April 2022

GEORGIA PATHWAYS

MAGAZINE

The STEAM of NASCAR

The Chemistry of Cosmetics / A STEAM Career

TAG
Technology Association of Georgia

TAG | TAG-Ed
Education Collaborative

The Technology Association of Georgia Education Collaborative (TAG-Ed) strengthens the future workforce by providing students with relevant, hands-on STEAM learning opportunities and connecting them to Technology Association of Georgia (TAG) resources. Formerly the TAG Foundation, TAG-Ed is a 501(C)(3) non-profit organization formed by TAG in 2000. Later, the organization's name was re-branded to TAG Education Collaborative to facilitate our role as the leaders for K-12 STEAM education in Georgia.

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Welcome to another issue of Georgia Pathways Magazine.

TAG
Technology Association of Georgia

A few weeks ago, we concluded the application process for our 2022 Summer Internship Program. Hosting companies are not only excited to embrace the new talent Georgia has to offer, but also to watch the emergence of a new generation of business tech leaders in the region and beyond. Dozens of 2022 applicants provide support for our hosting industries while fostering experience and opportunities for all participants.

There is no substitute for the mentoring and learning opportunities that will be provided to this diverse group of interns. Past internship programs have fostered many successful young leaders who, with the support of their host companies, have discovered vibrant career paths that promise innovation and prosperity for all. Internships are critical in setting our students up for success, as students with internship experience have starting salaries that are $15,000 to $20,000 higher than those with no internship experience at all. And, at a time when talent shortage is at an all-time high, internship programs serve as meaningful pipelines for employers to find the talent of the future.

TAG and TAG-Ed continue to be optimistic about this and other career development offerings scheduled for 2022 and beyond. Our dedication to the professional development of Georgia's students and young professionals is unwavering, just like our commitment to the hosting companies across a variety of industries.

With the many programs and initiatives on our calendar, including Pathways To Leadership and Mentorships, Fellowships and Talent Acquisition events, Georgia Pathways Magazine will continue to expand our understanding of the importance and value of STEAM education and STEAM skills.

This April issue includes unique perspectives and career applications we may not have considered before, as previewed on the cover. Please enjoy and share this issue across Georgia in hopes of inspiring our workforce to broaden their paths and continue to develop as leaders.

Larry K. Williams
President
TAG / TAG-Ed

Larry K. Williams serves as the President and CEO of the Technology Association of Georgia (TAG) and President of the TAG Education Collaborative (TAG-Ed). TAG-Ed's mission is to strengthen Georgia's future workforce by providing students with relevant, hands-on STEM learning opportunities by connecting Technology Association of Georgia (TAG) resources with leading STEM education initiatives.

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CYBERWARRIOR FOUNDATION
CyberWarrior.org/diversity

WORKFORCE DIVERSITY PROGRAM

The CyberWarrior Foundation, in partnership with the Security & Infrastructure Security Agency (CISA), is creating high-wage career opportunities for historically underrepresented communities, including the underserved, women, veterans, and underemployed individuals.

Our mission is to bridge the technology skills and diversity gaps by providing cybersecurity training, employment opportunities, and transitional support necessary for people to gain the knowledge, skills, and abilities for career opportunities and growth. We understand that strength lies in differences, not in similarities, so diversity is our core value, and we actively promote it through the cybersecurity industry.

Our Cybersecurity Workforce Development and Training Program for Underserved Communities, in coordination with the Department of Homeland Security and CISA, serves people from the Northeast (CISA Region #1) and the Southeast (CISA Region #4).

If you are from a state on one of the following maps, visit cyberwarrior.org/diversity for more information.

BOOTCAMP PROGRAM OVERVIEW

CyberWarrior has developed a training that brings together vocational lab-driven exercises delivered by ethical hackers and industry experts, combined with the hands-on knowledge, tools, and certifications necessary to launch a career in cybersecurity. Further, the content was built using the National Institute of Standards and Technology (NIST) framework and mapped to the National Initiative for Cybersecurity Education (NICE).

CLASSROOM AND LAB TRAINING

4	800	28	7
national recognized certifications	Hours	weeks	proprietary technical courses

INDUSTRY-RECOGNIZED CERTIFICATIONS + PROPRIETARY TECHNICAL COURSES

- CompTIA Network+
- CompTIA Security+
- EC-Council Certified Ethical Hacker (CEH)
- EC-Council Certified Network Defender (CND)
- Malware Analysis
- Incident Response
- Security Automation
- Firewalls and IDPS
- Vulnerability Management
- Package Analysis
- Security Monitoring

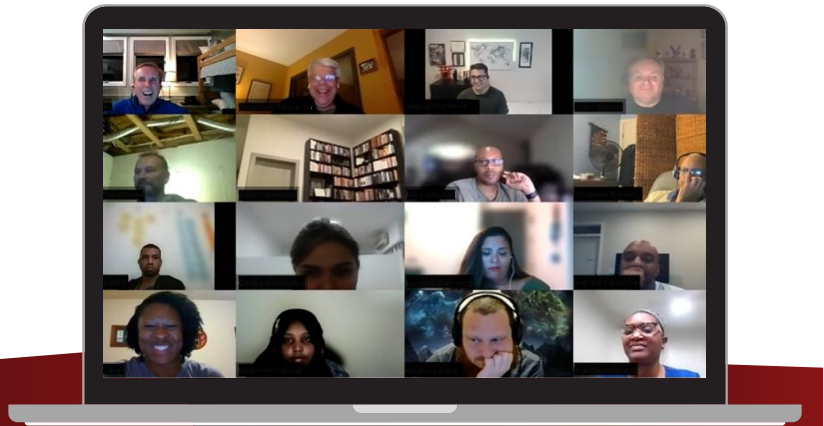
Our students have the opportunity to receive 27 college credits, making CyberWarrior Cybersecurity Bootcamp the most comprehensive cybersecurity program today.

Our innovative Career Hacks course delivers the soft skills to engage in the “business” of cybersecurity. Moreover, CyberWarrior exclusively connects the students with industry practitioners (recognized CISOs, security directors, and more) to share real-world experiences, “a day in the life” of a Cybersecurity professional, what the student should expect upon graduation, and receive personal mentorship each week.

DELIVERY METHODOLOGY

CyberWarrior’s curriculum is refined for online learning and is purposely dynamic to meet the evolving needs of our employer partners. Our model includes 4-hour online classes with live instructors, quizzes, and hands-on labs, in individual and group settings. Instructors are experts who can give real examples of our content’s relevance during an attack.

Launch your cybersecurity career in just six months. To learn more, visit us at CyberWarrior.org/diversity.



Parents reading this magazine often notice the shortcomings of STEM education in Elementary and Middle School education. While public and private schools are making strides in growing their STEM programs, supplementary STEM education is also an option. This recovery or advancement can come through summer camps, after-school enrichment programs, and in-school field trips. There are more providers every year, but choosing the right one for your child can be challenging.

When evaluating supplemental STEM education programs for a child, consider the reputation of the company and the social fit for your child. Children interested in STEM often look for like-minded friends that they are not meeting in their regular school activities.

Attending a supplementary STEM program can allow the child to learn new skills from positive role models and make life-long connections with like-minded friends.

At Club SciKidz, we know that you want to be the parent who chooses the best camp for your kid. In order to do that, you need a fun and safe camp where your child will learn new skills from positive role models. The problem is that planning your kid's summer activities can be overwhelming. We believe you can plan a great summer experience for your kid. We understand, we have kids, and our children's well-being is our top priority, which is why we're proud that 70% of our campers each year come from referrals and repeat business.

https://atlanta.clubscikidz.com/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The STEAM of NASCAR

An 8 part series

By Wayne Carley

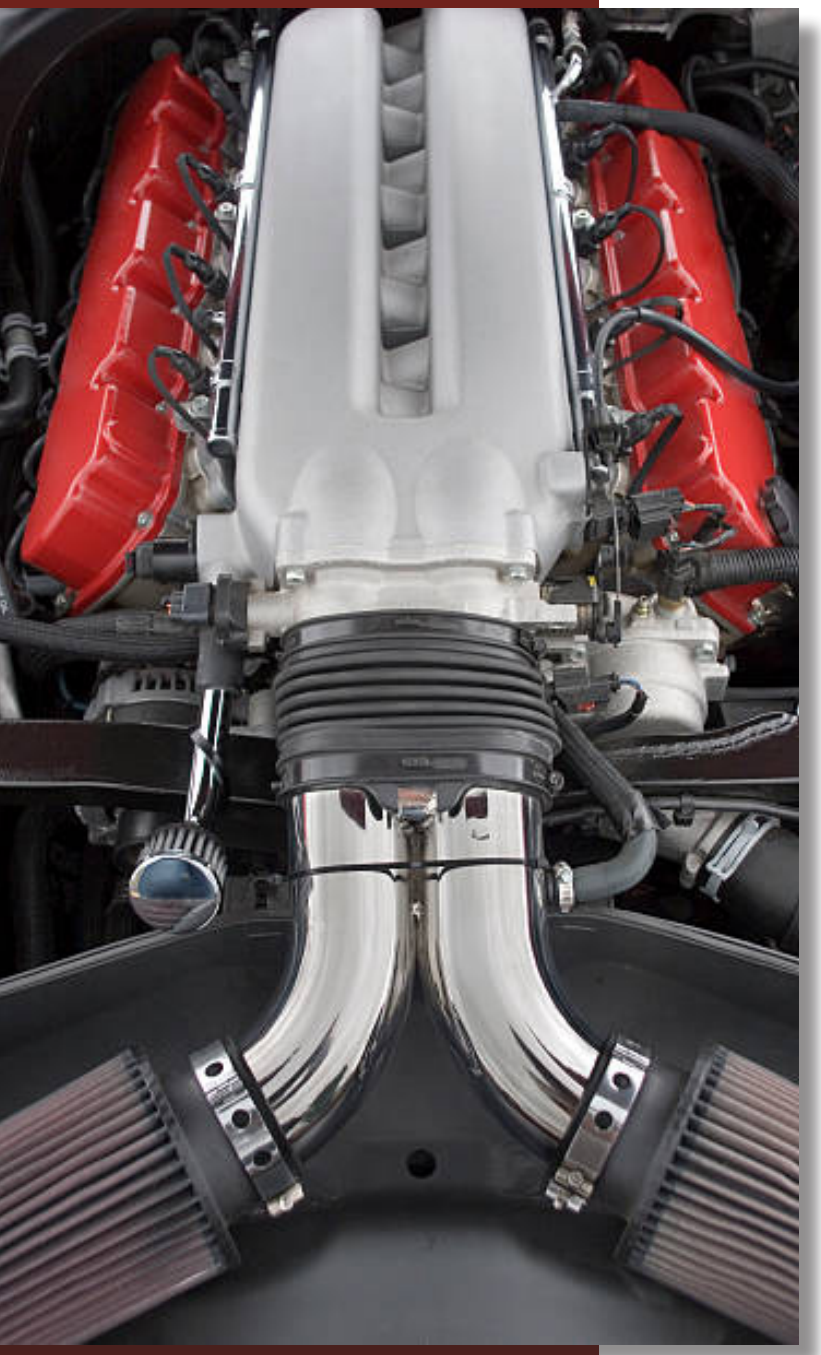
The science, technology, engineering arts and math of NASCAR and motor sports are extraordinary and an excellent example of how the array of career opportunities available within this sport fit most any career category you can imagine. Motor sports is a broad and complex industry generating billions of dollars with diverse arena's and racing associations that include NASCAR, Formula One, Drag Racing, Speed Boats, motorcycles, trucks, carting and so many more, not to mention the tracks and venues that host these events globally.

This is the first in a series of articles on the STEAM of NASCAR, highlighting many of the career paths available and how the components and responsibilities of a racing team and their car incorporate science (the systematic accumulation of knowledge), technology (the practical application of the science), engineering (the problem solving and decision making), and mathematics (the science of numbers and their operations, interrelations, combinations, generalizations, and abstractions) and arts (creative processes).

In the beginning, the race cars were driven off the street and onto the track, but as performance and technology advanced, dramatic changes were made to cars resulting in the racing machines of today that are more complicated and technologically sophisticated. Our thanks continues to go out to Bill France who in 1947, organized the first meeting to discuss the creation of the National Association for Stock Car Auto Racing - NASCAR, and the rest is history.

This first of 8 articles will consider one basic feature of NASCAR, which is the engine itself and the STEAM therein. We'll give a brief overview of the structure and limitation rules associated with the physical and mechanical aspects of the car, and focus on the mechanics each team employees to carry their driver to victory. Future articles will include the physics of aerodynamics, physiology and psychology associated with the driver, track design, new innovations, and a look down the road at where NASCAR may be in 5 years.

"There's nothing stock about a stock car"



NASCAR has very specific guidelines of race car construction that must be followed precisely and are checked prior to each racing event, whether it is the teams short track car or long track car. These limitations can level the playing field in most regards, promoting a more competitive racing experience regardless of the financing available to the team. The idea is to make the race more about driver ability and less about a possible unfair advantage through financing or unusual components.

Over time, modifications to the car have continued, to increase performance and safety, with the only differences between teams being limited to the body shell and engine. The basic shape of the body, fuel, tires, suspension, transmission, and electronics are identical.

Through the science (accumulated knowledge) of racing, NASCAR determined their preferred engines to be used, manufactured by Ford, Chevrolet and Toyota. In general, the gasoline combustion engine (piston driven) is limited to 358 cubic inches (v8) and 675 horsepower with an approved list of mechanical components to be incorporated in their final design.

Engine Science / The Job of the Mechanic

The engines purchased by the teams may be about equal in most regards, but it's the teams mechanics who transform the ordinary into extraordinary.

Engine mechanics are a true form of "engineer" best defined as problem solvers and decision makers. The possible problems being, why didn't the engine perform as expected and how can we fix that? Keep in mind that this career path goes far beyond NASCAR to every engine in every car, ever built – and those yet to come. If you like to work with your hands, this career path is for you.

Each team is allowed to make ever so slight physical changes to the engine that on the surface may seem inconsequential, but over the course of a few hours and hundreds of miles, may result in:

- great distances ahead or behind the competition
- reliability of function issues
- fuel efficiency differences
- responsiveness and power output

A few of those approved changes are minor machining of cylinder inner dimensions (increase in compression and power), and changes in the mass (size and weight) of the overall engine and a few components (creative).

These changes are limited but can be dramatic by the end of the day.

The "raw" engines are sold to the teams by their chosen manufacture (mentioned earlier) allowing the team mechanics to begin their total rebuild to include their preferred modifications based on past builds - but the limits are firm and inspected thoroughly by NASCAR.

The implementation of these minor modifications is documented in great detail, both electronically and physically, during and after the race. This data is used for later review to prepare for the next engine build and race. This accumulated knowledge (science) makes all the difference in the world to the mechanics as they decide (engineering method) what worked and what didn't after the last build.

The "how do we do better" equation (problem solving) is a post-race ritual as construction of the next engine is already underway. A millimeter here or there, an extra turn of the screw left or right, one less ounce or a minor shift in center of gravity may make all the difference in next weeks' race results. The 1-2% of mechanicals variations made can win or lose the event, and it's certain that all 40 of the NASCAR teams are doing the same weekly.

Common questions mechanics may ask during their engine design are:

- How long do we have to run?
- What engine temperatures can we tolerate?
- What's the weather forecast?
- What weaknesses do we anticipate during the race and can we adjust in the pit?
- How did the last build perform?

After each race, the mechanics complete disassemble the engine and inspect every part. Some parts may be reused while others are discarded. It's here where the mechanic (engineer) gains important information (science) about the wear and tear of mechanical components, thus helping to make critical decisions (engineer) to improve the next outcome. Since there is a small group of mechanics involved on every team, collaboration and communication are also critical during post race evaluation and decision making

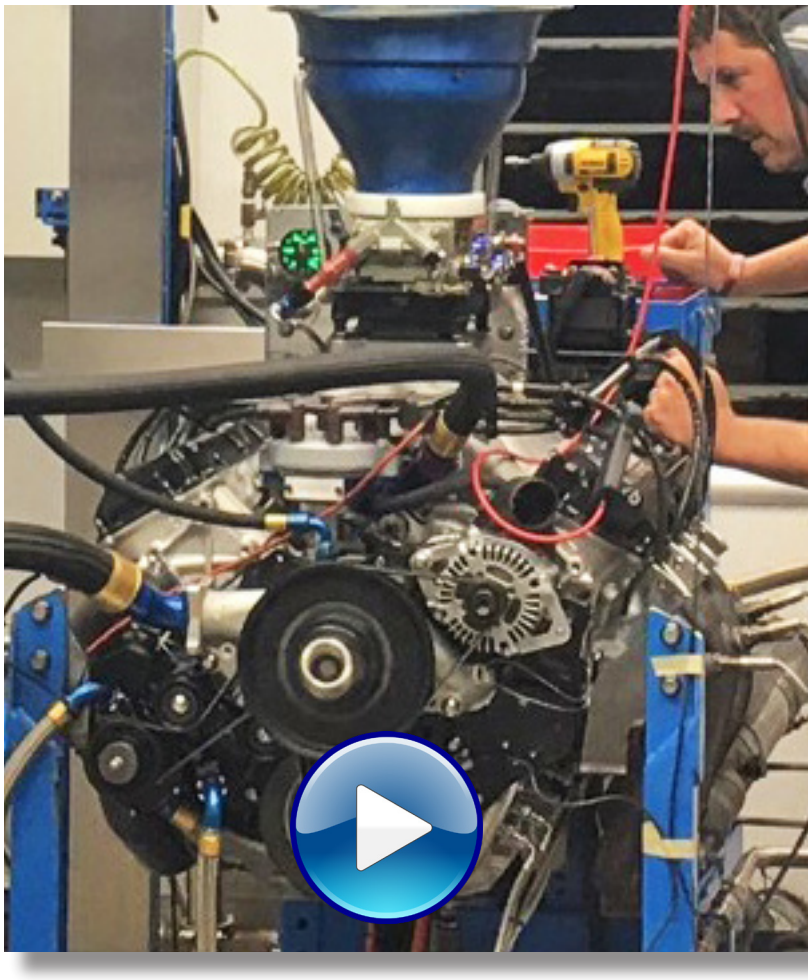
for future builds.

We've talked about the science and engineering, so let's move on to the technology and mathematics of NASCAR engines. Technology is defined as the "practical application of science", so the accumulated knowledge we've described is now applied through more efficient use of available customizing, monitoring and efficiency of the engine.

Mechanics will explore alternate materials (approved), styles and effectiveness of a variety of parts to potentially solve problems, monitor performance electronically and catch potentially poor trends in engine behavior and perhaps find that critical little tweak that will give them the edge they have been looking for.

In the shop, as the build is underway, an array of tools from wrenches and screw drivers, to microscopes, scanning equipment, vibration sensors and pressure gauges will be used to examine the metals, expansive behaviors and responses from the engine during testing. Consider it a complete physical, over and over, until race day.

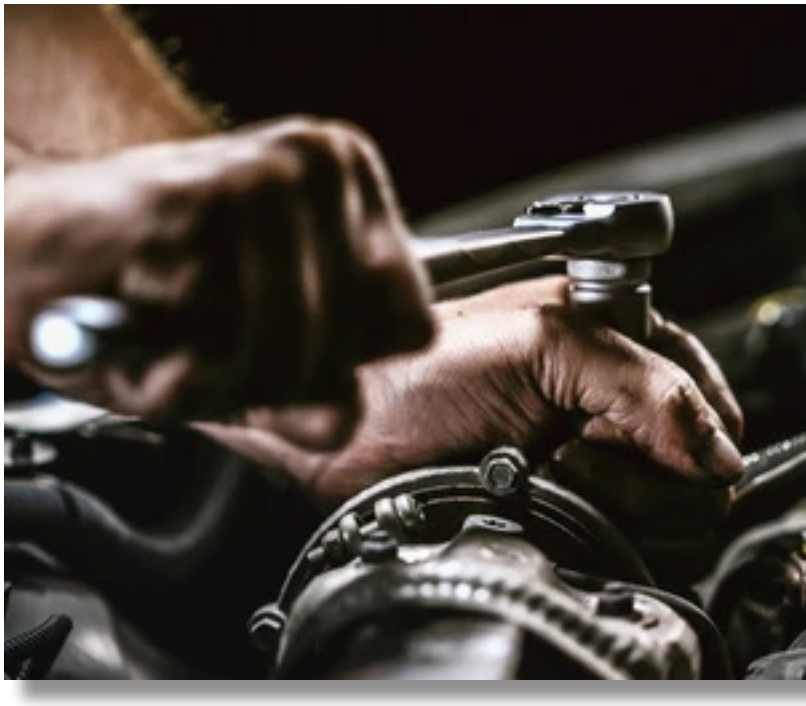
Monitoring an engine's internal functions during its operation is an amazing opportunity to see into the heart of the power plant for the mechanics. Having the ability to monitor friction, pressures, temperatures, movement, part interaction, vibrations and power output provide the information needed for the mechanics to "fine-tune" the engine for what they hope is a winning combination.



The importance of mathematics in an engine build cannot be overstated. The typical combustion engine has about 200 parts that need to work as one to be most effective. How those parts fit together is a matter of micrometers (25,400 micrometers per inch) and must be measured precisely using tools such as:

- Micrometer Set
- Dial Bore Gauge
- Dial Caliper
- Snap Gauges

Knowing how to use these tools is certainly a systematic accumulation of knowledge (science). Using them effectively is a must as incorrect measurements during the build do not lead to the winners circle. As engines heat up, metals expand changing how many engine parts fit together, affecting function and performance. The mechanical engineer knows this, anticipates it, and compensates for it. After the post race tear-down, they learn from it.



So, with 40 cars on the track, all with essentially the same engine, it's interesting to see the wide variety of differences in engine performance, reliability and results at the checkered flag.

- Depth Micrometer
- Dial Indicator
- Magnetic Base
- Calibration Blocks
- Rod Bolt Stretch Gauge
- Height Micrometer
- Stroke Gauge
- Leakdown tester
- and Camshaft Lift Check, to name a few.

Next time in Georgia Pathways Magazine

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"In the slip stream"

NASCAR aerodynamics.


AdventHealth
BUSCH
Coca-Cola
GEICO
xfinity
CUP SERIES
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ICO's

BY WILLIAM ZIMMERMAN

An Initial Coin Offering (ICO) is an unregulated way of raising capital for a new venture, usually a crypto-currency venture using Bitcoins, Litecoin (LTC), Ethereum (ETH), Zcash (ZEC), Dash, Ripple (XRP), and Monero (XMR) to name a few of the largest and most influential.

The firm Crypto Head said it analyzed the genders of the founders of the world's leading crypto companies and discovered that of the 121 listed founders, only five were female. This is the perfect opportunity for women to play a powerful role in a new and innovation financial arena. If you don't know ICO's, study up.

Concerns about crypto-currency risks and scams have shown to be justified as with any new financial innovation. The get rich quick lure does pay in many cases in the short term until the illegitimate players have been exposed, expelled and the honest financial adults set the bar with integrity.

Will ICO's become over regulated, limiting the freedom and opportunity they initially offered, as a whiplash effect from the scams and volatility?

Since ICO's and crypto-currencies are so young, it's far too soon to predict their future impact, but women will be leading the way. It's been said that as soon as you think you've got it all figured out….. ***you're wrong***.

Early investors in the operation were usually motivated to buy the crypto-coins in the hope that the plan becomes successful after it launches which could translate to a higher crypto-coin value than what they purchased it for before the project was initiated.

An example of a successful ICO project that was profitable to early investors is the smart contracts platform called Ethereum which has Ethers as its coin tokens. In 2014, the Ethereum project was announced and its ICO raised $18 million in Bitcoins or $0.40 per Ether. The project went live in 2015 and as of this month, has a market capitalization of over $347 billion.

ICOs are similar to IPOs (Initial Public Offering) and crowdfunding. Like IPOs, a stake of the startup or company is sold to raise money for the companie's early operations. The big difference is IPO's

deal with investors while ICOs deal with supporters that are keen to invest in a new project much like a crowdfunding event. But ICOs differ from crowdfunding in that the backers of ICO's are motivated by a prospective return in their investments, while the funds raised by crowd-funding are basically donations. For these reasons, ICOs are referred to as crowdsales.

On September 24, 2021, the People's Bank of China's (PBOC) published a Q&A on its website stating, according to English translations of the original text, that all digital currency services for trading, order matching, token issuance and derivatives of virtual currencies are strictly prohibited.

The central bank said tokens cannot be used as currency on the market and banks cannot offer services relating to ICOs.

This does impact cryptocurrency companies as regulations find their way into the industry. But these changes are to be expected and should not deter women from pursuing opportunities as innovators.

To keep China's decision in perspective, in the past China also banned the streaming of several popular TV shows like "The Big Bang Theory", "NCIS", "The Good Wife", and "The Practice", due to damaging content to the fabric of their nation.

China also bans Facebook, Twitter, Google, Brad Pitt, Harrison Ford and Richard Gere because of their support and portrayal of the Dalai Lama.

Banking on trends is how you play the game, unless those trends change daily which can be the case from time to time. Investors don't like that kind of volatility if it can be avoided, thus the lack of enthusiasm about "disruption".

A strong disruptive influence for good is coming from women in the financial sectors. Though gender disparities continue to dog the financial services industry,

The "disruptive" influence ICO's represent are the very characteristics many find it appealing. Disruption does shake things up and most adults by nature do not care much for change. Changing things is hard to predict and making money is all about prediction.

We continue to see huge market fluctuations from the mere "mention of a word", or the fear of something that may not become reality. So it comes as no surprise that fluctuations in how crypto-currencies are viewed or regulated can also create temporary financial trends.

cryptocurrencies like bitcoin, ethereum, and dogecoin have been promoted as a way to democratize a traditionally male field, welcoming new and more diverse investors into the fold. Only about one in 10 people in the U.S. (11%) currently invest in cryptocurrencies, but so far the industry has not yet been able to make inroads among the key demographic group of women.

Historically, women are better than men when it comes to handling money securely, so as they enter these new markets, we should watch their success for guidance.

Careers in finance are certainly relevant to entrepreneurs, investors and anyone interested in business success, which will lean heavily on STEAM skills.

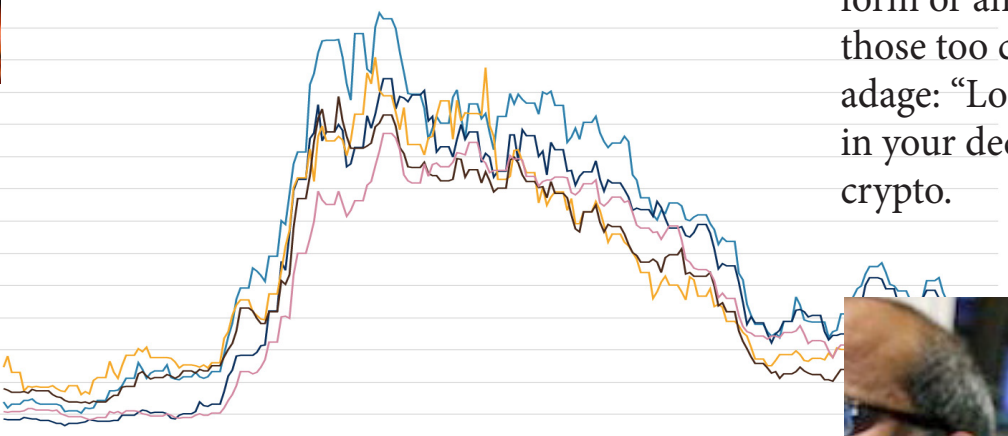
The technology (application of the science) and engineering (decision making and problem solving) are critical aspect of our involvement in finance such as the stock market and possible involvement in innovation that include cryptocurrencies.

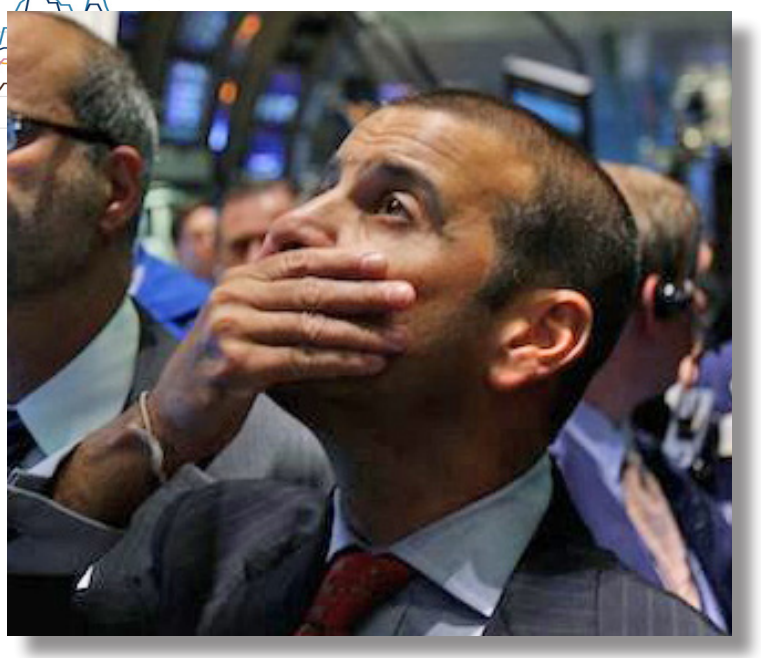
Understanding the STEAM of ICO's and finance in general should be important to every young professional entering the workforce as they develop a plan for financial success, financial security and eventually retirement.

With any career plan, knowledge is power and STEAM understanding is vital. Regardless of the industry, a common denominator is "opportunity". When an appealing opportunity comes along, you'll have to use your STEAM-sense to make the best decisions about the path to follow for that moment, with a clear understanding of the potential consequences that could come from your decision.

Companies and apps will come an go, and disruptive behaviors in business will continue, but it's important to remember that disruption for the sake of disruption does not guarantee financial wealth, business success or personal career satisfaction.

Using your STEAM skills as you prepare for, or continue in your career choice will be invaluable as change is certain in one form or another. As for opportunities, those too come and go. Perhaps the adage: "Look before you leap", holds true in your decision making, risk taking, and crypto.





Donate to Georgia public schools and reduce your state taxes

Georgia Foundation for Public Education encourages support of state schools

Davis Knox is a resident of Athens-Clarke County and founder and CEO of Fire & Flavor. He serves as chair of the Georgia Foundation for Public Education. In this guest column, he explains the foundation's purpose and encourages Georgians to donate to public schools through the foundation.

By Davis Knox
Our schools have been through a lot in the last two years, and students and teachers need our support. If you love the state of Georgia and want to see our public schools strengthened, consider supporting public schools through a donation to the Georgia Foundation for Public Education. In exchange for your donation, you can receive a dollar-for-dollar state tax credit, which we call the Qualified Education Donation (QED) tax credit.

Donated funds are directed toward innovation in Georgia public schools, with a specific focus on the lowest-performing 5% of schools. Schools and school districts have the opportunity to apply for grant funds for projects they propose, meaning the ideas and projects we fund are developed and steered from the ground up, by those who know students best.

In May 2021, Gov. Brian Kemp signed legislation merging the Innovation Fund Foundation — formerly housed within the Governor's Office of Student Achievement — with the Georgia Foundation for Public Education, the philanthropic arm of the Georgia Department of Education. The two organizations now operate under the GFPE name, expanding our capacity to fund innovation and meet financial needs in Georgia's K-12 public schools. Specifically, the merger expands fundraising capacity for the Qualified Education Donation — we are working to increase donations made through the tax credit program and ultimately provide more funding to support innovation and expand opportunities for students.

The Qualified Education Donation has previously funded support for COVID-19 relief efforts in Georgia schools, Innovative Education Fund grants for teachers, the Governor's Honors Program, and more.

Specific examples include:

- Early County High School used an Innovative Education Fund grant to implement a program emphasizing real-world science experiences, with a focus on agriculture — helping students learn skills they could apply to future careers. The program trained students to use unmanned drone devices to survey farmland and collect data for local farmers.

- The Richmond County School System used an Innovative Education Fund grant to provide 24/7 on-demand and live instruction for K-12 students, allowing students the opportunity to receive tutoring services aligned with their needs and family schedules.

- Ivy Preparatory Academy used an Innovative Education Fund grant to implement Raspberry Pi, a program designed to teach students the fundamentals of computer science.

- Houston County's Northside Middle School used an Innovative Education Fund grant to establish a STEAM Farm to enhance hands-on and project-based learning. Specifically, the grant allowed the school to expand its recycling program and raised vegetable beds, and add hydroponic towers, a quail hatchery, an arboretum, and seating for an outdoor classroom.

All Georgians — from parents, families, and students to educators to business owners — benefit from a strong public education system. Donating through the Qualified Education Donation is one of the simplest and most impactful ways you can show tangible support for public schools in our state.

I encourage you to become a donor and invest in public education today.

To learn more, including tax credit limits based on filing status, go to gfpe.org/tax_credit/donor_information.

The Chemistry of Cosmetics

A STEAM Career

By *Kim Carley*

Cosmetics are not a modern invention. Humans have used various substances to alter their appearance or accentuate their features for at least 10,000 years, and possibly a lot longer.

Women in Ancient Egypt used kohl, a substance containing powdered galena (lead sulphide – PbS) to darken their eyelids, and Cleopatra is said to have bathed in milk to whiten and soften her skin. By 3000 B.C. men and women in China had begun to stain their fingernails with colors according to their social class, while Greek women used poisonous lead carbonate ($PbCO_3$) to achieve a pale complexion.

Clays were ground into pastes for cosmetic use in traditional African societies and indigenous Australians still use a wide range of crushed rocks and minerals to create body paint for ceremonies and initiations.

Emulsions

The majority of creams and lotions are emulsions. An emulsion can be defined simply as two immiscible fluids in which one liquid is dispersed as fine droplets in the other.

Homogenized milk is an example of a typical oil-in-water (o/w) emulsion. Milk fat (oil) is dispersed in water as fine droplets by the homogenization process. The reason the fat does not float to the top immediately is due to the presence of emulsifiers; in this case, a milk protein called sodium caseinate as well as several phopholipids. In the case of water-in-oil (w/o) emulsions, water is dispersed as droplets and suspended in the oil phase. The non-dispersed liquid or external suspending phase is also called the continuous phase.

Mayonnaise, vinegar water dispersed as fine droplets in a continuous phase of soybean oil, is an example of a water-in-oil emulsion. Lecithin from eggs stabilizes the mayonnaise emulsion.

Surfactants

Most emulsifiers can be considered surfactants or surface-active agents. These materials are able to reduce the surface tension of water. What makes an emulsifier surface active is related to its HLB, or hydrophile-lipophile balance. HLB is determined by the size of the hydrophilic (water-loving or polar) portion of a molecule as compared to the size of the lipophilic (oilloving or nonpolar) portion.

The HLB system was created to rank the relative polarity of materials. The most polar, water soluble, materials are at the top of the twenty-point scale with more non-polar, oil soluble, materials closer to zero.

Emollients

The majority of emollients used in personal care and beauty items are fats and oils, also called lipids.

Animal fat or tallow is composed primarily of stearic and palmitic acids with carbon chains lengths of 18 and 16 respectively. Many of the major cosmetic companies are moving away from animal-based materials like tallow to renewable vegetable-based materials. Coconut oil and palm kernel oil are often used.

Some of the key characteristics required in good emollients are good spreading properties, low toxicity/skin irritation and good oxidative stability. Oleic acid, a major constituent of olive oil has poor oxidative stability due to the presence of its double bond. Fats and oils are considered saturated if they do not have double bonds. Unsaturated oils like olive oil have double bonds that can react with oxygen, especially when heated.

The oxidation process can produce off colors and odors in lipids causing them to go rancid and unusable.

Moisturizers

The main distinction between moisturizers and emollients is their solubility in water. Healthy skin requires moisture. Moisturizers are generally polar materials that are hygroscopic in nature; they hold onto water.

Waxes

Waxes are composed primarily of long-chain esters that are solid at room temperature. Anyone who has ever dipped a finger in molten wax has experienced its sealing properties. Some common waxes used in cosmetics are beeswax, candelilla, carnauba, polyethylene, and paraffin.

The melting points of waxes vary widely depending on their unique composition and chain lengths. Commonly used in lip balms and sticks, waxes function as structuring agents, giving the stick enough rigidity to stand up on its own, as well as barrier properties. By combining waxes with different properties such as high shine, flexibility, and brittleness, optimal cosmetic performance can be achieved. Often waxes are combined with compatible oils to achieve the desired softness.

Thickeners

By incorporating enough wax into a thin lotion, a thick cream can be formed. Many thickeners are polymers. Cellulose, a fine powder polymer of repeating D-glucose units, swells in hot water creating a gel network.

Color

Pigments and dyes are used in products to impart a color. Titanium dioxide (TiO_2) is a white pigment that is mined. In combination with natural mined and synthetic iron oxides, which range in color from red, yellow, black and brown, depending upon the degree of oxidation and hydration, a range of color can be produced that will be suitable for almost every skin tone.

Face powders are produced by blending inorganic oxides and fillers. Fillers are inert, generally inexpensive materials such as kaolin, talc, silica, and mica that are used to extend and fully develop colors. Pressed powders like eye shadows and blushers are prepared by blending additional binding ingredients such as oils and zinc stearate and pressing the mixture into pans.

Eye shadows and lipsticks often contain pearlescent pigments commonly called pearls. Pearls sparkle and reflect light to produce a multitude of colors. They are prepared by precipitating a thin layer of color on thin platelets of mica. Varying the thickness of the color deposited changes the angle of light refracted though the composite, creating different colors.

Organic pigments are used to color lipsticks and eye shadows. When organics are precipitated on a substrate they are called lake pigments. The term lake refers to the laking or precipitating of the organic salt onto a metal substrate such as aluminum, calcium, or barium. They are called D&C (drug and cosmetic) and FD&C (food, drug and cosmetic) colors. Some examples are D&C Red#7 calcium lake and FD&C Yellow #5 aluminum lake.

Preservatives

Most cosmetic products require the addition of preservative to prevent microbial contamination and rancidity. Parabens and ester of parabenzoic acid are by far the most commonly used because of their effectiveness against gram-positive bacteria.

The cosmetic chemist will generally employ a mixture of preservatives to protect against different bacterial strains as well as yeasts and molds.

To say the least, the science, technology, engineering and math of cosmetic creation can be challenging, creative, inspiring and sometimes dangerous.

The next time you look at a model, consider the complexity of the multiple compounds and chemical ingredents on their face, as well as the careers associated with developing them.

OAK RIDGE National Laboratory

Precision Machining

produces tiny, light-guiding cubes for advancing info tech

By Dawn Levy / ORNL

Drilling with the beam of an electron microscope, scientists at the Department of Energy's Oak Ridge National Laboratory precisely machined tiny electrically conductive cubes that can interact with light and organized them in patterned structures that confine and relay light's electromagnetic signal. This demonstration is a step toward potentially faster computer chips and more perceptive sensors.

extreme confinement of light in specific locations and tunable control of its energy," said ORNL's Kevin Roccapriore, first author of a study published in the journal Small. "It's a way to connect signals with very different length scales."

The feat may prove critical for quantum and optical computing. Quantum computers encode information with quantum bits, or qubits, determined by a quantum

"100,000 times thinner than a human hair"

The seeming wizardry of these structures comes from the ability of their surfaces to support collective waves of electrons, called plasmons, with the same frequency as light waves but with much tighter confinement. The light-guiding structures are measured in nanometers, or billionths of a meter — 100,000 times thinner than a human hair.

"These nanoscale cube systems allow

state of a particle, such as its spin. Qubits can store many values compared with the single value stored by a classical bit.

Light — electromagnetic radiation that propagates by massless elementary particles called photons — replaces electrons as the messenger in optical computers. Because photons travel faster than electrons and do not generate heat, optical computers could have performance and

energy efficiency superior to classical computers.

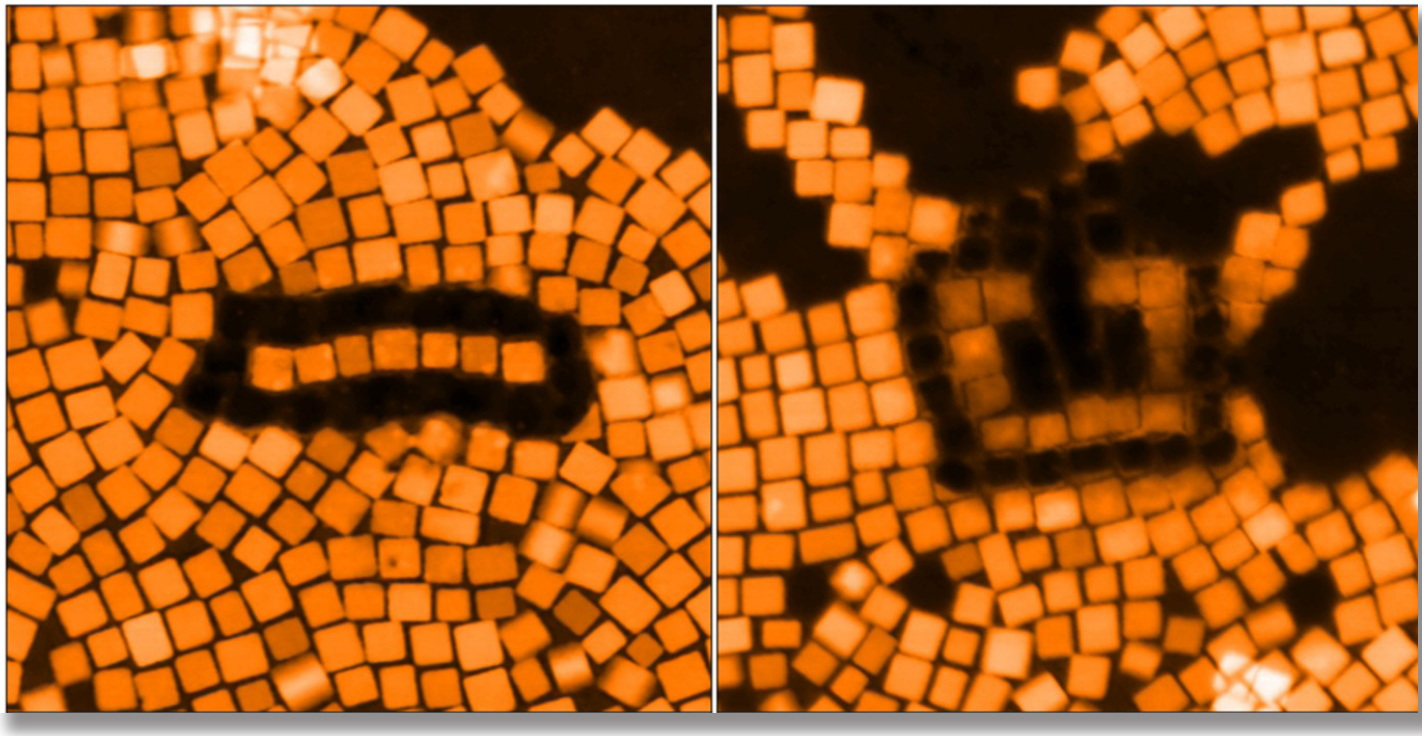
Future technologies may use the best of both worlds.

"Light is the preferred way to communicate with qubits, but you cannot connect contacts to them directly," said senior author Sergei Kalinin of ORNL. "The problem with visible light is its wavelengths range from about 380 nanometers for violet to around 700 nanometers for red. That's too big because we want to make devices only a few nanometers in size. This work aims to create a framework to move technology beyond Moore's law and classical electronics. If you try to put 'light' and 'small' together, that's exactly where plasmonics comes into play."

And if there's a great future in plasmonics, the ORNL-led achievement may help overcome a signal size mismatch that threatens the integration of components made of different materials. Those hybrid components will need to "talk" to each other in next-generation optoelectronic devices. Plasmonics may bridge the gap.

Plasmonic phenomena were first observed in metals, which are conductive because of their free electrons. The ORNL team used cubes made of a transparent semiconductor that behaves like a metal — indium oxide doped with tin and fluorine.

The fact that the cube is a semiconductor is the key to its energy tunability. The energy of a light wave is related to its frequency. The higher the frequency, the



Each cube shown has its own plasmonic behavior. Bring them together in patterns — an antenna, left image, or split ring resonator, right image — and they "talk," producing unique effects. Credit: Kevin Roccapriore/ORNL, U.S. Dept. of Energy

shorter the wavelength. Wavelengths of visible light appear to the human eye as colors. Because a semiconductor can be doped — that is, a small impurity can be added — its wavelength can be shifted on the spectrum.

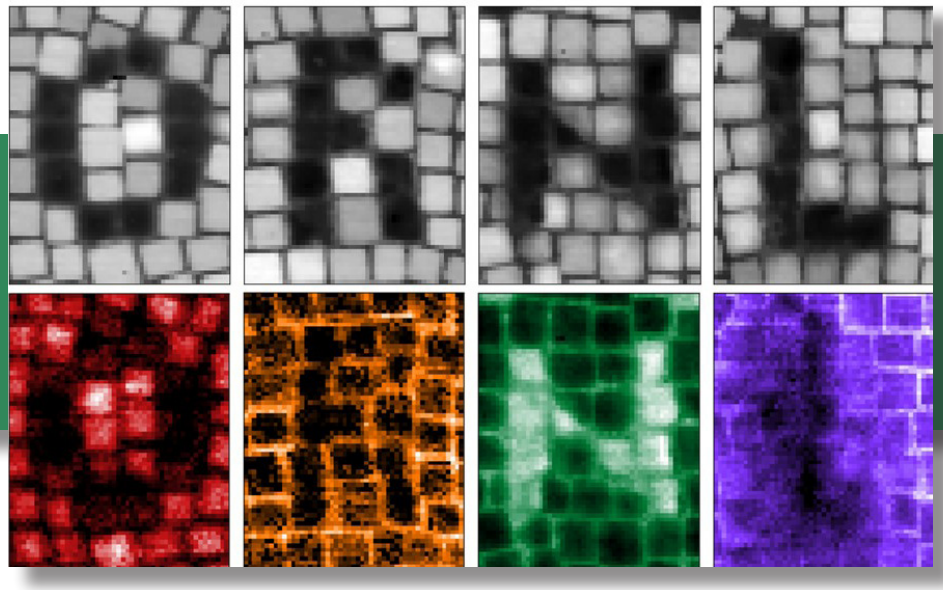
The study's cubes were each 10 nanometers wide, which is much smaller than the wavelength of visible light. Synthesized at the University of Texas at Austin by Shin-Hum Cho and Delia Milliron, the cubes were placed in a detergent to prevent clumping and pipetted onto a substrate, where they self-assembled into a two-dimensional array. A shell of detergent surrounded each cube, spacing them apart evenly. After the detergent was removed, the arrays were sent to ORNL.

"That the cubes do not directly touch is important for the collective behavior," said Roccapriore, who organized the cubes into diverse structures.

"Each cube individually has its own plasmon behavior. When we bring them together in geometries like a nanowire, they talk to one another and produce new effects that are not typically seen in similar geometries that aren't made up of individual elements."

The study builds on prior work to sculpt three-dimensional structures as small as a nanometer with an electron beam. "The current paper proves that the plasmonic effect, as well as the structure, can be sculpted," Roccapriore said. "At the end of the day, we're interested in the electron wave — where is it and what is its energy? We're controlling those two things."

Kalinin added, "We want to transition from using what exists in nature by chance to fabricating materials with the right responses. We can take a system of cubes, shine light on it and channel energy into small volumes localized exactly where we want them to be."



ORNL scientists used an electron beam for precision machining of nanoscale materials. Cubes were milled to change their shape and could also be removed from an array. Credit: Kevin Roccapriore/ORNL, U.S. Dept. of Energy

The project was a natural for Roccapriore, who conducted a lot of electron-beam lithography in graduate school and even built a machine in his garage to make and mill 3D-printed structures. At ORNL, experimenting with the beam of an electron microscope, he adjusted its current to intentionally shift from imaging to modification mode.

He found he could remove bits of cubes or entire cubes from an array to make patterned objects at will. He also discovered that, just like addition of chemical elements enables tuning of cube energies, so too does selective removal of chemical elements. Such atomic precision is possible with scanning transmission electron microscopy, or STEM.

The key to characterizing plasmonic behavior within single cubes and among collective cube assemblies was a technique called electron energy loss spectroscopy. It uses a STEM instrument with an electron beam filtered to energies within a narrow range. The beam loses energy as its electrons pass through the sample, interact with electrons in the material and transfer a little energy to the system by exciting plasmons.

"Electron energy loss spectroscopy provides deep insights into exotic physics and quantum phenomena related to plasmonic behavior," said co-author Andrew Lupini of ORNL, who helped map the energies of electrons in the cubes and arrays of cubes. Lupini is one of the developers of aberration-corrected STEM, which made pioneering advances possible. "Electron energy loss spectroscopy lets us analyze evolving plasmonic responses in real time as the cubes are sculpted. We can figure out relationships between arrangements of cubes and their plasmonic properties."

The scientists plan to create a library of relationships between materials, structures and plasmonic properties. That new knowledge will provide the foundational understanding needed to eventually mass-produce structures that can direct the flow of light in plasmonic nanocircuits. According to Roccapriore, "the idea is to understand the relationships using machine learning and then automate the process." The title of the paper is "Sculpting the plasmonic responses of nanoparticles by directed electron beam irradiation."

DOE's Office of Science and ORNL's Laboratory Directed Research and Development Program supported the work. The study used resources of the Center for Nanophase Materials Sciences, a DOE Office of Science user facility at ORNL.

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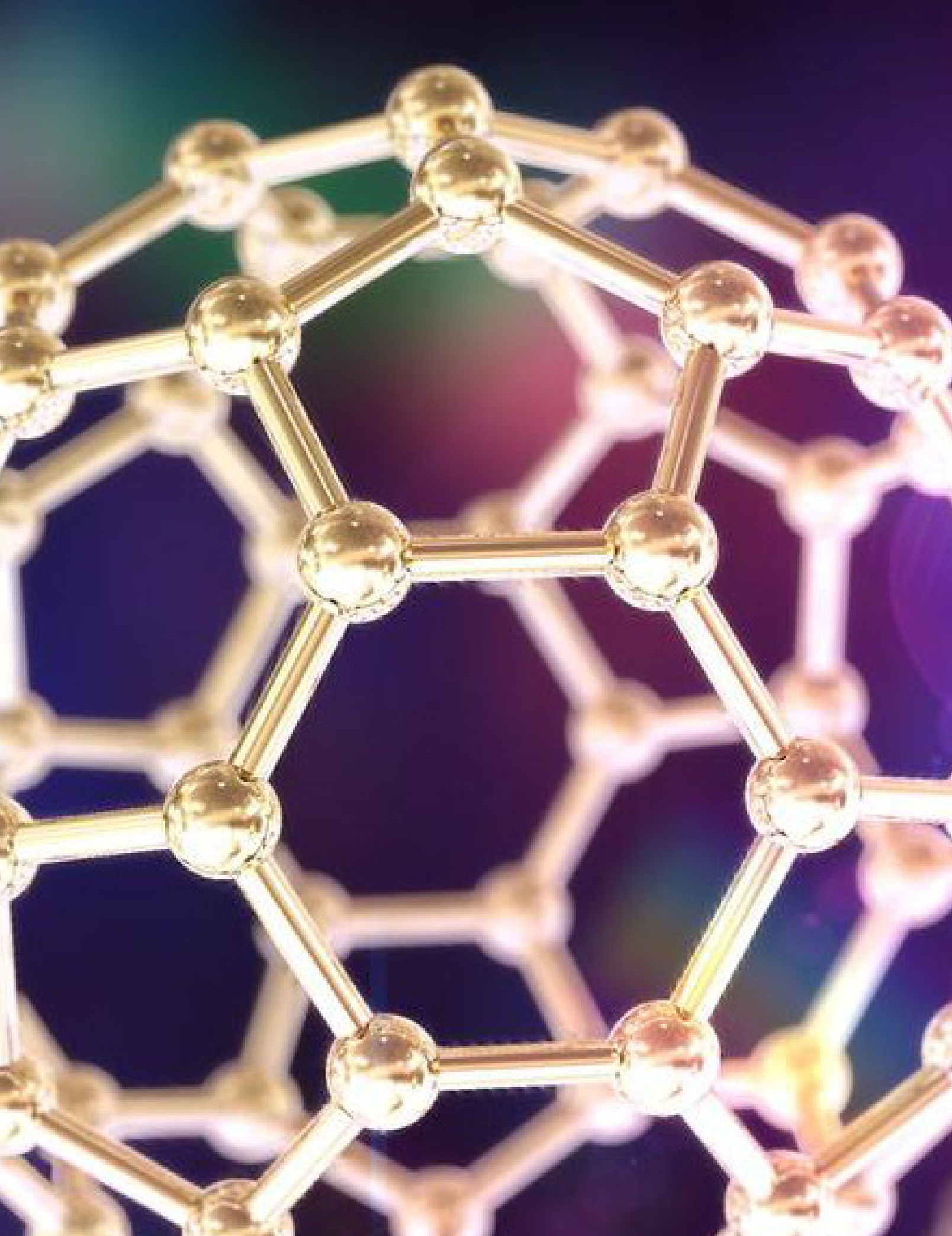
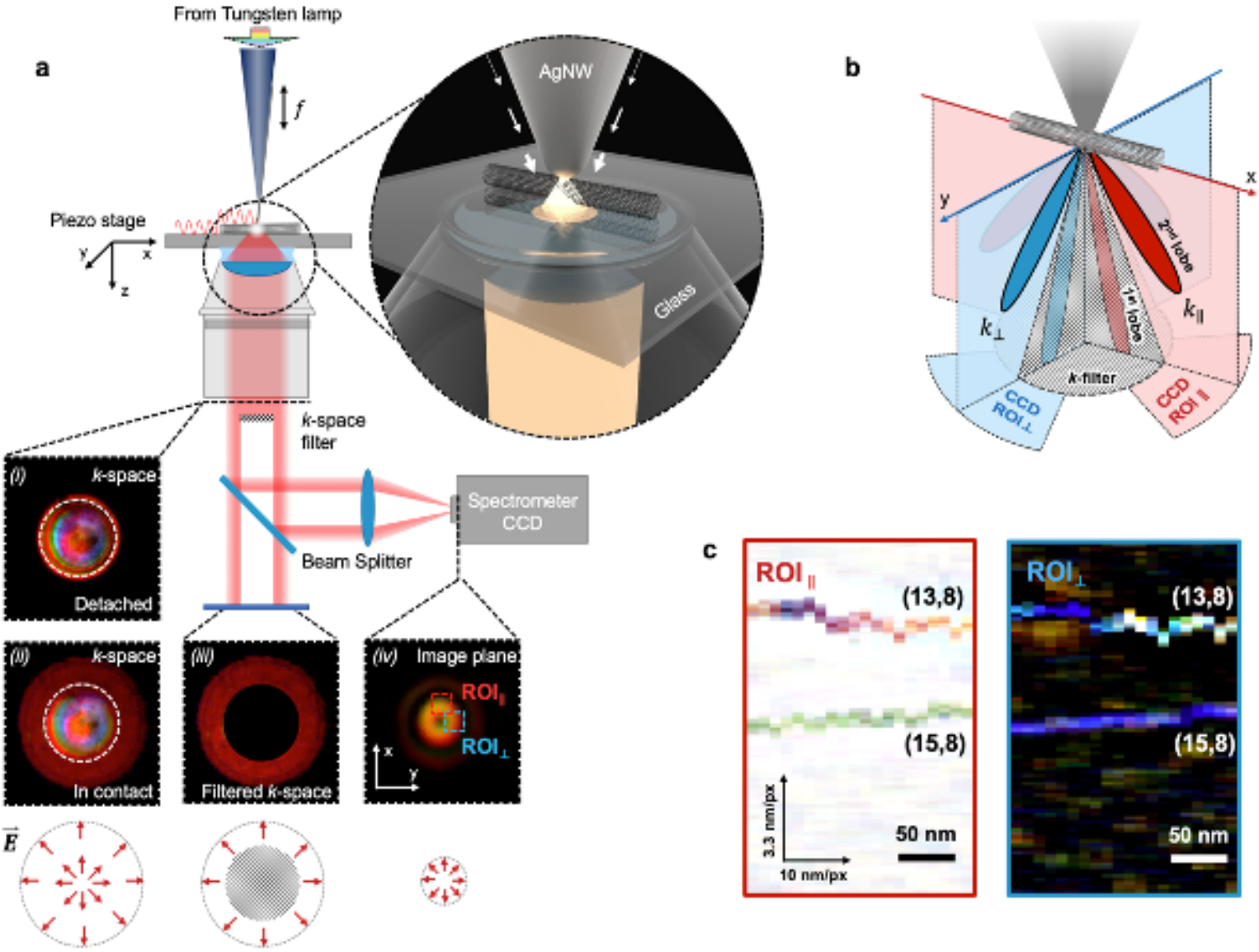


Nanometer-sized Spotlight

By Holly Ober

Scientists have developed new materials for next-generation electronics so tiny that they are not only indistinguishable when closely packed, but they also don't reflect enough light to show fine details, such as colors, with even the most powerful optical microscopes.



Under an optical microscope, carbon nanotubes, for example, look grayish. The inability to distinguish fine details and differences between individual pieces of nanomaterials makes it hard for scientists to study their unique properties and discover ways to perfect them for industrial use.

White" light from a tungsten lamp is focused into the tip of a silver nanowire to check the light scattering and absorption of a sample with high fidelity. (Ma et. al, 2021)

In a new report in Nature Communications, researchers from UC Riverside describe a revolutionary imaging technology that compresses lamp light into a nanometer-sized spot. It holds that light at the end of a silver nanowire like a Hogwarts student practicing the "Lumos" spell, and uses it to reveal previously invisible details, including colors.

The advance, improving color-imaging resolution to an unprecedented 6 nanometer level, will help scientists see nanomaterials in enough detail to make them more useful in electronics and other applications.

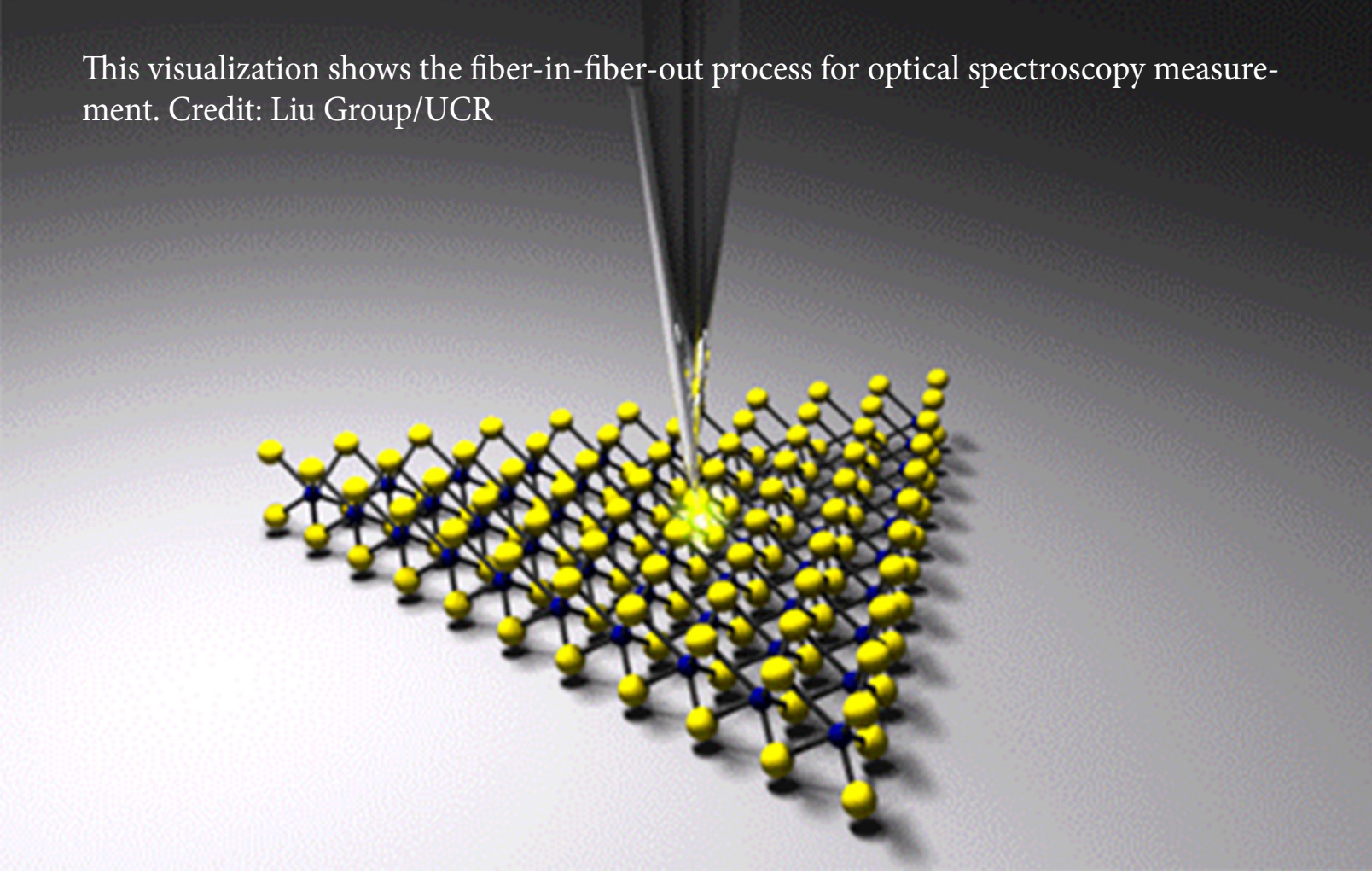
Ming Liu and Ruoxue Yan, associate professors in UC Riverside's Marlan and Rosemary Bourns College of Engineering, developed this unique tool with a superfocusing technique developed by the team. The technique has been used in previous work to observe the vibration of molecular bonds at 1-nanometer spatial resolution without the need of any focusing lens.

In the new report, Liu and Yan modified the tool to measure signals spanning the whole visible wavelength range, which can be used to render the color and depict the electronic band structures of the object instead of only molecule vibrations. The tool squeezes the light from a tungsten lamp into a silver nanowire with near-zero scattering or reflection, where light is carried by the oscillation wave of free electrons at the silver surface.

The condensed light leaves the silver nanowire tip, which has a radius of just 5 nanometers, in a conical path, like the light beam from a flashlight. When the tip passes over an object, its influence on the beam shape and color is detected and recorded.

"It is like using your thumb to control the water spray from a hose," Liu said, "You know how to get the desired spraying pattern by changing the thumb position, and likewise, in the experiment, we read the light pattern to retrieve the details of the object blocking the 5 nm-sized light nozzle."

The light is then focused into a spectrometer, where it forms a tiny ring shape. By scanning the probe over an area and recording two spectra for each pixel, the researchers can formulate the absorption and scattering images with colors.



This visualization shows the fiber-in-fiber-out process for optical spectroscopy measurement. Credit: Liu Group/UCR

The originally grayish carbon nanotubes receive their first color photograph, and an individual carbon nanotube now has the chance to exhibit its unique color.

"The atomically smooth sharp-tip silver nanowire and its nearly scatterless optical coupling and focusing is critical for the imaging," Yan said. "Otherwise there would be intense stray light in the background that ruins the whole effort."

The researchers expect that the new technology can be an important tool to help the semiconductor industry make uniform nanomaterials with consistent properties for use in electronic devices.

The new full-color nano-imaging technique could also be used to improve understanding of catalysis, quantum optics, and nanoelectronics.

Liu, Yan, and Ma were joined in the research by Xuezhi Ma, who worked on the project as part of his doctoral research at UCR Riverside.

Researchers also included UCR students Qiushi Liu, Ning Yu, Da Xu, Sanggon Kim; Zebin Liu and Kaili Jiang at Tsinghua University, and UCR professor Bryan Wong.

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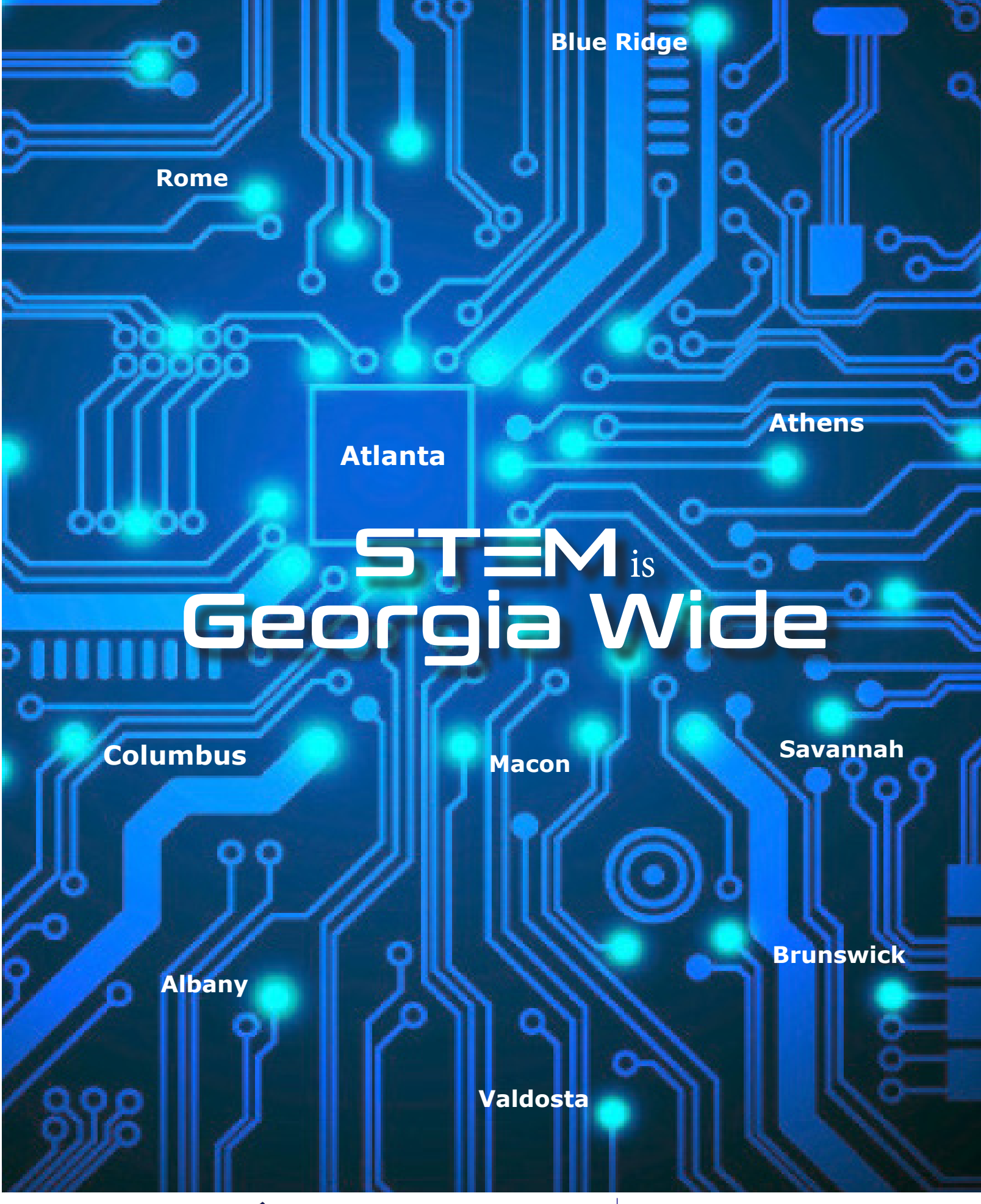

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