HUNTSVILLE ELECTRO-OPTICAL SOCIETY

6 April 2018

2018 Alabama Science and Engineering Fair (ASEF)
Special Awards in Optics and Photonics

The Huntsville Electro-Optical Society (HEOS) was able to award over $800 in scholarships at the 2018 Alabama Science and Engineering Fair (ASEF) for Special Awards in optics and photonics related projects. The award funding was generously provided by SPIE, NASA, and HEOS. HEOS would like to thank all the volunteer judges for taking the time out of their schedules to participate in this event. The volunteer judges for this year were:

Phil Stahl – NASA MSFC
Tommy Cantey – K Sciences

These judges were responsible for evaluating the merit and application of photonics in the science fair entries. All winners received SPIE or HEOS certificates and award scholarships. HEOS is greatly appreciative of the opportunity to help inspire the nation's future scientists and engineers. HEOS is about community and our optics community only works with continued dedication and participation of our membership.

Recipients from SPIE Awards (Senior)

SPIE Awards

<u>Senior Division Awards</u>

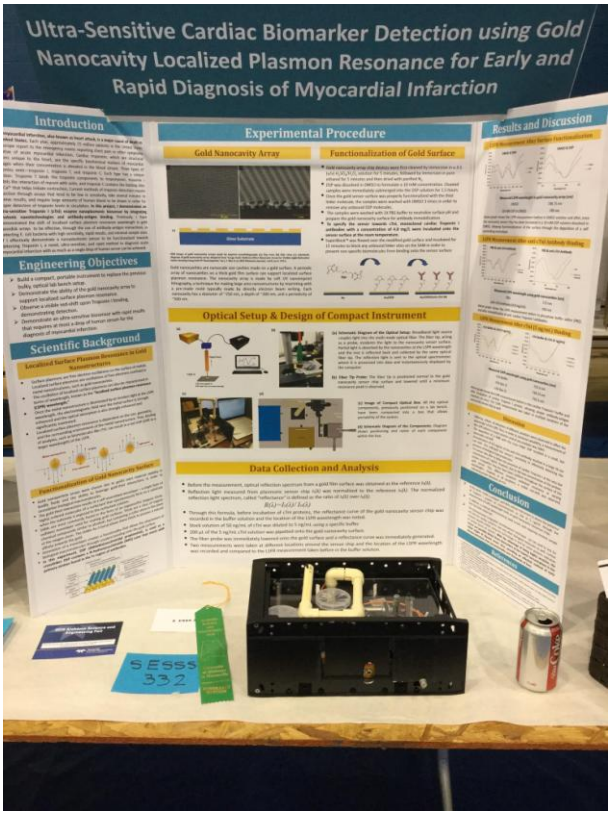
First Prize ($250) – Sophie Guo
"Ultra-Sensitive Cardiac Biomarker Detection using Gold Nanocavity Localized Plasmon Resonance for Early and Rapid Diagnosis of Myocardial Infarction"
12th grade, James Clemens High School, Madison
Sponsor Carol Bohatch (ESSS-332)

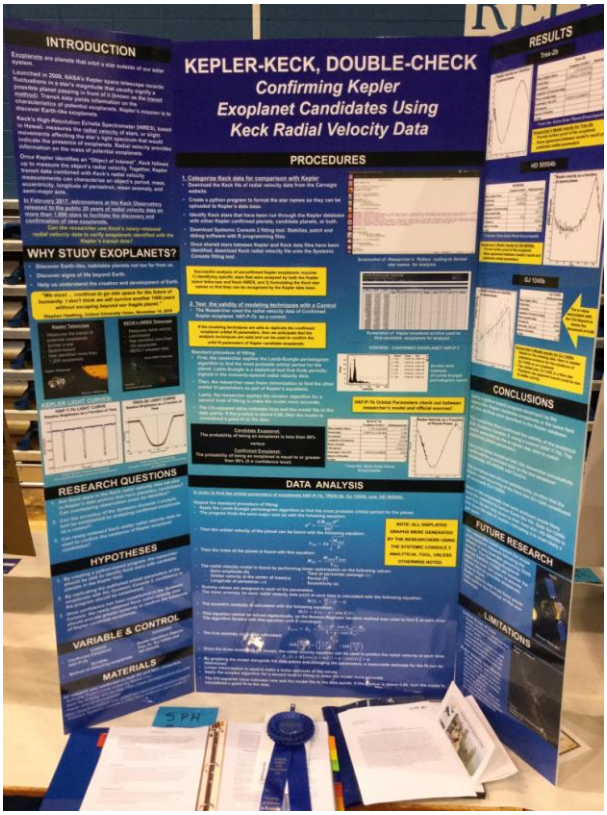
Second Prize ($150) – Mary Alice Jouve, "Kepler-Keck, Double-Check: Confirming Kepler Exoplanet Candidates using Keck Radial Velocity Data"
11th grade, McGill-Toolen Catholic High School
Sponsor Adrian O'Keefe (PH-361)

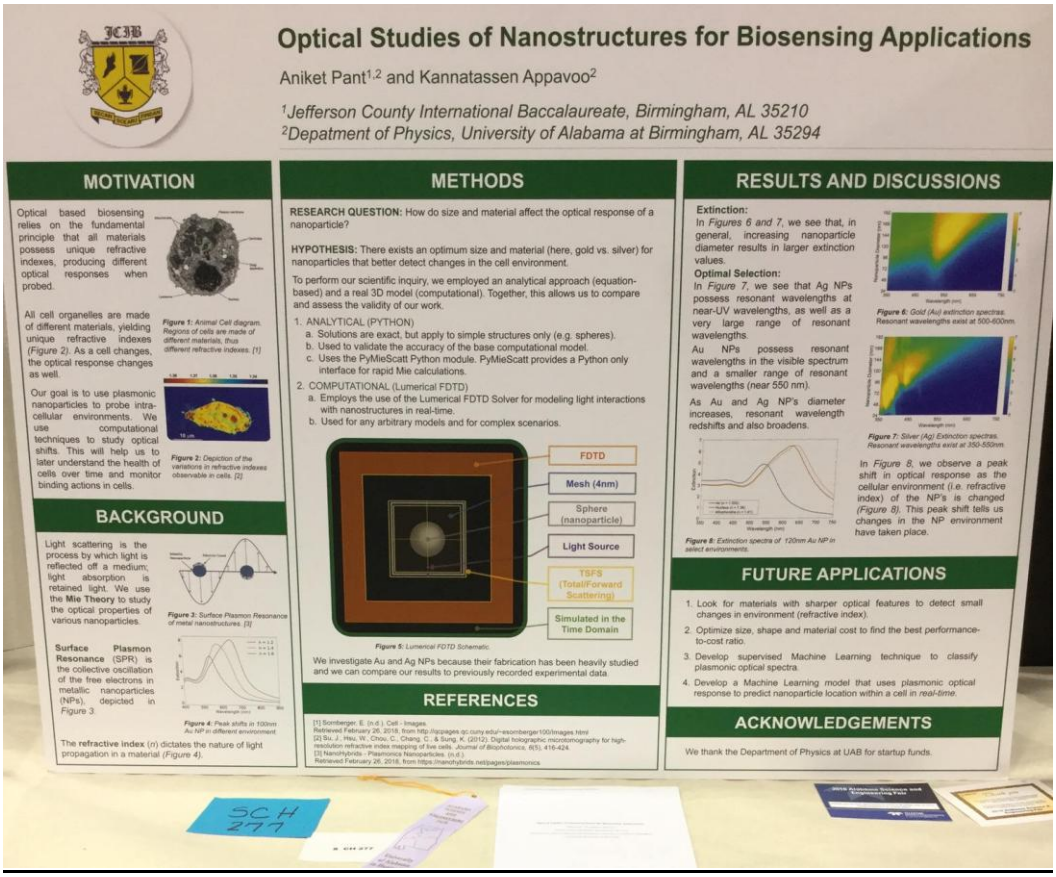
Third Prize ($100) – Aniket Pant
"Optical Studies of Nanostructures for Biosensing Applications"
10th grade, Jefferson County International Baccalaureate High School
Sponsor Kelly Breland (CH-277)

Honorable Mention Prize ($50) – John Dennis, "A Novel Robotic Fire Extinguishing Device Utilizing Machine Vision for Flame Detection"
12th grade, Wetumpka High School
Sponsor Virginia Vilardi (RI-380)

Honorable Mention Prize ($50) – Jayden Vanterpool, "Can Nanoparticles Prevent Staphylococcus Aureus Induced Apoptosis in Endothelial Cells? Part 3"
9th grade, Oakwood Adventist Academy
Sponsor Nanetta Pressley (BI-254)






Optical Studies of Nanostructures for Biosensing Applications
Aniket Pant[1,2] and Kannatassen Appavoo[2]
[1]Jefferson County International Baccalaureate, Birmingham, AL 35210
[2]Depatment of Physics, University of Alabama at Birmingham, AL 35294
MOTIVATION
Optical based biosensing relies on the fundamental principle that all materials possess unique refractive indexes, producing different optical responses when probed.
All cell organelles are made of different materials, yielding unique refractive indexes (Figure 2). As a cell changes, the optical response changes as well.
Our goal is to use plasmonic nanoparticles to probe intra-cellular environments. We use computational techniques to study optical shifts. This will help us to later understand the health of cells over time and monitor binding actions in cells.
Figure 1: Animal Cell diagram. Regions of cells are made of different materials, thus different refractive indexes. [1]
Figure 2: Depiction of the variations in refractive indexes observable in cells. [2]
BACKGROUND
Light scattering is the process by which light is reflected off a medium; light absorption is retained light. We use the Mie Theory to study the optical properties of various nanoparticles.
Surface Plasmon Resonance (SPR) is the collective oscillation of the free electrons in metallic nanoparticles (NPs), depicted in Figure 3.
The refractive index (n) dictates the nature of light propagation in a material (Figure 4).
Figure 3: Surface Plasmon Resonance of metal nanostructures. [3]
Figure 4: Peak shifts in 100nm Au NP in different environment
METHODS
RESEARCH QUESTION: How do size and material affect the optical response of a nanoparticle?
HYPOTHESIS: There exists an optimum size and material (here, gold vs. silver) for nanoparticles that better detect changes in the cell environment.
To perform our scientific inquiry, we employed an analytical approach (equation-based) and a real 3D model (computational). Together, this allows us to compare and assess the validity of our work.
1. ANALYTICAL (PYTHON)
a. Solutions are exact, but apply to simple structures only (e.g. spheres).
b. Used to validate the accuracy of the base computational model.
c. Uses the PyMieScatt Python module. PyMieScatt provides a Python only interface for rapid Mie calculations.
2. COMPUTATIONAL (Lumerical FDTD)
a. Employs the use of the Lumerical FDTD Solver for modeling light interactions with nanostructures in real-time.
b. Used for any arbitrary models and for complex scenarios.
FDTD
Mesh (4nm)
Sphere (nanoparticle)
Light Source
TSFS (Total/Forward Scattering)
Simulated in the Time Domain
Figure 5: Lumerical FDTD Schematic.
We investigate Au and Ag NPs because their fabrication has been heavily studied and we can compare our results to previously recorded experimental data.
REFERENCES
[1] Sormberger. E. (n.d.). Cell - Images. Retrieved February 26, 2018, from http://pcpages.qc.cuny.edu/~esomberger100/Images.html
[2] Su, J., Hsu, W., Chou, C., Chang, C., & Sung, K. (2012). Digital holographic microtomography for high-resolution refractive index mapping of live cells. Journal of Biophotonics, 6(5), 416-424.
[3] Nanohybrids - Plasmonics Nanoparticles. (n.d.). Retrieved February 26, 2018, from https://nanohybrids.net/pages/plasmonics
RESULTS AND DISCUSSIONS
Extinction:
In Figures 6 and 7, we see that, in general, increasing nanoparticle diameter results in larger extinction values.
Optimal Selection:
In Figure 7, we see that Ag NPs possess resonant wavelengths at near-UV wavelengths, as well as a very large range of resonant wavelengths.
Au NPs possess resonant wavelengths in the visible spectrum and a smaller range of resonant wavelengths (near 550 nm).
As Au and Ag NP's diameter increases, resonant wavelength redshifts and also broadens.
Figure 6: Gold (Au) extinction spectras. Resonant wavelengths exist at 500-600nm.
Figure 7: Silver (Ag) Extinction spectras. Resonant wavelengths exist at 350-550nm
Figure 8: Extinction spectra of 120nm Au NP in select environments.
In Figure 8, we observe a peak shift in optical response as the cellular environment (i.e. refractive index) of the NP's is changed (Figure 8). This peak shift tells us changes in the NP environment have taken place.
FUTURE APPLICATIONS
1. Look for materials with sharper optical features to detect small changes in environment (refractive index).
2. Optimize size, shape and material cost to find the best performance-to-cost ratio.
3. Develop supervised Machine Learning technique to classify plasmonic optical spectra.
4. Develop a Machine Learning model that uses plasmonic optical response to predict nanoparticle location within a cell in real-time.
ACKNOWLEDGEMENTS
We thank the Department of Physics at UAB for startup funds.
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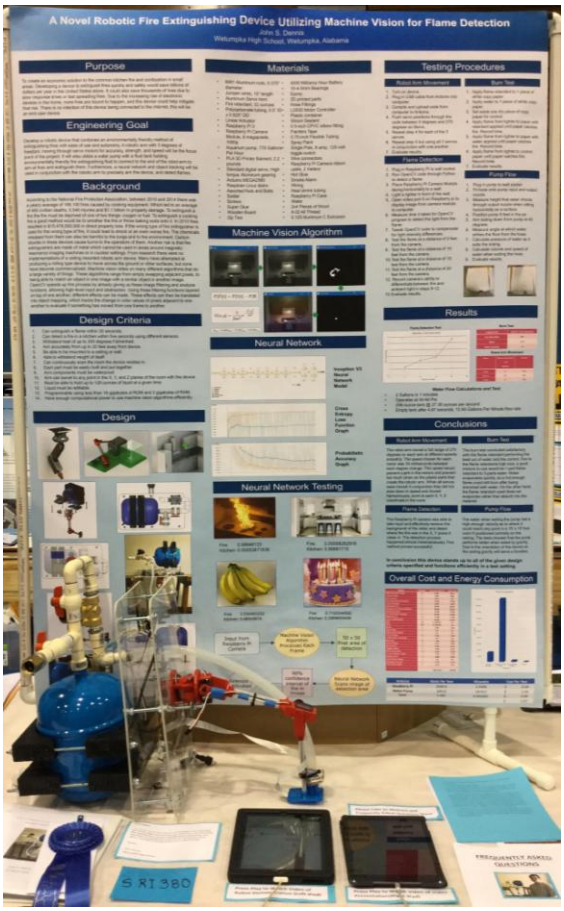
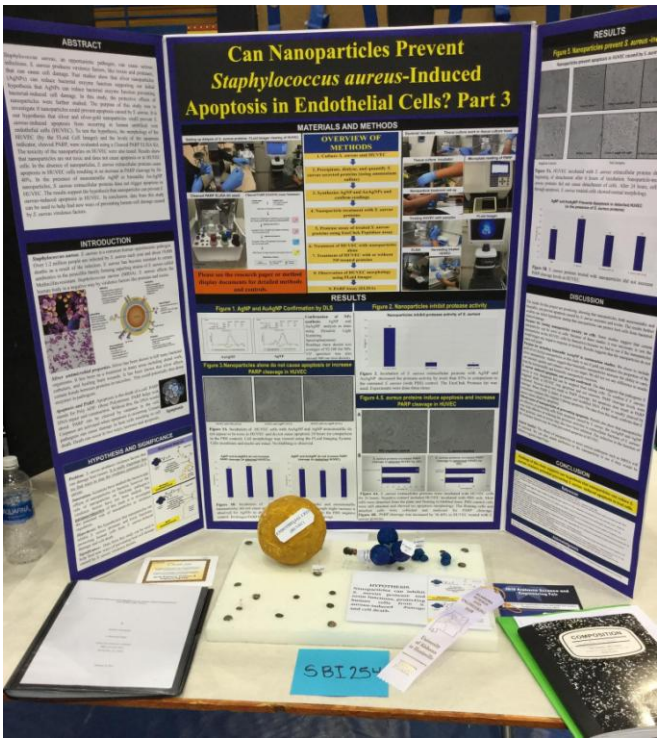

A Novel Robotic Fire Extinguishing Device Utilizing Machine Vision for Flame Detection
John S. Dennis
Walumpka High School, Walumpka, Alabama
Purpose
Engineering Goal
Background
Design Criteria
Design
Materials
Machine Vision Algorithm
Neural Network
Neural Network Testing
Testing Procedures
Results
Conclusions
Overall Cost and Energy Consumption
FREQUENTLY ASKED QUESTIONS
SRI380


Can Nanoparticles Prevent Staphylococcus aureus-Induced Apoptosis in Endothelial Cells? Part 3
ABSTRACT
INTRODUCTION
HYPOTHESIS AND SIGNIFICANCE
MATERIALS AND METHODS
OVERVIEW OF METHODS
RESULTS
CONCLUSION
DISCUSSION
SBI254

HEOS Awards

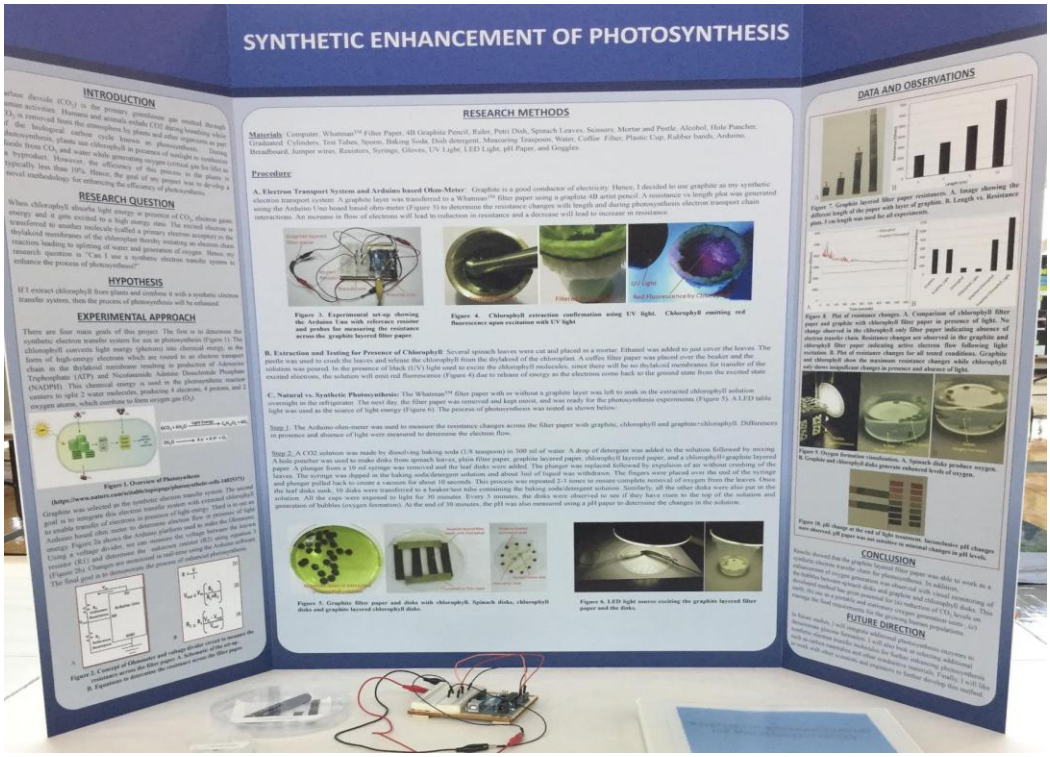
Recipients from HEOS and NASA Optics Awards (Junior)

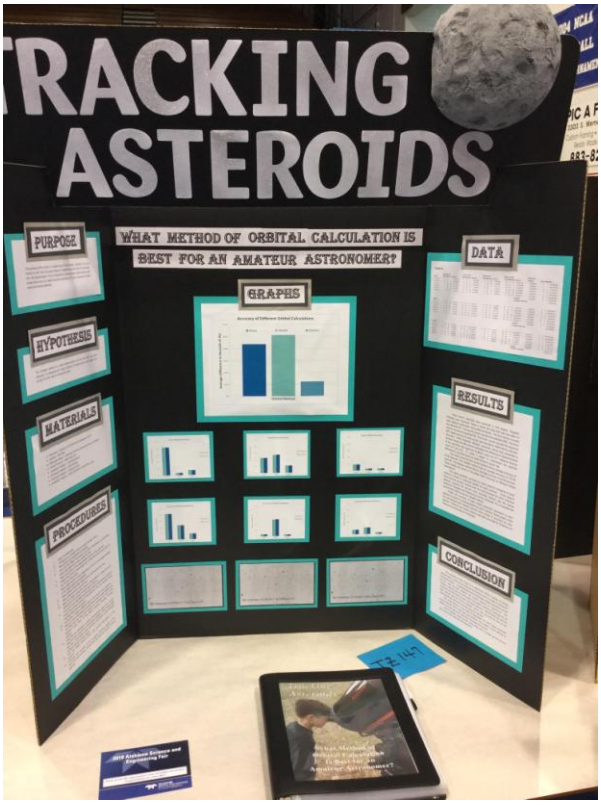
<u>Junior Division Awards</u>
First Prize ($150) – Ashwin Prabhakar,
"Synthetic Enhancement of Photosynthesis"
7th grade, Discovery Middle School, Sponsor William Smith (E-67)

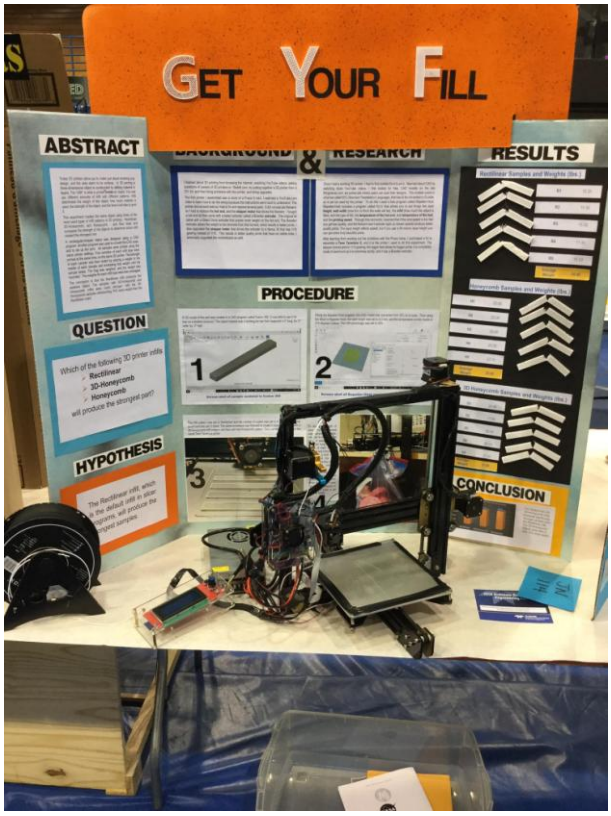
Second Prize ($100) – Jack Revera, "Tracking Asteriods"
5th grade, Horizon Elementary School, Sponsor Elizabeth Bero (Z-147)

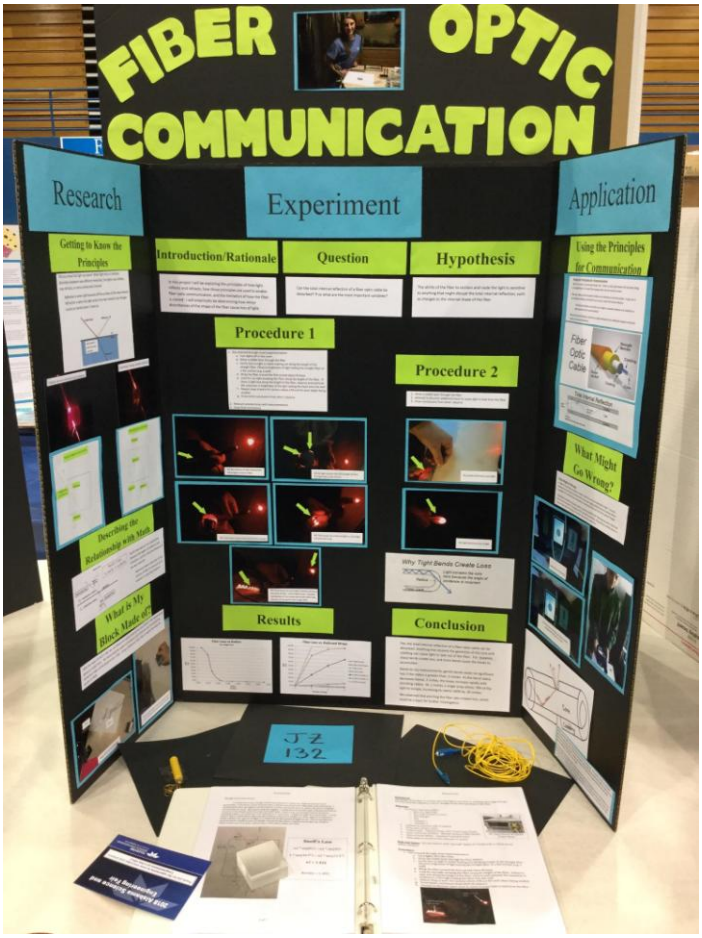
Third Prize ($50) – William Tomlinson, "Get Your Fill"
8th grade, St. Joseph Regional Catholic School, Sponsor Rita Magrini (N-114)

Honorable Mention Prize ($50) – AnnaBekah Cress
"Fiber Optic Communications"
7th grade, Libertas, Sponsor Jared Cress (Z-132)


SYNTHETIC ENHANCEMENT OF PHOTOSYNTHESIS
INTRODUCTION
RESEARCH QUESTION
HYPOTHESIS
EXPERIMENTAL APPROACH
RESEARCH METHODS
DATA AND OBSERVATIONS
CONCLUSION
FUTURE DIRECTION


RACKING
ASTEROIDS
WHAT METHOD OF ORBITAL CALCULATION IS BEST FOR AN AMATEUR ASTRONOMER?
PURPOSE
HYPOTHESIS
MATERIALS
PROCEDURES
GRAPHS
DATA
RESULTS
CONCLUSION


GET YOUR FILL
ABSTRACT
RESEARCH
RESULTS
PROCEDURE
QUESTION
HYPOTHESIS
CONCLUSION


FIBER OPTIC COMMUNICATION
Research
Experiment
Application
Getting to Know the Principles
Introduction/Rationale
Question
Hypothesis
Using the Principles for Communication
Procedure 1
Procedure 2
Fiber Optic Cable
What Might Go Wrong?
Describing the Relationship in My Math
What Is My Block Made Of?
Why Tight Bends Create Loss
Results
Conclusion
JZ
132

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