The Student Inquiry and Research Program at IMSA

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Illinois Mathematics and Science Academy (IMSA)

- Residential academy for gifted students
- IMSA is a Public School
- Approximately 650 students 10th-12th grade
- Approximately 50% female and 50% male
The Student Inquiry and Research Program (SIR)

• Open to 11\textsuperscript{th}-12\textsuperscript{th} grade students

• Purpose of SIR
  • Provide an authentic research opportunity for students
  • Opportunity to work alongside working scientists
  • Students learn to communicate their research findings

• NOTE!!! Not all SIR projects are science!
  • Science
  • Mathematics and Computer Science
  • Engineering
  • Humanities and Social Sciences
Presentation of SIR Results

• Communication of research is critical!
• IMSAloquium (April 21, 2021)
  • All SIR students give oral presentation of results
  • Abstracts are in IMSA Digital Commons
    https://digitalcommons.imsa.edu/sir_presentations/
• Japan Super Science Fair (JSSF)
• International Student Science Fair (ISSF)
• Publications in peer-reviewed journals (not common nor is it required)
The Student Inquiry and Research Program (SIR)

• Structure of SIR
  • Wednesdays (1 days) are for SIR projects
    1. Work with a non-IMSA mentor (off campus)
    2. Work individually with an IMSA mentor (on campus)
    3. Participate in an IMSA SIR course (on campus)
  • Students can participate in summer SIR

• Student Participation
  • 2019-2020: 239 students
  • 2020-2021: 184 students
Where our students do off-campus research (examples)

- Northwestern University Feinberg Medical School
- Northwestern University
- University of Chicago
- University of Illinois at Chicago
- University of Illinois Urbana-Champaign
- Fermi National Accelerator Laboratory
- Argonne National Laboratory
- Washington University, St. Louis
- Northern Illinois University
- Loyola University
On-campus SIR courses

- Drug Discovery
- Particle Physics (in conjunction with FermiLab)
- Econometrics
- Sea Phages (Viruses) (not currently offered during pandemic)
- Protein Engineering (not currently offered during pandemic)
- Molecular Modeling (not currently offered during pandemic)
- Money in Ancient History (not currently offered during pandemic)
Can this program be modeled at public high schools?

No

...and Yes...

I had a small group at Lockport Township High School

Suggestions if interested

Keep the group small

Encourage “library” research if lab work can’t be done

Present at IJAS or JSHS
Abstract/Project intention:

Analyzing medical images allows tracking of trends in types of medical images along with detecting problems in the images. In recent years, the technology to analyze these images has greatly improved so that thousands of similar images can be analyzed together. Python, which was the language used in this investigation, can be used to look at all of these images and gather information. To begin, a few datasets from Kaggle.com were examined, along with corresponding Python notebooks that had been written, which were found along with the datasets. From this I learned the proper method of programming in this context, which led me to write a few programs based on those I had seen. I worked with a histopathological cancer image dataset, with which I wrote a program.
Abstract/Project intention:

Microglia are macrophage cells found throughout the brain and spinal cord, and they function as the main form of active immune defense in the central nervous system. In a normal, healthy brain, resting state microglia have a ramified morphology. After a pathological event, however, microglia transform into an activated form that has amoeboid morphology, by sensing factors that trigger cellular remodeling into the active state. Receptor-induced Ca2+ signals play a central role in microglial activation and function. Calcium signals are maintained by a process involving store-operated calcium entry (SOCE), namely the opening of plasma membrane Ca2+ channels after the release of Ca2+ from intracellular stores. Once depletion has occurred, stromal interaction molecules (STIM) sense the reduced level of Ca2+ and in response, activates the channel protein Orai and promotes Ca2+ refilling. SOCE dysregulation may trigger a disruption of intracellular Ca2+ signaling in glial cells, resulting in the pathogenesis of neurodegenerative diseases. In many immune cells, SOCE plays a central role to calcium signaling, however, it is not yet known whether this is the case with microglia. We hope to understand the properties of SOCE for microglia activation, and how extrinsic factors such as the bacterial lipopolysaccharide (LPS) protein, which activates microglia, affects SOCE. These studies will help illustrate basic calcium signaling in microglia as well as how the pathway is activated by microglia activation.
Abstract/Project intention:

The Collins-Soper angle, referred to as \(\cos(\Theta^*)\), measures the angle of the negatively charged lepton in dilepton events with respect to the beam axis. When we reconstruct events that are simulated using Monte Carlo, we sometimes encounter situations where both leptons in the dilepton pair share the same sign. This sign error originates from our particle detector because the curvature of high-energy electrons is hard to measure. However, the calculation of \(\cos(\Theta^*)\) requires the leptons to have opposite signs. Rather than randomly assigning charges to the lepton and antilepton, we determined that we should trust the sign of the particle with the lower pseudorapidity. Instead of guessing correctly half of the time, our new strategy identified the negatively charged leptons at a 70% success rate. Using the modular framework that we built to analyze \(\cos(\Theta^*)\), we have continued to investigate the behavior of our simulated data by looking at acceptance, migration, and mass resolution.
SIR website

https://www.imsa.edu/academics/student-inquiry-and-research-sir/
Dave and Sowmya would like to acknowledge the great work of our SIR Administrative Assistant - Ms. Cathy Cunz