2700K). The butterflies that grew under high CCT light sources pupated and emerged from chrysalides earlier than the ones that were under low CCT lights. This research suggested that artificial night light stimulates the development of the painted lady butterflies. Whether artificial night light induces similar effects in other species of insects remains to be explored, but light induced changes in phenology could have ecosystem wide effects.

### **A Study of the Biodegradation of Dimethyl Benzyl and Didecyl Dimethyl Quaternary Ammonia Compounds by Antibiotic Resistant Bacteria**

*Zheer Ahmed*

*Martin Luther King Magnet School, Nashville, TN, Tennessee JSHS;*

*Teacher/Mentor/Sponsor: Dr. Thomas Byl, US Geological Survey; Dr. Chand Desai, Martin Luther King Magnet School*

Quaternary Ammonia Compounds are commonly used in industrial, domestic, agricultural, and healthcare related fields; consequently, 25% of these compounds are discharged into wastewater and little is known about their environmental fate in ecosystems. Despite this, QACs are vulnerable to the process of biodegradation. The objective of this project was to determine the role of biofilm development on biodegradation rates of QACs (didecyl dimethyl and dimethyl benzyl ammonium chloride). Bacteria resistant to QACs were collected from a decontamination station to test whether biofilm bacteria or free-living non symbiotic bacteria were more efficient at biodegrading QACs. All microcosms received 250 mL of the same solution containing QAC and bacteria and were allowed to equilibrate for 4 weeks to account for sorption and biofilm development. The QAC concentrations were periodically measured (with three replicate samples). The microcosms with high surface area and biofilm development had half-lives of 15 days while the ones without surface area for biofilm development had QAC half-lives of 60 days. Additional experiments indicated that the bacteria were thermophilic, gram negative, and slightly acidophilic.

### **Confirming next generation sequencing (NGS) data on the effects of NAG-1-induced cancer cells**

*Amany Alshibli*

*Farragut High School, Knoxville, TN, Tennessee JSHS;*

*Teacher/Mentor/Sponsor: Dr. Seung J. Baek, University of Tennessee; Mrs. Neely Tonos, Farragut High School*

Non-steroidal anti-inflammatory drug-activated gene (NAG-1) plays a complex role in cancer development as a tumor inhibitor; its mechanism of such activity, however, is unknown. One possible mechanism may be through the regulation of various genes, producing a cascade that may lead to the suppression of tumor growth. This study sought to confirm NGS data which found that NAG-1 regulates the expression of 142 genes in osteosarcoma (U2OS) cells. The data was confirmed through polymerase chain reaction amplification of genes NRP1, HMGB1, ZMAT4, and IGFBP5. The expression of these amplified genes in the NAG-1-induced U2OS and human embryonic kidney (HEK) cells was then compared to similar amplifications in wildtype U2OS and HEK cells by analyzing agarose gel electrophoresis images. The results showed that genes ZMAT4 and HMGB1 are up-regulated in NAG-1-induced U2OS cells, confirming NGS data and suggesting that these genes may inhibit tumor growth. Additionally, NRP1 and IGFBP5 exhibited down-regulation in NAG-1-induced HEK cells, suggesting that they may promote tumor growth. These findings further the investigation of the central causes of NAG-1 tumor suppression, and suggest future study of the aforementioned genes that may play significant roles in carcinogenesis.

## **Effect Of Artemesinin And Aleuropein Compounds In Colorectal Cancer Cell Growth**

*Grace J. Baek*

*Knoxville, TN, Tennessee JSHS*

Effect of artemesinin and oleuropein compounds in colorectal cancer cell growth Natural compounds are a viable, cost-efficient option in cancer treatment compared to potentially harmful existing treatments. Artemesinin and oleuropein have been shown to inhibit tumor growth in various well-known cancers such as breast, liver, and leukemia. Artemesinin, a compound derived from a woody herbaceous plant, *Artemisia Annua*, has been recognized by the World Health Organization in treating malaria. Oleuropein, a compound derived from the olive tree, a plant that is widespread as well as readily available in the Mediterranean climates and food cultures. It has been shown to prevent atherosclerosis. The experiment tested to see artemesinin and oleuropein's effectiveness by dosage in different bovine serum concentrations. HCT-116 (human colorectal tumor) cells were put through a cell proliferation assay to measure cell death by absorbency in two different serum levels. Versus the 10% serum media, the 2% serum media showed to have the most effective environment for the two compounds, oleuropein and artemesinin, in initiating cell death. This innovative research offers a view on the importance of media serum levels and cancer proliferation assays.

## **Prediction of Epileptic Seizures using an Android Application**

*Maria D'Azevedo*

*Oak Ridge High School, Oak Ridge, TN, Tennessee JSHS;*

*Teacher/Mentor/Sponsor: Tammy Carneim, Oak Ridge High School; Dr. Lee Hively, Oak Ridge National Laboratory*

Epilepsy afflicts 50 million people worldwide, and any type of seizure has the potential to be dangerous, especially if the victim is unprepared. Epileptic patients need an easy and convenient way to predict seizure events so that they have sufficient time to prepare. We developed an Android application in order to address this need. The app reads and analyzes electroencephalogram (EEG) data, and then graphs and measures the dissimilarity between baseline and current data. After analysis, the program informs the patient whether a seizure event has been predicted. It accurately predicts whether or not a seizure will occur 58/60, or 45/60, if the precision of the data is halved in order to save memory. The app will benefit patients, doctors, and insurance companies. It can potentially be modified to work on an iPhone™ or on cheaper handheld devices for developing countries, where the vast majority of epileptic patients have no access to treatment.

## **Testing the Bayesian Model of Hypothesis Evaluation**

*Vijaya R. Dasari*

*White Station High School, Memphis, TN, Tennessee JSHS;*

*Teacher/Mentor/Sponsor: Nikki Marinsek, University of California, Santa Barbara; Maridee Cornell, White Station High School*

Bayesian updating is a mathematical theory that describes how individuals update and revise beliefs based on new observations. The aim of this experiment was to 1) determine how well the Bayesian model explains subjects' hypothesis evaluation and 2) identify instances, if any, where subjects deviate from ideal Bayesian behavior. To this end, we used a modified version of the Wisconsin Card Sorting Test in which subjects guessed which stimuli, attribute, or rule, was relevant in a given trial and were given feedback on their guess. Additionally, we used probabilistic feedback to 1) dissociate the receipt of negative feedback and a rule change and 2) simulate the real-world uncertainty of evidence. We found that the Bayesian model accurately describes high-performing subjects' belief updating behavior. We can now use this model in future studies to pinpoint the areas that support hypothesis evaluation and make improvements in delusional patients who do not ideally evaluate their hypotheses.



## **Enhanced Third-Generation Biofuel Production from Genetically Modified Algae**

*Dara W. Li*

*Jasper High School, Plano, TX, Texas JSHS;*

*Teacher/Mentor/Sponsor: Neil Milburn, Plano West Senior High School; Pat Kite, Jasper High School*

Algae are one of the most promising sources of bio-fuels because of their environmental sustainability, and the direct use of algal lipids as fuels. Traditional methods of extracting these lipids, however, prevent algal biofuels from being a commercially viable option. This project introduces a novel technique that cuts costs of biofuel extraction through genetically modifying algae. As opposed to conventional hexane extractions that break the cell wall, thereby killing the algae, gene modifications of acyl-ACP synthetase and thioesterase allow for automatic excretion of lipids. In addition, lipid production itself was also optimized. As hypothesized, cell functions were not inhibited by the transformation; therefore, a single culture of algae is able to continually produce lipids as opposed to re-culturing. In order to maintain high algae cultures for large-scale production, an original raceway system, CACBA, was developed to efficiently culture algae through specifically engineered cultivation conditions. This brought the algae culture on par with the biofuel demand; each culture of algae holds millions of lipid-excreting cells. Emissions tests were conducted on biofuel/fossil fuel mixtures for a vision of a smooth transition from petroleum to biofuels. It was found that as the percentage of biofuel increased, the harmful emissions causing air pollution decreased.

## **Pan-Neuronal Over-Expression of the GCLc Gene to Mitigate Redox Stress and Mitochondrial ETC Complex Dysfunction in Alzheimer's Disease**

*Lisa P. Michaels*

*Plano West Senior High School, Plano, TX, Texas JSHS;*

*Teacher/Mentor/Sponsor: Neil Milburn, Plano West Senior High School*

Effective therapies have eluded Alzheimer's disease for over a century. This multi-phased project investigates potential biomarkers, cellular Glutathione levels and Mitochondrial enzyme activity for the early detection and treatment of Alzheimer's disease. Transgenic *Drosophila melanogaster* with pan-neuronal over-expression of the GCLc gene were created by cross breeding Alzheimer Abeta42 (c155-elav/elavGAL4;UAS-Ab42/cyo) and antioxidant GCLc-GAL4 flies. These Abeta42-GCLc *Drosophila* were subjected to redox stress and their lifespan compared with yellow-white and Abeta42 *Drosophila*. The mitochondrial bioenergetics of the Electron Transport Chain complexes of the *Drosophila* groups was then analyzed at the Genetics Lab using Colorimetric Enzymatic Assays. The lifespan of Abeta42-GCLc *Drosophila* were significantly and statistically higher at 128% compared to Alzheimer's flies, and up to 136% higher under redox stress. The Mitochondrial ETC activities in all complexes were significantly lower by 40-70% in the Alzheimer flies compared to the yellow-whites. In each mitochondrial complex, the A $\beta$ -GCLc flies' enzyme activity doubled as compared to the Alzheimer's flies, especially in complexes I, III and IV encoded by mitochondrial DNA. This Patent Pending research suggests diagnostic protocols using mitochondrial bioenergetics and Glutathione levels as biomarkers in Alzheimer's. It points to the potential of neuro-specific gene therapy for Alzheimer's by increasing pan-neuronal in-vivo Glutathione synthesis.

## **Novel Dilithium Phthalocyanine-Graphene Composite Electrodes for Hybrid Supercapacitor Applications**

*Michael N. Trinh*

*Plano East Senior High School, Plano, TX, Texas JSHS;*

*Teacher/Mentor/Sponsor: Dr. Kenneth Balkus Jr., University of Texas at Dallas*

Supercapacitors are energy storage devices that facilitate higher power densities than those of batteries and fuel cells and higher energy densities than those of capacitors. Due to their ability to charge and discharge quickly and in high magnitude, supercapacitors are an enticing solution for the energy crisis. Graphene, an sp<sup>2</sup> hybridized carbon allotrope with high electrostatic charge capabilities, is extremely conductive while dilithium phthalocyanine, due to its redox activity, can provide pseudocapacitance. In this work, a novel hybrid supercapacitor is fabricated with electrodes that exploit the synergy between the electric double layer capacitance of graphene and the pseudocapacitance of dilithium phthalocyanine in composite electrodes. It was hypothesized that coin cell supercapacitors with graphene-dilithium phthalocyanine composite electrodes could be synthesized via ultrasonication and filtration to yield higher overall capacitance, energy density, and power density than those of pure graphene supercapacitors. It was observed that when the concentration of phthalocyanine to graphene was at 5%, there was a statistically significant difference in performance of the cell. Therefore, it was concluded that a cheap (about 20 cents per unit), reusable, and flexible composite electrode can maximize quality of a supercapacitor, which suggests novel functions where previously inefficient supercapacitor applications were substandard.

## **A Natural Way to Improve Chemotherapy: Investigating the effect of Biochanin A on the efficacy of Thapsigargin in a *C. elegans* cancer model**

*Audrey L. Francis*

*Loudoun Academy of Science, Sterling, VA, Virginia JSHS;*

*Teacher/Mentor/Sponsor: Dr. Julie Sohl, Loudoun Academy of Science*

Multidrug resistance is a major obstacle in the treatment of cancer. One of the major causes of resistance is P-glycoprotein, an ATP binding cassette transporter that binds and removes toxins from cells, enabling cells to eliminate drugs and toxins before damage is incurred. This study aimed to test the effect of a potent P-glycoprotein inhibitor, Biochanin A, on the efficacy of an anticancer drug called Thapsigargin. Interestingly, it has been found that Biochanin A is able to specifically target cells that overexpress P-glycoprotein, potentially enabling it to increase the accumulation of chemotherapeutic drugs in cancer cells without causing further harm to healthy cells. The nematode *Caenorhabditis elegans* has been used as an alternative cancer model for certain drugs such as Thapsigargin because it possesses a homolog for a calcium ion transporter that is targeted by Thapsigargin. In this study, *C. elegans* were used to model cancerous tumors and were treated with Thapsigargin either alone or in combination with Biochanin A. It was found that treating worms with Biochanin A in conjunction with Thapsigargin produced significantly greater reductions in population than Thapsigargin alone, indicating that Biochanin A may be able to improve the effectiveness of chemotherapy and prevent or reverse drug resistance. Additional trials are being conducted to confirm these findings.

## **The Impact of Community Acquired Ciprofloxacin-Resistant strain of *Pseudomonas aeruginosa* on Rates of Ciprofloxacin-Resistant *Pseudomonas aeruginosa* in the hospital**

*Tarun V. Kamath*

*Thomas Jefferson High School for Science and Technology, Alexandria, VA, Virginia JSHS;*

*Teacher/Mentor/Sponsor: Dr. Nancy Donnegan, Medstar Washington Hospital Center; Dr. Barbara Wood, Thomas Jefferson High School for Science and Technology*

In this experiment, the percentage occurrence of ciprofloxacin resistant *Pseudomonas aeruginosa* (CRPA) in community and hospital settings from 1990 to 2013 was studied. The purpose was to determine the relationship between the two settings. The data of had been previously collected. Two statistical analyses were used: first a Fourier transform of the data which indicated that both community and hospital graphs had similar frequencies. Second method used superposition to demonstrate whether hospital affected community or vice versa. For this, the curves were stretched to overlay each other To show that the curves were statistically similar, the Pearson's 'r' value of the trend lines were calculated and compared using Fisher's 'r' to 'z' transformation. It was found that the two curves were statistically similar. Based on above, it can be concluded that at first the hospital percentage resistance affected the community percentage resistance, however over time percentage resistance changes were in tandem. Furthermore, when the percentage resistance is in decline, it starts at the community and spreads to the hospital whereas in times of resurgence, it is more likely to begin in the community and spread to the hospital.

## **THE PARADOX OF EMOTIONAL DIMENSIONALITY: The Effect of the Dimensionality of Audio Stimuli on the Brain's Electrical Activity. - A Neuroscience Study -**

*Michelle M. Marquez*

*Math & Science High School at Clover Hill, Midlothian, VA, Virginia JSHS;*

*Teacher/Mentor/Sponsor: Dana Johnson, Math & Science High School at Clover Hill; Dana Johnson, Math & Science High School at Clover Hill*

There is tangible proof that music therapy works in treating symptoms of mood disorders, neurological disorders, and anxiety disorders such as Post-Traumatic Stress Disorder. The mechanisms of action and the origins of these phenomena present a confusing picture to experts in the field. The purpose of this research study was to find a mathematical correlation between the Fractal Dimension (Dimensionality) of audio stimuli and the selective emotions induced by the stimuli and to monitor if these results would be confirmed and verified using Electroencephalography. This study reveals that the internal mathematical structure of the sound-stimuli itself could be responsible for the induction of selective emotions. There is a trend between low Fractal Dimension audio stimuli and the "positive" emotional responses of joy along with a shortening effect on time perception. Meanwhile, high Fractal Dimension audio stimuli were shown to predominantly trigger "negative" emotional responses of fear with a lengthening effect on time perception. These results support the idea that primary emotions could be universal across cultures and may have an evolutionary and biological basis. This study provides a fundamental understanding to advance the fields of biomathematics, emotional research, and music therapy.

## **A Novel Beamforming Approach to Stereo Sound**

*Samuel E. Rohrer*

*Thomas Jefferson High School for Science and Tech, Alexandria, VA, Virginia JSHS;*

*Teacher/Mentor/Sponsor: David Bell*

The goal of this ongoing project is to determine the best method of creating stereo sound and separation within the footprint of a tablet in the near-field (less than six feet from the user). Beamforming (creating directional wavefronts) was used to achieve this; however, the best method of near-field beamforming was unknown. Three techniques were simulated and compared using MATLAB: point and sum (a new method developed during research), delay and sum beamforming, and no beamforming. Simulation results showed that point and sum beamforming was the superior method. This technique was then tested in hardware. To do this, the logic for the processing was defined using VHDL and synthesized onto a Field Programmable Gate Array (FGPA). On a high-level, this processing circuitry samples all audio inputs and then transfers the data to a matrix of registers. The data was then selected from the registers based on the delays that had already been calculated to create the beamforming. Results suggest the system is functioning correctly by separating the sound as many users have confirmed. It is clear point and sum beamforming is the best method for near-field beamforming and that stereo separation can be created in the footprint of a tablet.

## Generation of Power Using Piezoelectric Leaves

*Maeve W. Harris*

*Sequim High School, Sequim, WA, Washington JSHS*

The vibration of leaves in the wind provides a potential renewable energy source. The goal of my project was to design an artificial leaf system that would mimic the oscillation of natural leaves. New technologies such as piezo-electrics could convert this small-scale vibrational energy to electrical energy. I initially tested nine different leaf shapes with varying petiole configurations. I employed a Slam Stick accelerometer to record the acceleration in g's and the frequency in Hz. I analyzed the collected data using a Fast Fourier Transform (FFT) in the Slam Stick Software. Results indicated that the optimum system was a birch leaf with a round, bent-wire petiole 4 cm long with the leaf oriented 30 degrees to the wind. This system produced an average of 0.1389 g's at an average 35.9564 (Hz). I identified a piezoelectric, Volture Vibration Energy Harvester, that would operate within the acceleration and frequency indentified by the Slam Stick. I replaced the Slam Stick with the energy harvester. I tuned the piezoelectric energy harvester to the optimum frequency which I then connected to a rectifier board. This circuit was attached to a Vernier Meter and the data was transferred to the Logger Pro software on the computer.

## M9 Earthquakes as a Basis for Soil Liquefaction Analysis

*Katherine Landoni*

*Sequim High School, Sequim, WA, Washington JSHS;*

*Teacher/Mentor/Sponsor: Ms. Beckett, Sequim School District; Ron Tognazzini, Sequim Science Club*

Earthquakes have caused property damage and infrastructure damage from soil liquefaction. Analytical methods used in the United States to predict liquefaction potential were developed with data from small magnitude, short duration earthquakes. The Magnitude 9 subduction zone earthquake on March 11, 2011 off the Pacific Coast of Japan resulted in liquefaction. Simplified liquefaction analytical methods use a Magnitude Scaling Factor (MSF) as a proxy for duration during an earthquake. The purpose of this investigation is to develop a Duration Scaling Factor (DSF) based on large magnitude, long duration shaking from subduction zone earthquakes and apply it to the simplified liquefaction analytical method. Records of digitized acceleration data within 30 km of sties that liquefied during four subduction zone earthquakes were obtained. I calculated the significant duration of strong ground shaking for each record from the Cumulative Absolute Velocity (CAV). I developed the DSF from a regression analysis of duration and magnitude, and compared liquefaction potential of three sites using the DSF and MSF. The results indicated that the MSF is not adequate as a proxy for Duration. This indicates that the use of a DSF would predict liquefaction potential at about 5% lower ground shaking than the standard MSF.

## **Cranberry Extracts: A Quorum Sensing Inhibitor and the Novel Application of Cranberry Extracts as an Environmental Measure to Inhibit *Pectobacterium carotovorum* in Crops.**

*Indira Rayala*

*Henry M. Jackson High School, Mill Creek, WA, Washington JSHS;*

*Teacher/Mentor/Sponsor: Andrew Sevald, Henry M. Jackson High School; Carol Tanner, Henry M. Jackson High School*

Bacteria exhibit complex methods of communications called quorum sensing. Quorum sensing allows bacteria to chemically determine when species density becomes high enough to overcome the host cells ability to produce an effective immune response. If quorum sensing was to be inhibited then bacteria would not be able to launch virulence. Plant disease is an economic problem and the current methods to treat plant pathogens are varied and hazardous to the environment. Nearly all plant pathogens are gram-negative bacteria and use AHL autoinducers to launch virulence in the host. Cranberry Extracts (Dehydrated Crushed Cranberry Powder and cPACs) will be tested for their potential as an environmental antibiotic for plant disease. The anti-quorum sensing abilities of Cranberry Extracts were assessed with a Diffusion Assay using the biosensor strain *Agrobacterium tumefaciens* to measure beta-galactosidase activity and showed anti-quorum sensing abilities ( $p < .001$ ). The extracts had a significant effect on the integrity of AHLs. ( $p < .05$ ) Cranberry Extracts were applied to *Pectobacterium carotovorum* to measure inhibition of biofilm formation ( $p < .05$ ). The extract's ability to prevent post-harvest losses was also assessed and results show that the Cranberry Extract did display inhibition of infection in potatoes. ( $p < .05$ ).

## **Does BPA Cause Hearing Loss? Assessing the Potential Ototoxicity Induced by Bisphenol-A in *Danio rerio* Lateral Line**

*Meghal Sheth*

*Camas High School, Camas, WA, Washington JSHS;*

*Teacher/Mentor/Sponsor: Dr. Allison B. Coffin, Washington State University Vancouver; Mrs. Kimberly Newman, Camas High School*

Does BPA Cause Hearing Loss? Assessing the Potential Ototoxicity Induced by Bisphenol-A in *Danio rerio* Lateral Line Meghal Sheth Camas High School, Camas, WA Mentor, Dr. Allison B. Coffin, Washington State University Vancouver Teacher, Mrs. Kimberly Newman Camas High School Bisphenol-A, (BPA) is a plasticizer used in the production of polycarbonate plastics, epoxy resins, and thermal paper. BPA has been shown to cause many health defects, which is why research is being done to learn more about the adverse effects of BPA. In my research, I have tested for the ototoxic effects of BPA, and have begun to identify how BPA specifically causes hair cell death and hearing loss. Hearing loss is often caused by the loss of hair cells, which are mechanosensory cells in the cochlea that receive sound stimuli and transfer it to the brain via auditory nerve. The human body produces about 15,000 auditory hair cells and once lost, hair cells cannot be replaced. Many researchers use zebrafish as a model for hair cell toxicity studies in vivo because the lateral line structure along the body of the fish contains hair cell bearing organs called neuromasts that allow for the accurate identification of damaged hair cells. I have concluded that 24-hour exposure to BPA causes hair cell death, and that certain compounds, like antioxidants, can prevent this damage in humans, which could potentially alter the way the household consumer views BPA and the importance of hearing.

## **Synthesis, Characterization and Solar Cell Application of Zinc-Oxide Nano-Structures**

*Swetha V. Shutthanandan*

*Richland High School, Richland, WA, Washington JSHS;*

*Teacher/Mentor/Sponsor: Vaithiyalingam Shutthanandan, Pacific Northwest National Lab*

The dye sensitized nanoparticle solar cell (DSNSC) is one of the new types of solar technology that converts solar energy into electrical energy. TiO<sub>2</sub> is the typical nano material used in DSNSC. However, because of its very low electron mobility, TiO<sub>2</sub> based solar cell suffer from electron recombination effects at the cell. This reduces the overall efficiency. As such scientists have been trying to discover new materials to overcome this issue. Zinc Oxide based nanostructures show some promising effects in this direction. In this work, several different nanostructures of ZnO were synthesized using “Self-Catalytic assisted Vapor-Liquid-Solid” growth process. Different types of nanostructures such as wires, rods, flowers, and sheets were formed on the substrates depending on their location in the synthesis tube. These nanostructures were characterized by using X-Ray Photoelectron Spectroscopy for surface composition, Rutherford Backscattering Spectrometry for bulk composition/porosity, and Helium Ion Microscopy for morphology. Four different DSNSC were fabricated using these nanostructures. For comparison purposes, two additional DSNSC were fabricated using commercially available ZnO and TiO<sub>2</sub> nanoparticles. The I-V characteristics of these cells were obtained for different lighting conditions. DSNSC fabricated from ZnO nano-wires showed the largest efficiency, while the cell synthesized from nano-flower showed the least efficiency.

## **The Effect of Body Mass Index on the Concentrations of Acetone, Isoprene, and 1-octene in Human Breath**

*Carrie M. Stump*

*Columbia River High School, Vancouver, WA, Washington JSHS;*

*Teacher/Mentor/Sponsor: Kelly Cameron, Columbia River High School; Todd Rogers, Columbia Basin College/ Center for Laboratory Services at RJ Lee Group*

Obesity is an epidemic in the United States; it is becoming more vital that a deeper understanding of human metabolism be gained. New technologies such as Proton Transfer Reaction - Mass Spectrometry (PTR-MS) enable a faster and more cost effective analysis of human breath where human breath is examined under the premise that it contains Volatile Organic Compounds (VOCs) that are metabolic byproducts. The research question is: What is the effect of body mass index (BMI) on the concentration of acetone, isoprene and 1-octene in human breath samples?

Breath samples were collected in Tedlar Bags from 31 teachers of varying BMIs at Columbia River High School. Participants inflated the bag, which was then sealed and locked for transport to Columbia Basin College and RJ Lee Group in Pasco, WA. Heights and weights, from which BMIs were calculated, were measured 1-2 days later. Isoprene concentration, which demonstrated a weak positive correlation with BMI, had a 95% significance. Acetone concentration had a weak negative correlation with BMI and a confidence of 90%. 1-octene demonstrated almost no correlation between octene concentrations and BMI. Overall, the study was limited by a lack of controlled diet and potential time from sample collection to PTR-MS analysis.

### **Evaluating the toxicity of triclocarban on a sensitive algal strain, *Scenedesmus subspicatus***

*Kaitlin M. Brueggen*

*West Salem High School, West Salem, WI, Wisconsin JSHS;*

*Teacher/Mentor/Sponsor: Barb Thompson, West Salem High School*

Triclocarban (TCC) is a chemical compound that is often added to household products, such as hand and dish soap, to impart antimicrobial properties. Antimicrobial products are used to kill infectious microbes, but have also been shown to lead to many negative effects, including antimicrobial resistant bacteria, negative health effects, and negative effects on the environment. Little is known about the toxicity of TCC and how it may affect algae if the compound were to contaminate aquatic ecosystems. To determine TCC toxicity, the green alga *Scenedesmus subspicatus* was grown in solutions containing different concentrations of TCC. By counting the cells present in each flask over a period of three days, cellular reproduction was monitored. It was determined that *S. subspicatus* cannot grow in conditions containing 50.0 ppb of TCC. Because TCC has been found to be toxic at relatively low concentrations, use of it in antimicrobial products should be considered carefully.

### **Comparing the Trophic Position of Burbot (*Lota lota*) in the Apostle Islands Archipelago (Lake Superior, USA) to Determine Factors Promoting Contaminant Bioaccumulation**

*Ellie L. Hoopman*

*Bayfield High School, Bayfield, WI, Western Wisconsin, Upper Michigan JSHS;*

*Teacher/Mentor/Sponsor: Richard Erickson, Bayfield High School; Toben Lafrancois, Northland College; Bill Route, National Park Service*

Nearshore coastal fisheries of Lake Superior are understudied relative to their economic and cultural importance, yet studies of contaminant bioaccumulation show unexplained patterns across nearshore environments. The goal of this research is to identify spatial patterns of food web position using elemental analysis of burbot (*Lota lota*). Stable isotope analysis provides insight into the factors that influence persistent toxin bioaccumulation in apex predators. Fifty burbot were sampled from commercial fishery by-catch along a gradient from inner to outer islands in and near the Apostle Islands National Lakeshore archipelago. Tissue biopsies were taken for isotope analysis from caudal fins, pectoral fins, and dorsal muscle tissue. Otoliths were collected to determine age. Carbon and nitrogen isotope ratios in dorsal muscle tissue were significantly different than those found in pectoral and caudal fin clips. Linear regression equations were developed to correlate isotope ratios in burbot dorsal muscle tissue to fin clips. Carbon isotopes were significantly higher for burbot caught in the outer versus inner islands, indicating that burbot in the outer islands were feeding on a more benthic-dominated food web. Analysis of the isotope  $\delta^{15}\text{N}$  indicated the burbot from the inner and outer islands were positioned at approximately the same trophic level (5.1). Results showed no statistical relationship between stable isotope accumulation and age. Differences found in burbot bioaccumulation will be used in ongoing work to help determine sources and pathways of contaminants in the Lake Superior nearshore ecosystem and to refine methods of comparing food web studies that use different tissue sources.



## **Planktonic Food Web Structure of Island Lagoons and Nearshore Waters: Tools for Determining Pathways of Contaminant Accumulation in Bald Eagles of the Apostle Islands National Lakeshore (USA)**

*Emily L. Hoopman*

*Bayfield High School, Bayfield, WI, Western Wisconsin, Upper Michigan JSHS;*

*Teacher/Mentor/Sponsor: Richard Erickson, Bayfield High School; Toben Lafrancois, Northland College; Bill Route, National Park Service*

Determining the structure of lower trophic levels of the Lake Superior food web is necessary for understanding patterns of contaminant accumulation in top-level predators. A study of bald eagles (*Haliaeetus leucocephalus*) of the Apostle Islands indicated that nestlings on the islands farthest from the mainland contained the highest DDE levels. The purpose of this project was to analyze the bottom-up pathways of contaminant accumulation by quantifying effects of different nearshore habitats in structuring the base of the food web. Plankton samples were collected in pairs from Lake Superior nearshore and Apostle Islands lagoons. Samples were analyzed using stable isotope ratios of carbon and nitrogen to identify variance between location, habitat type, and size fraction (0 to 35  $\mu\text{m}$ , 35 to 63  $\mu\text{m}$ , and >63  $\mu\text{m}$ ). Analysis of  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  distributions over all size fractions showed significant heterogeneity among all interactions. Analysis of zooplankton (63+ $\mu\text{m}$ ) showed a significant difference in  $\delta^{13}\text{C}$  ( $p < 0.001$ ) and  $\delta^{15}\text{N}$  ( $p < 0.001$ ) between habitat types, as well as a  $\delta^{15}\text{N}$  difference between locations ( $p = 0.012$ ). Lagoon sites were depleted in  $^{13}\text{C}$  and enriched in  $^{15}\text{N}$ , indicating that plankton from nearshore sites was situated at a lower trophic level that is more characteristic of a benthic food web pathway. Proceeding analysis of zooplankton communities suggests that FCL is longer in the lagoon pelagic communities studied. This research validates the idea that the “inner” and “outer” islands support more than one primary food web, and informs ongoing work to determine pathways of contaminant accumulation.

## **The Relationship between the use of Foliar Fungicides and the Improvement of Alfalfa Forage Production**

*Carrie A. Urbanek*

*Cashton High School, Cashton, WI, Western Wisconsin, Upper Michigan JSHS;*

*Teacher/Mentor/Sponsor: Mrs. Julie Lundeen, Cashton High School*

This project was conducted to evaluate the effect of popular foliar fungicides and insecticides on the quality and quantity of alfalfa. I hypothesized the fungicide and insecticide treated plots would generate a higher profit than the plot with just the insecticide treatment, because of the presence of fungus and insects initially observed at the start of the project. I also hypothesized the section treated with both treatments would generate the highest profit, regardless of the cost of the treatment, because the protection on the alfalfa plant would greatly increase the yield and quality at harvest. As control variables in this experiment, the same brand of alfalfa seed was used, along with the same brands of foliar fungicides. The independent variable was the type of treatment used. The dependent variable was the quality and yield of alfalfa. When a significant difference was found in my data, most of the time the fungicide + insecticide treatment generated a higher yield, but the insecticide treatment had better quality. This study will help farmers make an educated decision on whether foliar fungicides should be applied to their alfalfa, and which treatment is most effective.

## **Evaluating Differences in Electrolyte Concentration Among Beverages**

*Casey R. Urbanek*

*Cashton High School, Cashton, WI, Western Wisconsin, Upper Michigan JSHS;*

*Teacher/Mentor/Sponsor: Mrs. Julie Lundeen, Cashton High School*

Each year, sports drink companies spend millions of dollars advertising their product, but are sports drinks really the best choice for athletes? In my experiment, I tested the electrolyte concentrations of sports drinks, coconut water, orange juice, and milk. I hypothesized that the milk will have the most electrolytes because milk is hypertonic, meaning high in electrolyte content. In addition, I hypothesized that orange juice and coconut water would contain more electrolytes than sports drinks because they are high in potassium which is an important ion released for electrolytes. In my experiment, the independent variable was the beverage tested; I used several sports drinks, fruit juices and milk to test electrolyte content. The dependent variable was the electrolyte concentration of the drink. I used distilled water as a control variable to compare with tested electrolyte values. My hypothesis was incorrect, coconut water had the highest electrolyte concentration, but chocolate milk was also high. I concluded that chocolate milk is the best choice for exercise recovery because it is the high in electrolytes and contains more beneficial vitamins and higher levels of calcium.

## **L-selectin and $\alpha 4\beta 7$ interactions with VCAM-1 cooperate in regulatory T cell adhesion under shear stress**

*Jenna R. Lieungh*

*Divine Savior Holy Angels High School, Milwaukee, WI, Wisconsin JSHS;*

*Teacher/Mentor/Sponsor: Dr. Douglas Steeber, University of Wisconsin-Milwaukee; Jessica Lopnow, University of Wisconsin-Milwaukee; Mrs. Betty Jo Azpell, Divine Savior Holy Angels High School*

Regulatory T (Treg) cells can be both beneficial by suppressing immune response and detrimental by preventing bodily elimination of tumors. Treg cell migration and recirculation are important for facilitating effective suppressive immune responses. Lymphocyte migration is mediated by adhesion molecules that bind to ligands on the endothelium and regulate Treg movement. Specifically, L-selectin mediates capture of the cells from the blood stream and facilitates high velocity rolling. Then,  $\alpha 4\beta 7$  decreases lymphocyte velocity and binds to VCAM-1. The role of L-selectin and  $\alpha 4\beta 7$  integrin in Treg rolling and adhesion is currently unknown. To determine if L-selectin and  $\alpha 4\beta 7$  /VCAM-1 interactions cooperate to facilitate Treg cell adhesion, an in vitro flow chamber assay was used. Lymphocytes from peripheral murine lymph nodes were withdrawn over transfected EA.hy926 endothelial cell lines. After treatment of lymphocytes with  $\alpha 4\beta 7$  blocking antibody (DATK32), adhesion of total lymphocytes significantly decreased by 54.0%. In addition, treatment with  $\alpha 4\beta 7$  blocking antibody resulted in a 42.0% reduction in Treg cell adhesion after 10 minutes. These results indicate cooperation between L-selectin and  $\alpha 4\beta 7$  /VCAM-1 interactions in total lymphocyte and Treg adhesion under shear stress. Further studies of Treg migration could pave the way for novel anti-cancer therapeutic strategies.

## **Describing RuPAH Dye Excited-States In Polyelectrolyte Multilayer Films: A Method For Absorbance Correction**

*Andrew K. Saydjari*

*Lincoln High School, Wisconsin Rapids, WI, Wisconsin JSHS;*

*Teacher/Mentor/Sponsor: Dr. Blake Simpkins, Naval Research Lab*

Ruthenium trisbipyridine was covalently bound to poly(allylamine hydrochloride) (PAH) to promote its direct incorporation into multilayer films constructed via layer-by-layer self-assembly with poly(sodium 4-styrene-sulfonate) (PSS). Observation of spectral phenomenon surrounding absorption of dye in multilayer films prompted an investigation utilizing various ionic deposition conditions. Plots tracking the maximas of dye absorption peaks displayed non-linear oscillatory behavior. Both physical and spectral properties of the incorporated ruthenium dye of the films were monitored via atomic force microscopy (AFM), UV-vis absorption spectroscopy, and fluorescence spectroscopy. AFM profiles indicated despite spectral phenomenon, films grew linearly, behaving as expected physically. Modulation of the expected linear absorbance increase was attributed to an optical interference effect. A model was developed to describe this effect and a method for correction of absorbance spectra was proposed that improves upon current methodology. This model may facilitate far-reaching applications in technologies ranging the medical field to space travel. Emission spectra were tentatively categorized by ionic charge of deposition solution. Results were analyzed with respect to an initial hypothetical Franck-Condon based mechanism.

## **Immune Characterization of Conjunctiva-Associated Lymphoid Tissue(CALT)**

*Sonali Srivastava*

*Brookfield East High School, Brookfield, WI, Wisconsin JSHS; Teacher/Mentor/Sponsor: Dr. Anthony J. St. Leger, National Institutes of Health (NEI-NIH); Mr. Ben Westphal, Brookfield East High School*

Aberrant inflammation at mucosal tissues routinely leads to discomfort and tissue damage as seen in the well-studied inflammatory bowel disease (IBD). While ocular manifestations of inflammation are less well-studied, the ramifications are just as severe. For example, ocular inflammation due to pathogens and/or allergens can lead to blindness. Many propose that lymphoid follicles residing in ocular mucosal tissue, otherwise known as conjunctiva associated lymphoid tissue (CALT), play a functional role in ocular disease; however, the role of CALT in the context of ocular immune responses remains unknown. In this study, we isolated CALT from WT, IL-10 KO, and IL-22R KO, and C57BL/6 mice that were challenged with innate receptor stimulants to assess the ocular immune response. Interestingly, our results show that CALT harbors a significant population of innate lymphoid cells (ILCs) whose dysregulation is linked to gut inflammation and disease. Upon stimulation with cytokines, IL-1 $\beta$  and IL-23, these cells produce the potentially pathogenic cytokine, IL-17, suggesting a role for ILCs in ocular inflammation. In response to challenge with innate receptor stimulants, mice deficient in regulatory cytokine signaling (IL-10 KO or IL-22R KO) had elevated numbers of IL-17+ cells. These data suggest that IL-10 and IL-22 signaling could help maintain ocular immune homeostasis. Consequently, this discovery opens up modulation of IL-10, IL-17, and IL-22 signaling as a mechanism to control ocular inflammation during eye infection, dry eye disease, and autoimmune disease. Additionally, this study emphasizes a previously unrecognized role of ILCs in innate immune signaling, and inflammatory responses within the CALT.

## **Factors Affecting the Persistence of Quagga Mussel Shells in Lake Michigan**

*Clarise E. White*

*Divine Savior Holy Angels High School, Milwaukee, WI, Western Wisconsin, Upper Michigan JSHS; Teacher/Mentor/Sponsor: Dr. Carmen Aguilar, University of Wisconsin Milwaukee School of Freshwater Sciences; Dr. Russell Cuhel, University of Wisconsin Milwaukee School of Freshwater Sciences; Betty Jo Azpell, Divine Savior Holy Angels High School*

The purpose of this research is to analyze the rate at which quagga mussel shells dissolve under various conditions in order to determine the residence time of the remains and the effect of the mussels on the chemical composition of Lake Michigan's water. Several factors affecting the persistence of quagga mussels were examined, such as incubation temperature, shell age, and sterilization methods. The hypotheses are as following: temperature will be proportional to the shell dissolution; using a sterilization method will inhibit dissolution of the shells; shells that were dead at collection will dissolve more readily than shells that were freshly dissected. The quagga mussel shells were incubated in water in syringes under the various conditions, and water samples were taken each week. The water samples were then used for CO<sub>2</sub> testing with a conductivity detector and calcium testing with an atomic absorption spectrometer in order to determine the amount of dissolution per week. As predicted in the hypotheses, the data proved the following: incubation temperature is indeed proportional to shell dissolution; sterilization method affects dissolution at 18°C but not at 8°C; mussel shells that were dead at collection dissolved less due to a difference in their sample location.

### **The Effect of Phytoremediation on Heavy Metals**

*Alex L. Henkle and Mason Sundstrom*

*Newcastle High School, Newcastle, WY; Wyoming, Eastern Colorado JSHS*

The purpose of the experiment was to find out which plant would phytoremediate lead out of water the best out of our choices: sunflower, hyacinth, ornamental grass, and alyssum. It was hypothesized that if these plants are used, then the sunflower will phytoremediate lead the best due to its tendency to phytoremediate well. To test this, the materials needed were obtained and buckets of water with suspended blocks of rock wool with each seed test and one of no seeds (control) growing in them were put inside. The water was then tested for lead content after the plants had grown. After watering the plants with 4% lead water for a few days, samples of the water were taken to be tested to see if lead was still present. The result was that the sunflower phytoremediate the most lead, resulting in a 0.8% concentration. The hyacinth was really close, however, with a 0.89% lead concentration. In conclusion, going through the tests and collecting the data, it was found that the sunflower plant was most effective at phytoremediate. After the data was collected the hypothesis: if the sunflower plant is used then it will phytoremediate lead out of water best due to its tendency to phytoremediate lead well was supported.

### **Effect of Oil and Gas Development on Atmospheric Levels of Hydrocarbons and Tropospheric Ozone**

*So-Yun Kim*

*Fairview High School, Boulder, CO, Wyoming, Eastern Colorado JSHS;*

*Teacher/Mentor/Sponsor: Dr. Gabrielle Petró, NOAA; Dr. Gregory Frost, NOAA*

Unconventional oil and natural gas have been an increasingly significant source of energy in the United States due to modern technology such as hydraulic fracturing. The consequences of the production and processing of oil and gas development to climate and air quality are imperative to understand, especially in prevalent oil and gas sites like Colorado, Wyoming, and Utah. In this study, the data from a tower observatory in Colorado from 2008 to 2012 are utilized to characterize chemical composition of oil and gas emissions and investigate the impact of these emissions on tropospheric ozone. Alkane and benzene are significantly enhanced in the air originated from oil and gas development region in Denver-Julesburg Basin, which confirms the results in previous researches for different time periods. This study is the first to examine direct relationship between hydrocarbons and concurrently measured ozone in summer in Colorado. Under the conditions of high hydrocarbons concentrations, ozone concentration is high and tends to increase as hydrocarbon accumulates. Chemical analysis suggests large contribution of propane and butane from oil and gas development to ozone. Additional studies on a national level are beneficial to fully understand the relationship between hydrocarbons from oil and gas explorations and tropospheric ozone.

## **Network Response to Intrusion Detection: Probabilistic methods in machine informatics to secure multiple targets**

*Stephen L. Parish, Home School, Colorado Springs, CO*

*Wyoming, Eastern Colorado JSHS; Teacher/Mentor/Sponsor: Maureen Parish, Home School*

Computer network security is an increasingly important concern to business, industry, defense and government operations. Current network security practice uses a generic model based on a static network description that characterizes the risk from future intrusions based on past experience. Such a generic model ignores new and present threats and loses the opportunity to limit attacks in-progress. Moreover, fluid mobile networks quickly obsolete such static analyses. The problem is that current algorithms ignore what network engineers actually do. Network engineers typically work with individual computers and specific threats as they identify network intrusions. A dynamic solution is needed. When a threat is suspected, my solution is to rapidly apply my computer-driven algorithms to: (1) build a topological junction tree of subnets, (2) replicate a custom probability model as an attack graph that applies computer-by-computer, (3) detect the intrusion and isolate it from spreading into more subnets. At this point affected computers can be cleaned and recertified to continue normal operations.

My prototype Network Response to Intrusion Detection (NRID) software algorithms will keep cyber attacks from decimating entire computer networks. The innovative algorithms use mathematical hypergraphs, evaluate Bayesian mathematical models on Indicators Of Compromise (IOCs), and gather computer evidence using my own analysis software. My algorithms will discover a minimal response set that will defeat an on-going intrusion into a computer network. I create a hypothetical network where I perform the topological analysis. Testing this concept shows that the algorithms can potentially be applied throughout an entire computer network.

## **Application of Biomimicry to 3D Printing: Creating Lighter, Stronger, and Cost Efficient Structures**

*Ian J. Wilkins*

*Fairview High School, Boulder, CO, Wyoming, Eastern Colorado JSHS;*

*Teacher/Mentor/Sponsor: Dr. Paul Strode, Fairview High School*

3D printing is a process of making a three-dimensional object through deposition of successive layers of material. Despite many advantages, considerable room exists to optimize the cost, strength, and weight of designs. Biomimicry is the imitation of the models, systems, and elements of nature for the purpose of solving complex human problems. The present research evaluates the use of hexagonal prisms, often found in nature, in the design of sandwich beams. Theoretical analysis of three point loading of sandwich beam and solid designs was conducted. For example, a 10% increase in weight (0.1 core density), produced a beam with more than seven times the stiffness and three and half times the strength. Conversely, reduced weight designs with comparable or greater stiffness are also possible. For example, a minimum weight design (constant core density of 0.1) reduced weight by 76.2%, albeit with a 38.5% reduction in strength. An alternative optimal design achieved 106% greater stiffness, with a 70% weight reduction and strength comparable to the solid model. A finite element analysis of the solid beam and 70% weight reduction beams confirmed the theoretical results. Biomimicry shows considerable promise to optimize 3D printing. Directions for future work are highlighted.