

## **Smita Bhoopatiraju, Wayzata High School, Grade 12**

*Phonological and Semantic Features in Four- and Six-Year-Olds' Foreign Word Learning*

### **Twin Cities Regional Science Fair**

- Research Paper Competition Finalist signifying qualification to the North Central Tri-State Junior Science & Humanities Symposium in March

Studying how children learn words in a foreign language can shed light on how language learning changes with development. In this experiment, we examined whether four- and six-year olds could learn and remember words for familiar pictured objects in a foreign language. All children learned foreign words that consisted of high and low frequency sounds in English. A semantic network was constructed that consisted of four clusters of words that were close in meaning (foods, clothing, body parts, and animals), words linked the clusters (e.g., milk was linked to food and to animals), and isolates that were only closely associated to one other word in the network. Children were randomly assigned to learned foreign words in three conditions:

- (1) items in the semantically related clusters (e.g., milk, cookie);
- (2) items that linked the clusters; and
- (3) items that were isolates.

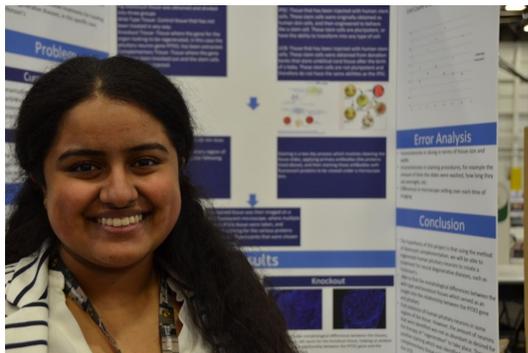
Both age groups learned foreign words that consisted of highly frequently English sounds better than words that consisted of low frequency sounds, and this was especially true when they were learning words for the semantic isolates. We also found that the 6-year-olds could remember the words learned after a few days better than the 4-year-olds. Implications for foreign word learning are discussed.

Advisor: Dr. Maria Sera, Institute of Child Development, University of Minnesota

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## **Gauri Binoy, Wayzata High School, Grade 12**

*Exploring the relationship between the PITX3 gene and pituitary as a site for neural regeneration for treatment of neurodegenerative diseases through blastocyst complementation of knockout brains*



### **Twin Cities Regional Science Fair**

- International Science & Engineering Fair Competitor, awarded an opportunity to attend Intel's international competition in May 2017 in Los Angeles, CA
  - Top ribbon signifying qualification to the Minnesota State Science Fair Competition in March
- Neurodegenerative diseases are one of the deadliest debilitating diseases in the world.

Neurodegeneration is the progressive loss of neural function. This study analyzes the relationship between the PITX3 gene and the pituitary, and then explores the potential of pituitary neural regeneration through blastocyst complementation as a treatment for degenerative diseases. The PITX3 gene is important in the development of the lens, dopamine neurons of the substantia nigra, and pituitary. However, the extent of its role in the pituitary has not been fully explored.

Using the method of blastocyst complementation, a process in which stem cells are injected into blastocysts and are genetically engineered to disrupt the function of a unique gene for organ regeneration, the goal of this project is to direct blastocyst complementation to regenerate the human pituitary neurons.

At the outset of the project, blastocyst pituitary tissue that both had and did not have the PITX3 gene was examined. Two types of human stem cells were then injected into PITX3 disrupted blastocysts and were allowed to develop for 62 days. Following this, the pituitaries were sliced and tissue was stained using fluorescent antibodies. Sections were imaged using a fluorescent microscope to identify growth of

pituitary neurons and to observe if human stem cells were able to develop into appropriate cell types.

If the PITX3 gene does indeed play a large part in the pituitary development and human cells are found in abundance within complemented animals, the conclusion arrived at is that this is a viable option to treat degenerative diseases afflicting the pituitary.

Advisor: Dr. Walter Low, Department of Neurosurgery, University of Minnesota

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## Meghana Iyer, Edina High School, Grade 12

*Bioengineering the Lung: Directed Differentiation of Human Pluripotent Stem Cells into Definitive Endoderm on a Lung Extracellular Matrix*

### Twin Cities Regional Science Fair

- International Science & Engineering Fair Competitor, awarded an opportunity to attend Intel's international competition in May 2017 in Los Angeles, CA
- Second place high school research paper out of 196 entries
- Society for In Vitro Biology Award
- Top ribbon signifying qualification to the Minnesota State Science Fair Competition in March
- Research Paper Competition Finalist signifying qualification to the North Central Tri-State Junior Science & Humanities Symposium in March



Lung disease, which includes asthma, emphysema, cystic fibrosis and cancer, is one of the leading causes of death in the world, with more than 3 million deaths annually. Transplantation is usually the only option for patients with irreversible structural lung damage; however, numerous complications and limitations arise with this process due to the paucity of organ donors and immune rejection responses. Regeneration of lung tissue from human-induced pluripotent stem cells (hiPSCs) derived from human skin cells is a novel alternative to transplantation. Hence, this research seeks to understand a possible method through which functional lung epithelial cells can be *efficiently* derived from hiPSCs using a lung extracellular matrix (ECM). To the best of the author's knowledge, the effects of the lung ECM *alone* on the growth and differentiation of stem cells have not yet been investigated.

I hypothesized that the proteins from the lung ECM would facilitate the differentiation of the hiPSCs into definitive endoderm (DE) cells. In order to test this hypothesis, I synthesized a hydrogel derived from a decellularized lung ECM, defined the media conditions to grow the hiPSCs into DE using the hydrogel, identified marker genes for DE within the hydrogel-cultured cells, and finally, injected the cells into a mouse lung scaffold as an end-point assay to determine their regenerative potential.

Data from the research indicate that the ECM has the potential to facilitate the differentiation of hiPSCs into DE and thus represents a significant step forward in the fields of personalized and regenerative medicine.

Advisor: Dr. Angela Panoskaltis-Mortari, Masonic Cancer Research Center, University of Minnesota

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## Serena Jing, St. Paul Central High School, Grade 12

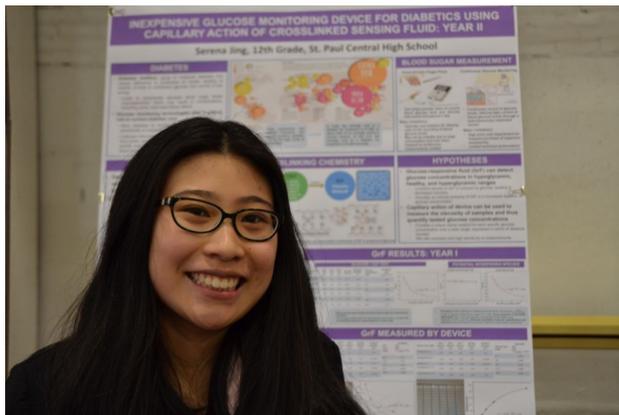
*Inexpensive Glucose Monitoring Device for Diabetes Using Capillary Action of Crosslinked Sensing Fluid*  
Year 2

### Siemens Competition in Math, Science & Technology

- Named a 2016 Siemens Competition Semifinalist

### Twin Cities Regional Science Fair

- International Science & Engineering Fair Competitor, awarded an opportunity to attend Intel's international competition in May 2017 in Los Angeles, CA
- 3M Foundation Sponsor Award
- St. Paul Youth Fund Sponsor Award
- Top ribbon signifying qualification to the Minnesota State Science Fair Competition in March
- Research Paper Competition Finalist signifying qualification to the North Central Tri-State Junior Science & Humanities Symposium in March



Diabetes currently affects over 346 million people worldwide and is one of the leading causes of death. Current treatment requires frequent blood-glucose tests followed by necessary insulin injections to avoid complications. Manufacture and use of blood-glucose monitors can be costly, as tests need to be performed frequently, and inaccessible to diabetic populations in developing countries. Last year, I successfully developed an inexpensive glucose-responsive fluid (GrF) capable of detecting glucose concentrations in all blood-glucose ranges, even maintaining selectivity to glucose in the presence of other species (lactate, sucrose, blood). GrF was composed of boric acid crosslinked with polyvinyl alcohol (PVA), which provided crosslinking sites selectively displaced by the presence of glucose. Once glucose dissociated crosslinks, GrF's viscosity decreased. As viscosity is an intrinsic property of GrF, it became of interest this year to engineer a device that could provide GrF viscosity measurements in a precise, portable, inexpensive and continuous manner. The device was created with capillary tubes embedded in polydimethylsiloxane: capillary action prompts immediate flow of samples in tube and distance travelled correlates to sample's viscosity—a function of glucose concentration. Glucose concentrations covering all blood-glucose ranges were tested and demonstrated GrF and device's accuracy in providing unique signal readouts (in terms of distance) for each glucose concentration. A cost analysis concluded that single test using GrF and device is less than 1 cent. Results suggest possibility of utilizing GrF and accompanying device as an inexpensive portable blood-glucose monitoring system with potential for near-continuous measurements and global applicability.

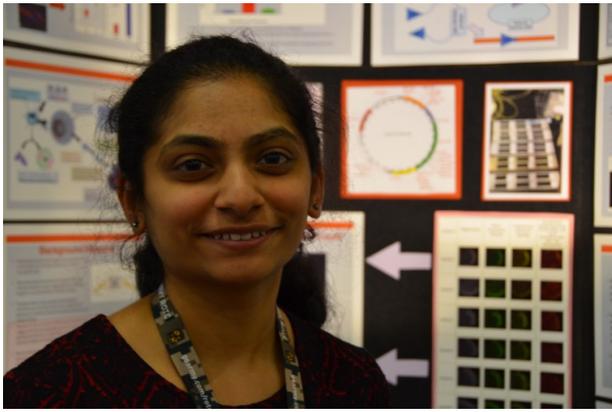
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## Harini Kethar, Minnetonka High School, Grade 12

*A Genetically Engineered Treatment for Chronic Pain and Peripheral Brain Damage through Vector-Mediated Gene Therapy*

### Twin Cities Regional Science Fair

- International Science & Engineering Fair Alternate, awarded an opportunity to attend Intel's international competition in May 2017 in Los Angeles, CA
- United States Army Award
- Top ribbon signifying qualification to the Minnesota State Science Fair Competition in late March
- Research Paper Competition Finalist signifying qualification to the North Central Tri-State Junior Science & Humanities Symposium in late March



Chronic pain and peripheral brain damage is a global health concern affecting nearly 1.5 billion people annually. Initiated by impact of trauma, injury, or infection in the body, sensory neurons plague the brain and spinal cord to the localized site of pain, eventually causing chronic neuropathy (peripheral tissue damage). Current pharmaceutical options for treating this medical condition is through analgesics and OTC drugs. However, they have adverse side effects and only function at 35%-40% efficacy in attacking the nerve growth factor, VGF, located in the dorsal root ganglia (DRG).

This study designed a targeted gene therapy method to suppress chronic pain and peripheral tissue damage through an adeno-associated vector combined GFP protein (AAV9-GFP) approach and nano site-specific cre-lox recombinase technology (gene-deletion method).

By injecting the AAV9-GFP virus in mice, the rates of gene transfer and attack on targeted gene PKCgamma (injury-induced indicator for VGF) were measured and analyzed through immunohistochemistry. With 95% confidence, results show that AAV9-GFP has a high gene transfer efficacy by four fold compared to existing treatments, and the attack rate of targeted gene was 90-95% among collected samples. This indicates that the proposed treatment has a high efficiency and VGF acts as a neuromodulator in the central nervous system.

This study offers a novel therapeutic as well as a vital clinical test for drug efficiency. This method proposes a cost-effective, patient friendly, and permanent pain relief that move scientists one step closer to treating one of the largest diagnosed medical health issue in the world.

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## Samuel Kim, Wayzata High School, Grade 12

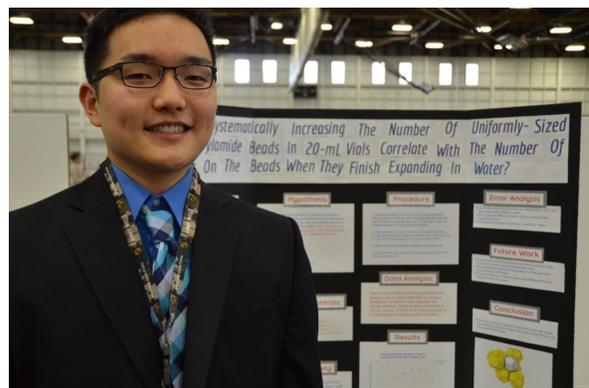
*Does systematically increasing the number of uniformly-sized polyacrylamide beads in 20-mL vials correlate with the number of faces on the beads when they finish expanding in water?*

### Twin Cities Regional Science Fair

- 3M Foundation Award
- American Chemical Society Award
- Top ribbon signifying qualification to the Minnesota State Science Fair Competition in March

The Kelvin Foam Problem asks how space can be divided among cells of equal volume such that surface area between them is minimal. The Weaire-Phelan structure superseded the original Kelvin structure when Irish researchers Weaire and Phelan found in 1993 that it used 0.3% less surface area than the Kelvin structure.

I experimentally determined that the Weaire-Phelan structure and other packing structures such as A15 phases also occur at the macroscopic level in spherical polyacrylamide beads of near-uniform density and dimensions when they are allowed to expand in water for a day in a 20-mL vial. Because the vials were approximately cylindrical, the beads were distorted by the curved surface of the vial, so the beads in the center of the vial were analyzed. I found that certain ranges of the number of beads in a single vial predicts certain packing structures.



Advisor: Dr. Mahesh Mahanthappa, Dept. of Chemical Engineering & Material Science, University of Minnesota