INDIVIDUAL WINNERS

Brian Huang of Fresh Meadows, NY, earned top individual honors and a $3,000 scholarship for developing a theorem that offers insights into the formation of black holes.

Brian Huang, a **senior** at Hunter College High School in New York, NY, won the individual category for his project entitled, “On Sufficient Conditions for Trapped Surfaces in Spherically Symmetric Spacetimes.”

Brian’s work built on a previous paper published in 1988 about the basic properties of black holes and curved space-time. For his project, he built a new mathematical model describing the structure inside black holes.

As much of the scientific community—and society at large—is discussing recent breakthroughs in proving the existence of gravitational waves, Brian’s theorem can provide a new way to interpret the data that scientists are collecting from LIGO (Laser Interferometer Gravitational-Wave Observatory) and the Virgo collaborations.

Judge quote: "Brian’s work offers foundational insights into the nature of time, space and gravity. Everyone knows about black holes, but what he has done is look at the underlying theory and determine new conditions relevant to black hole formation," said competition judge Dr. Tina Kahniashvili, an Associate Research Professor in the Department of Physics at Carnegie Mellon University. "This is the type of research people will be doing more intensely since the detection of gravitational waves."

Kenneth Jiao of Birmingham, AL, earned top individual honors and a $3,000 scholarship for discovering a new role of genes that could link to breast cancer metastasis.

Kenneth Jiao, a **senior** from Indian Springs School in Indian Springs Village, AL, won the individual category for his project entitled, "Retain CHD7, an Epigenetic Regulator, in the Nucleus to Combat Breast Cancer Metastasis."

Kenneth discovered a new role of the gene and its molecular processes that could link to breast cancer metastasis, which occurs when cancer cells spread from a primary site to distant organs. His research could lead to an improved molecular understanding of the growth and prognosis of breast cancer, as well as better methods of developing treatments for patients with breast cancer.

An estimated 90 percent of breast cancer deaths are a result of metastatic disease, either at diagnosis or recurrence. And, according to the Metastatic Breast Cancer Network, an advocacy group for patients with late-stage breast cancer, all deaths from breast cancer result from the

spread of breast cancer cells to other vital organs such as the bones, lung, liver or brain. Despite great progress in cancer therapy, treatments to cure metastatic breast cancer do not exist.

Judge quote: "Kenneth's research could bring scientists one step closer to developing a new biomarker for breast cancer metastasis and saving lives," said competition judge Dr. Z. Jeffrey Chen, D. J. Sibley Centennial Professor of Molecular Biosciences at The University of Texas at Austin. "It's rare to see this level of progress achieved in an independent project. Kenneth's work is phenomenal, and could help reveal the underlying mechanisms in breast cancer metastasis."

Andrew Komo of Bethesda, MD, earned top individual honors and a $3,000 scholarship for developing a coded system that protects online auctions from threats, such as cheating and fraud.

Andrew Komo, a **senior** at Montgomery Blair High School in Silver Spring, MD, won the individual category for his project entitled, "Cryptographically Secure Proxy Bidding in Ascending Clock Auctions."

Andrew developed a cryptographic protocol designed to protect online auctions from threats including collusion and fraud by prioritizing privacy. Bidders' bids are completely private from all other parties until the close of the auction. Despite this, auctioneers can be certain that these hidden bids are valid and know when to draw the auction to a close. Furthermore, the protocol is constructed in such a way that bidders can ensure an auction has run correctly once cryptographic information is revealed at the close of the auction, guaranteeing them an honest purchase price.

Andrew's system could be used for large-scale auction sites that manage billions of dollars of transactions, often run by governments. Each year, for example, the FCC auctions off bands of the electromagnetic spectrum to communications and media companies, which need access to this resource for communications such as cell phone, radio and television broadcasts. With Andrew's system in place, such large-scale auctions could be carried out with more transparency, fairness and security.

Judge quote: "Andrew's work is very impressive. The system he devised pulls together a novel implementation of disparate results, and uses some clever innovation to boot," said competition judge Dr. Jolyon Bloomfield, Lecturer in Physics at MIT. "I would not be surprised if some variation of this system actually becomes the standard for conducting these large-scale auctions in the future."

Sriharshita Musunuri from Mill Creek, WA, earned top individual honors and a $3,000 scholarship for designing a new polymer nanoparticle that could diagnose and treat a deadly form of sepsis caused by bacterial infections.

Sriharshita Musunuri, a **senior** from the Henry M. Jackson High School, in Mill Creek, WA, won the individual category for her project titled, “Computational and Experimental Design of MIP Nanoparticles: A Novel Theranostic Solution to Detect and Neutralize Endotoxins.”

Sriharshita’s project addresses a difficult challenge faced in U.S. hospitals every day: gram-negative bacteria that causes sepsis which can cause organ failure in patients, and is the leading cause of death in US hospitals. Lipopolysaccharides (LPS) are harmful biomolecules found on the surface of gram-negative bacteria and are responsible for over 50% of sepsis cases. Shriharshita designed a new polymer nanoparticle that captures the harmful LPS bacterial endotoxins and could be used to treat and diagnose the bacterial infection.

Judge quote: “Sriharshita’s research leads to faster diagnostic testing in clinical settings that could reduce patient deaths from sepsis,” says Dr. Brittany Needham, a postdoctoral scholar at Caltech. “She approached this problem in a far more comprehensive way than others have and her method was particularly impressive. She figured out a way not only to detect this life-threatening bacteria, she also found a way to help prevent it.”

Franklyn Wang, of Falls Church, VA earned top individual honors and a $3,000 scholarship for solving a longstanding mathematical problem that has a wide range of potential applications, from creating better algorithms for telecommunications to designing safer infrastructures, like roads and bridges.

Franklyn Wang, a **senior** at Thomas Jefferson High School for Science & Technology in Alexandria, VA, won the individual category and a $3,000 scholarship for his project entitled, “Monodromy Groups of Indecomposable Rational Functions.”

Using algebra, Franklyn worked through a complicated mathematical problem that has a wide range of potential applications, from creating faster, more secure algorithms for telecommunications to designing safer infrastructures, like bridges resistant to strong winds. His work is broadly relevant to a variety of problems in cryptography and various mechanical systems.

Through his project, Franklyn classified the local singularities and behavior of rational geometric functions. In mathematics, a singularity is a point at which a given mathematical object is not defined, or a point where it fails to be well-behaved in some predictable way. Building on several previous studies in the field, Franklyn’s work brings this mathematical problem closer to completion.

Judge quote: “For as long as I can remember, mathematicians have been obsessed with mathematical functions that behave erratically," said competition judge Dr. Tom Morley, Professor Emeritus at The Georgia Institute of Technology. "Franklyn worked through a professional piece of mathematics that will almost surely be published in a top mathematical journal. The findings are a significant step toward the understanding of applications requiring unusual function behavior.”

Neil Wary of Elmhurst, IL, earned top individual honors and a $3,000 scholarship for using CRISPR/Cas9 to investigate a rare life-threatening genetic disease called CHARGE syndrome.

Neil Wary, a **senior** from the Illinois Mathematics and Science Academy in Aurora, IL, won the individual category and a $3,000 scholarship for his project titled, “Connecting the Chromatin Remodeler CHD7 in the Regulation of CHARGE Syndrome and Autism.”

Neil’s project used a groundbreaking new gene-editing tool called CRISPR/Cas9 to investigate a rare life- threatening genetic disease called CHARGE syndrome. CHARGE affects many areas of the body, and is characterized by impairments in vision and the central nervous system, heart defects, blockages of the nasal passages, growth retardation, genital abnormalities, ear anomalies and sometimes deafness. Children with CHARGE often experience delays in development and communication, as well as behavioral difficulties including autism.

Often, the difficulty with studying human diseases is recreating them in the lab. Using CRISPR, Neil developed a “disease-in-a-dish” model of CHARGE, recreating the genetic disorder in a petri dish to better understand it and to study potential treatments. Using the method, he discovered a unique link between the genetic mutations that cause CHARGE and blood vessel dysfunctions associated with heart and other vascular features that characterize the syndrome. The research could one day lay the groundwork for treating the disease.

Judge quote: “Neil Wary’s devotion to studying CHARGE syndrome—a life-threatening genetic disorder—was truly admirable,” said Dr. Pinar Zorlutuna, assistant professor in the Department of Aerospace and Mechanical engineering at Notre Dame University. “From designing his genetic model to conducting the experiment using the CRISPR gene-editing tool, Neil has done great work in discovering what could be a significant link between vascular dysfunctions and this devastating disease.”

TEAM WINNERS

Gabrielle Liu – Junior from Ravenwood High School in Brentwood, TN, resides in Nashville and Allen Liu – Senior from The McCallie School in Chattanooga, TN, resides in Chattanooga

Gabrielle Liu (junior) of Nashville, TN, and **Allen Liu (senior)** of Chattanooga, TN, shared the $6,000 team scholarship for developing a faster computational system that could lead to improvements in data processing speed and facial recognition software.

Gabrielle Liu of Nashville, TN, and Allen Liu of Chattanooga, TN, won the team category for their project entitled, “Neural Networks without Multiplications.”

Gabrielle and Allen came up with a new mathematical concept for improving the running time in convolutional neural networks—a type of artificial intelligence computing system used in new technologies like facial recognition and driverless cars.

By replacing multiplications with addition operations, Gabrielle and Allen's mathematical framework could lead to significant improvements in data processing speed and machine learning. Today, the computational time for pattern and facial recognition can sometimes limit the application of these technologies to real-world problems, a limitation that will increase in importance as these technologies continue to advance.

Judge quote: "Gabrielle and Allen won not only because the mathematics for the project were outstanding, but because their framework has broad and important applications across the field," said competition judge Dr. Eva Lee, Director, NSF-Whitaker Center for Operations Research in Medicine and HealthCare and Virginia C. and Joseph C. Mello Chair Professor of Industrial and Systems Engineering at The Georgia Institute of Technology. "Their results allow for faster running time for computer vision and pattern recognition, and may open up real-time detection possibilities that lead to major breakthroughs for the field."

Jillian Parker – Junior at Half Hollow Hills High School West in Dix Hills, NY, resides in Dix Hills, Arooba Ahmed – Junior at Half Hollow Hills High School East in Dix Hills, NY, resides in Melville and Jiachen Lee – Junior at Half Hollow Hills High School East in Dix Hills, NY, resides in Dix Hills

Jillian Parker (junior) of Dix Hills, NY, **Arooba Ahmed (junior)** of Melville, NY and **Jiachen Lee (junior)** of Dix Hills, NY, shared the $6,000 team scholarship for their project, which identified a protein that was not previously known to play a role in cell division and could potentially play a role in a number of diseases, including Alzheimer's disease.

Jillian Parker, Arooba Ahmed and Jiachen Lee won the team category for their project entitled, "The Cilium and Centrosome Associated Protein CCDC11 is Required for Cytokinesis via Midbody Recruitment of the ESCRT-III Membrane Scission Complex." Jillian attends Half Hollow Hills High School West in Dix Hills, NY and Arooba and Jiachen both attend Half Hollow Hills High School East in DixHills, NY.

Jillian, Arooba and Jiachen found that when the presence of a specific protein (CCDC11) is decreased in a cell, the division of cells that produces new cells cannot be carried out properly. This finding has implications in
understanding the genetic basis of many diseases, including neurodegenerative diseases, such as Alzheimer's disease, amyotrophic lateral sclerosis (ALS) and Huntington's disease.

While many proteins are known to be involved in successful cell division, this is the first time that CCDC11 has been shown to be part of this process. CCDC11 is also known to be involved

in early development to ensure that organs develop on the correct side of the body. Understanding its role in cell division has the potential to better understand a number of diseases, including heart disease.

Judge quote: “This discovery can help better understand the complex defects that patients with mutations in the CCDC11 gene present in the clinic,” said competition judge Dr. John Woolford, Professor, Department of Biological Sciences at Carnegie Mellon University. “This could alert us to the fact that people who present with one disease or problem might have other seemingly unrelated problems. This could help us understand how different diseases stem from to the same genetic mutation.”

Katherine Tian – Junior at The Harker School in San Jose, CA, resides in Cupertino and Swapnil Garg – Senior at The Harker School in San Jose, CA, resides in Sunnyvale

Katherine Tian (junior) of Cupertino, CA, and **Swapnil Garg (senior)** of Sunnyvale, CA, shared the $6,000 team scholarship for developing a potentially more accurate way to classify kidney cancer tumors. They were among 101 students selected to compete in regional competitions across the country this month out of a pool of more than 1,860 projects submitted to the competition.

Katherine Tian and Swapnil Garg, both of The Harker School in San Jose, CA, won the team category for their project entitled, "Automated Clear Cell Renal Carcinoma Grade Classification with Prognostic Significance."

Katherine and Swapnil used computational techniques and machine learning to develop a potentially more accurate way to classify kidney cancer tumors as high- or low-grade—an important indication of how fast the cancer might spread. Kidney cancer is among the 10 most common cancers in both men and women. The current system used to stage kidney cancer—or renal carcinomas—is highly subjective, which can lead to disagreement between pathologists on how to approach treatment. Katherine and Swapnil’s classification method could provide a valuable, objective second opinion for pathologists, helping them make more accurate diagnoses and thus better treatment plans. In their study, Katherine and Swapnil’s system had a better correlation with disease outcome than traditional classification methods.

Judge quote: “I was particularly impressed with Katherine and Swapnil’s depth of understanding of renal carcinomas,” said competition judge Dr. Ky Lowenhaupt, Lab Manager and Research Specialist at MIT. “Because of their extensive background on the issue, they were able to use an existing strategy that, when applied to the problem of kidney cancer, is very cutting edge. They also clearly presented the strengths and limitations of their research, and how it could be applied in the future.”

Chelsea Wang – Senior at Fossil Ridge High School in Fort Collins, CO, resides in Fort Collins, Rachel Li – Junior at Spackenkill High School in Poughkeepsie, NY, resides in Poughkeepsie and Jainil Sutaria – Senior at Ardsley High School in Ardsley, NY, resides in Ardsley

Chelsea Wang (senior) of Fort Collins, CO, Rachel Li (junior) of Poughkeepsie, NY, and Jainil Sutaria (senior) of Ardsley, NY, won the team category and will share a $6,000 scholarship for their project entitled “Synthesizing and Characterizing Novel Gelatin and Pluronic F127 Hybrid Hydrogels as a Barrier Membrane for Guided Bone Regeneration Following Periodontitis."

Chelsea, Rachel, and Jainil developed a novel gel compound that acts as a barrier, preventing gum tissue from invading the bone tissue affected by gum disease, allowing guided regeneration of the bone surrounding the tooth root.

People with advanced periodontitis are at risk of bone loss and tooth loss, which in some cases can be reversed with regenerative procedures. The team’s research presents a promising new method for guided bone regeneration, a procedure in which surgically placed barrier materials prevent cells from the inflamed gum to enter the area of the damaged bone, allowing bone regeneration by osteoblast (bone cells) repopulation.

Judge quote: “The team’s research is an important contribution to the field of restorative dentistry and our understanding of the barrier materials allowing guided bone regeneration. It could have an impact on the lives of millions suffering from periodontitis," said competition judge Dr. Janet Zoldan, Assistant Professor at The University of Texas at Austin in the Department of Biomedical Engineering. “This project ultimately helps solve the tricky problem of having an effective barrier material that is strong enough to withstand the shearing forces applied on and by teeth yet degrades over time once bone is regenerated. I was very impressed with the team’s depth of knowledge of the field, techniques they used, and their thorough work.”

Anlin Zhang – Senior at Canyon Crest Academy in San Diego, CA,
Rachana Madhukara – Sophomore at Canyon Crest Academy in San Diego, CA, and
Kevin Ren – Senior at Torrey Pines High School in San Diego, CA, all reside in San Diego

Anlin Zhang (senior), Rachana Madhukara (sophomore) and Kevin Ren (Senior) from San Diego, CA won the team category and will share a $6,000 scholarship for their project entitled, “Epidemic Dynamics on Symmetric Networks.”

Anlin, Rachana and Kevin applied mathematical models to better identify and analyze the movement of dangerous infectious disease.

Recognizing the role that social interactions and social cliques, like families, groups or cities, play in the spread of disease, they created a new mathematical model to more precisely

analyze the spread of infectious disease. The threat of disease epidemics continues to be a global concern, and emergency preparedness and public health experts are constantly looking for innovations in the way they assess, track and predict the spread of health crises like Ebola, SARS, cholera and other diseases.

Judge quote: "The results provide novel insights into the fascinating topic of how diseases spread that should concern us all, as we are more closely linked as humans than ever before," said Dr. Richard Küng, a postdoctoral scholar in the Department of Computational and Mathematical Sciences at Caltech. "This work combines creativity in model design with a rigorous mathematical analysis. Typically the more realistic the model, the more complicated it is, but what was so remarkable about this project was that they were able to make models that are both realistic and simple enough to provide novel insights in how diseases may spread from a single patient and location like a child at school, to other children at the same school, to parents, and on to other cities, states and countries."

Brandon Zhu – Senior at Herbert Henry Dow High School in Midland, MI, and Daniel Zhang – Senior at Herbert Henry Dow High School in Midland, MI, both reside in Midland

Brandon Zhu (senior) and **Daniel Zhang (senior)**, both of Midland, MI, shared the $6,000 team scholarship for research in the development of controlled-release drug therapies, which could increase the effectiveness, and decrease the side effects of pharmaceuticals. They were among 101 students overall selected to compete in regional competitions across the country this month out of a pool of more than 1,860 projects submitted for the competition.

Brandon Zhu and Daniel Zhang, both of Midland, MI, won the team category for their project titled "Release of Active Pharmaceuticals Using Capped Hyperbranched Polyesters."

In the long-term, the research could be applicable in the development of controlled-release drug therapies, to increase the effectiveness, and decrease the side effects of many pharmaceuticals. All medications have side effects, but when released into the body in a slower and steadier manner, there are a number of benefits, including decreased toxicity, increased effectiveness, and less frequent dosing. Brandon and Daniel's research involves an early-stage method using what's called "polymer drug conjugates" to regulate the release of certain pharmaceutical compounds. They're interested in how this method could be applied using common medications such as: naproxen for pain relief; salicylic acid, a common acne treatment; and hydrocortisone, used to treat a variety of skin conditions.

Judge quote: "The drug delivery pipeline is long and complicated, but the research of Brandon Zhu and Daniel Zhang is a significant first step," said Dr. Haifeng Gao, an associate professor in the Department of Chemistry and Biochemistry at the University of Notre Dame. "These students have come up with important scientific questions --and demonstrated their findings well--regarding how to

regulate the release of drug therapies in the human body, which is critical to making sure that medications are both safe and effective.”