August 2020

GEORGIA PATHWAYS
M A G A Z I N E

Perseverance
On Earth and Mars

Computer Science
A Georgia Imperative

The STEM of Teaching
Every teacher is a STEM teacher

TAG Technology Association of Georgia

TAG TAG-Ed Education Collaborative


You were *born* wired for S.T.E.M.

I hope you'll enjoy and share this issue of Georgia Pathways Magazine, and as the fall school years is upon us, TAG-Ed continues to focus on educator and student resources as well as curriculum expertise to prepare Georgia students for their home grown career opportunities right here in Georgia. How the coming school year will look is yet to be determined, but the determination of TAG-Ed remains constant in light of education resources, inspiration and opportunity for all.

Our continued partnership with the Georgia Department of Education highlights opportunities for career preparation, whether it is to be on campus or remote learning, through the State Board approved CTAE Career Pathways coursed available to every educator, and student Georgia wide. As work-based learning, youth apprenticeships and internships continue to grow in popularity, courses are available to explore any number of exciting education and career pathways to engage and inspire students of all ages and interests.

The CTAE Career Pathways courses are diverse in their offerings with courses in agriculture and natural resources that include 35 different applications, from Forestry and Agriscience systems to Equine and Horticulture applications: truly something for every student's interests. Some of the other interesting courses include business, finance, IT, hospitality services, law, education and logistics to name a few.

TAG
Technology Association of Georgia

These Advanced Academic Pathways offers graduates who complete a sequence of required courses in English/Language Arts, Mathematics, Science and Social Studies and include an Advanced Placement, International Baccalaureate, or dual enrollment courses, with additional credits in two sequential courses in one world language. Advanced Academic Pathways are foundational courses for all career-related pathways and aligned occupations which are vast.

A vibrant and enthusiastic workforce in Georgia are critical to any future that lays ahead, and regardless of what student's interests may be, the Georgia workforce has a need for that profession and both TAG-Ed and the Ga. DOE will continue to support and provide the resources to make those dreams come true.

Larry K. Williams
President
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.

The Technology Association of Georgia Education Collaborative (TAG-Ed) strengthens the future workforce by providing students with relevant, hands-on STEM 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 2002. Later, the organization's name was re-branded to TAG Education Collaborative to facilitate our role as the leaders for K-12 STEM education in Georgia.

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To understand STEM...

...you must DEFINE STEM, but you cannot define an acronym using the words it stands for; *you must define the words the acronym stands for.*

Universities and organizations around the world continue to debate what a STEM career is. There is no doubt that "every career" uses STEM skills and this observation remains the focus of STEM Magazine.

SCIENCE: "The systematic accumulation of knowledge" (all subjects and careers fields)

TECHNOLOGY: "The practical application of science" (all subjects and careers)

ENGINEERING: "The engineering method: a step by step process of solving problems and making decisions" (every subject and career)

MATHEMATICS: "The science of numbers and their operations, interrelations, combinations, generalizations, and abstractions" (every career will use some form[s])

For a moment, set aside any preconceived notions of what you think a STEM career is and use the above dictionary definitions to determine the skills used in any career field you choose.

These definitions are the "real" meaning of STEM and STEM careers.

By Noelle Toumey Reetz

A Georgia State University researcher is mining social media data to document the experiences of so-called “long-haulers,” people who remain sick long after being diagnosed with COVID-19. Experts know little about the clinical course of COVID-19. In the early days of the pandemic, clinicians did not believe coronavirus symptoms could persist past two or three weeks.

Patients tended to either recover quickly or die from the infection. In late July, the Centers for Disease Control and Prevention published a report acknowledging that in a third of patients — even young adults with no preexisting conditions — COVID-19 can result in prolonged illness.

Juan Banda, assistant professor of computer science at Georgia State, has amassed one of the world’s largest publicly available datasets of COVID-19 Twitter chatter, made up of more than 602 million individual Tweets. Collaborating with researchers from Oxford University and Harvard Medical School, he used the dataset to identify common symptoms shared by long-haulers, some of whom take months to recover.

The work is important because clinical reports documenting long-term symptoms of COVID-19 are not accessible to the public.

“Clinical data is not easily available, and it does not always capture detailed follow-up of the patients,” Banda said. “However, those patients are sharing their experiences on social media, allowing us to study the progression of the disease based on self-reported experiences.” The researchers analyzed Tweets that were published in May — more than 60 days after the start of the pandemic ¬— through July. The 10 most commonly mentioned symptoms were malaise and fatigue, labored breathing, tachycardia or heart palpitations, chest pain, insomnia/ sleep disorders, cough, headache and joint pain or fever.

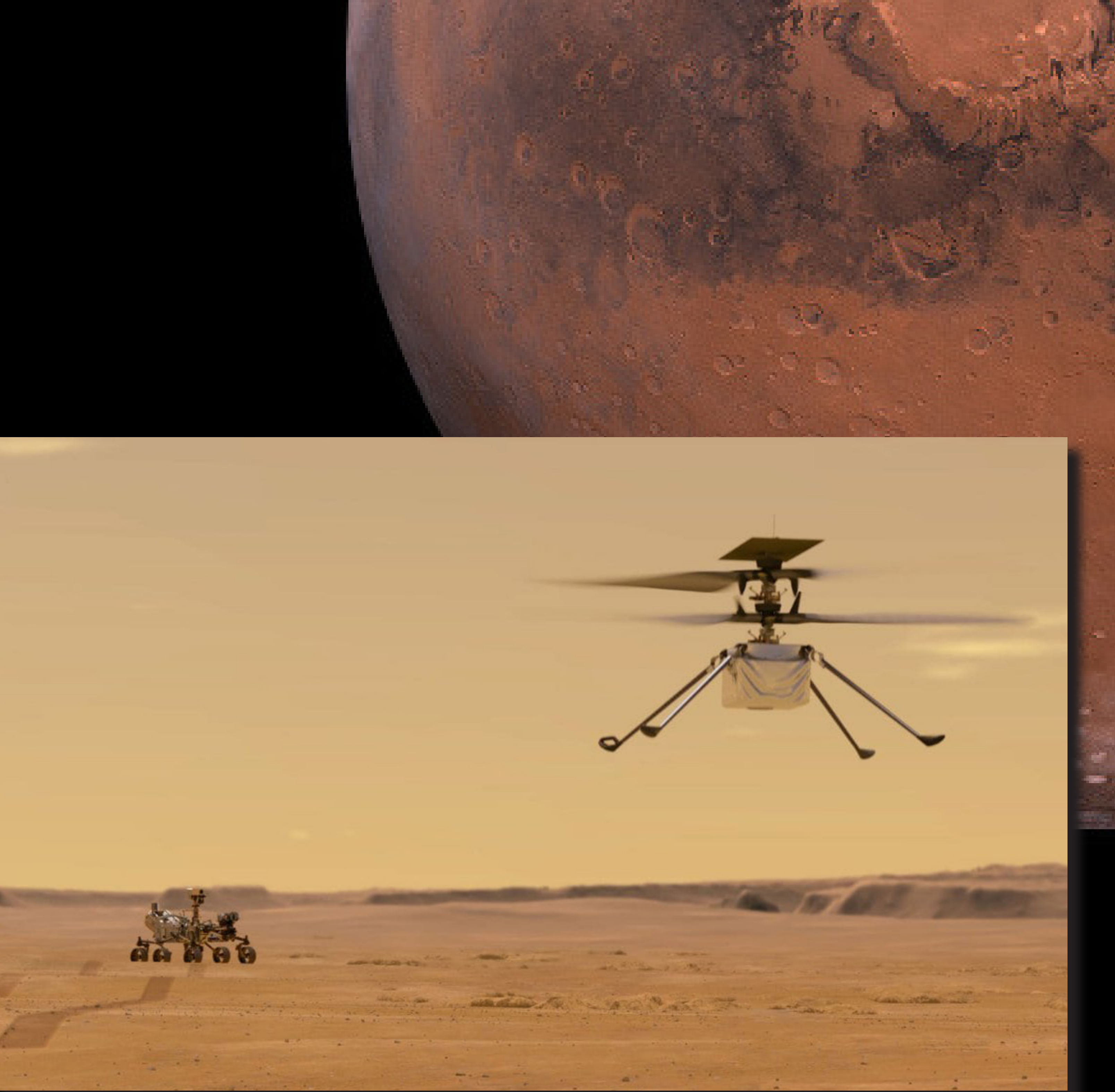
Some of the most serious reported health impacts for long-haulers were acute respiratory failure and acute organ injury, including kidney injury in 20 percent of patients and damage to the heart muscle in 20 to 30 percent of patients. Consequently, long-haulers may be likely to develop chronic conditions such as chronic kidney disease, heart failure and chronic obstructive pulmonary disease.

Banda and his colleagues chose to make the preliminary study public through the pre-print website medRxiv to aid the global push to learn more about the clinical manifestations of COVID-19.
"We have demonstrated that researchers can leverage social media data, specifically from Twitter, to conduct long-term studies of self-reported symptoms," Banda said.

The work is part of a massive research project to collect and track social media chatter related to COVID-19. Banda's team at Georgia State began collecting Tweets dedicated to coronavirus on March 10 and continue to collect nearly 4.5 million Tweets each day. Banda has also used the dataset to investigate the spread of misinformation relating to COVID-19 in various geographic areas. The dataset, which you can find here, is publicly available as a resource for the global research community.

"We have been contacted by scientists who are studying things like conspiracy theories, views and sentiments around personal protective equipment and the effects of the lockdown on society," Banda said. "There's a wide range of topics that other groups and experts are analyzing using our dataset."

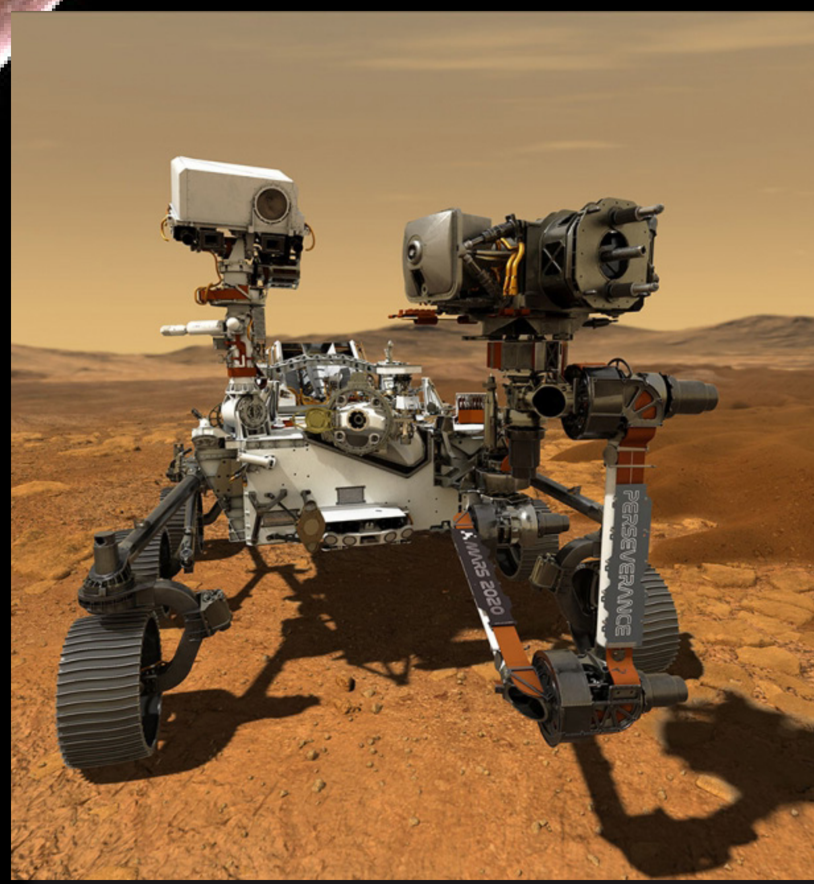
Banda's collaboration with Dani Prieto-Alhambra (Oxford), Gurdas Singh (Oxford) and Osaid Alser (Harvard Medical School) came about through the Observational Health Data Sciences and Informatics (OHDSI) collaborative, an interdisciplinary network focused on applying large-scale analytics to health data.



MARS 2020

Perseverance and Ingenuity

The Mars 2020 Perseverance Rover is well on its way to the red planet and will search for signs of ancient microbial life, to explore the past of Mars. With its sophisticated drill, the rover will collect core samples of Martian rock and soil, then store them in sealed tubes for pickup by a future mission that would bring them back to Earth for analysis. As with previous rover missions, the end goal of Perseverance will be to continue paving the way for future human exploration of our neighbor.



Along for the ride onboard Perseverance is an exciting addition to the Mars lander family in the form of a demonstration Mars Helicopter. Called Ingenuity, this drone style helo may provide us with a “Wright Brothers moment “ by testing the first powered flight across the sky of Mars.

Searching for Ancient Life, Gathering Rocks and Soil

The mission helps pave the way for future human expeditions to Mars and will explore a variety of technologies that may be useful in the coming missions. These include testing a method for producing oxygen from the Martian atmosphere, identifying other resources (such as subsurface water), improving landing techniques, and analyzing weather, dust, and other potential environmental conditions that could affect future astronauts living and working on Mars.

Recent technological innovations already demonstrated successfully will continue to be used and evaluated, especially for entry, descent, and landing (EDL). Like NASA's Curiosity rover, the Mars 2020 spacecraft uses a guided entry, descent, and landing system. The landing system on the Mars 2020 mission uses a parachute, descent vehicle, and an approach called a "sky crane maneuver" for lowering the rover on a tether to the surface during the final seconds of landing.

This type of landing system provides the ability to land a very large, heavy rover on the surface of Mars in a more precise landing area than was previously possible. It also adds new entry, descent, and landing (EDL) technologies, such as Terrain-Relative Navigation (TRN). This sophisticated navigation system allows the rover to detect and avoid hazardous terrain like boulders and craters by maneuvering around them during its decent.

A microphone allows engineers to analyze entry, descent, and landing. It might also capture sounds of the rover at work, which would provide engineers with clues about the rover's health and operations.

Perseverance will test a technology for extracting oxygen from the Martian atmosphere, which is 96% carbon dioxide. Using Mars' natural resources to support human explorers and improve designs for life support, transportation, and other important systems for living and working on Mars is a critical part of these missions. The rover also monitors weather and dust in the Martian atmosphere. Such studies are important for understanding daily and seasonal changes on Mars, and will help future human explorers better predict Martian weather.

Ingenuity

Ingenuity is a technology demonstration – a project that will test a new capability for the first time, with limited scope. Previous groundbreaking technology demonstrations include the Mars Pathfinder rover Sojourner and the tiny Mars Cube One (MarCO) CubeSats that flew by Mars in 2018.

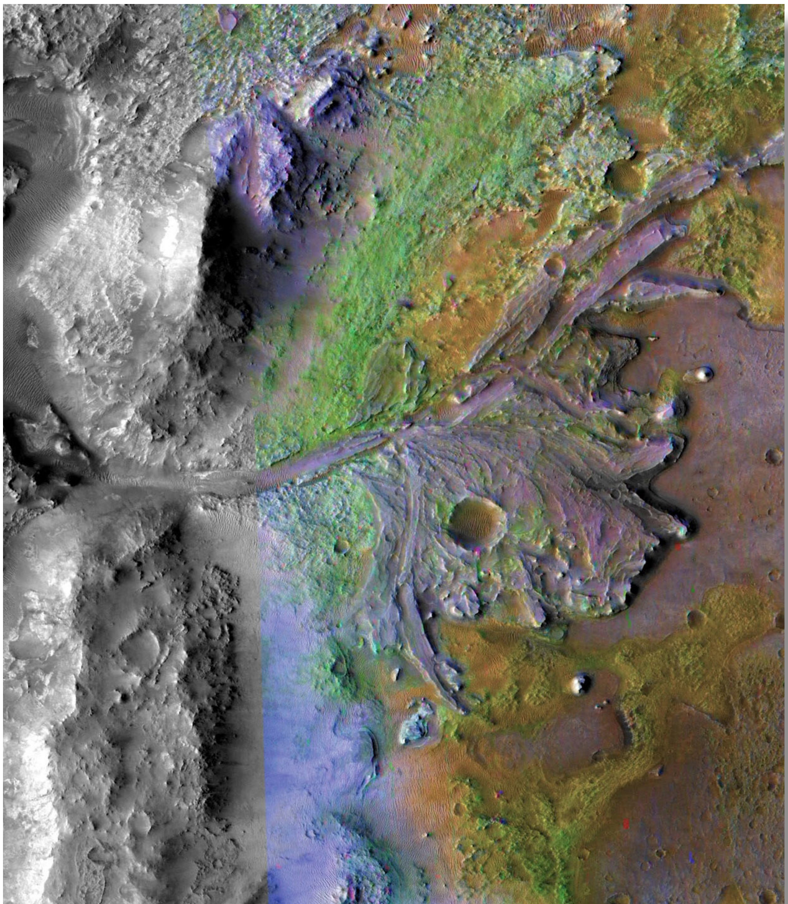
Ingenuity features four specially made carbon-fiber blades, arranged into two rotors that spin in opposite directions at around 2,400 rpm. Mars has a much thinner atmosphere than Earth, so the helicopter blades need to rotate much faster to lift off and fly.

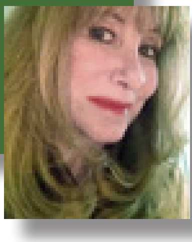
The innovative solar cells and batteries will also be a new addition to Ingenuity as it does not carry any experiment instrumentation to reduce weight.

The Mars Helicopter flight demonstration is an autonomous, 1.8 kilogram (3.96 pounds) helicopter, which will be deployed from Perseverance to the Martian surface after landing. As a technology demonstrator, the vehicle carries only a single high resolution color camera. NASA hopes the helicopter will overcome Mars' thin atmosphere and long communications delays to Earth in order to prove flight on Mars is possible. A successful demonstration would pave the way for future vehicles carrying scientific equipment.

Perseverance Rover's Landing Site:

Jezero Crater





By Kay Howard

Fixed Wing Aircraft Take-off Speeds

I love flying. Well, fixed wing aircraft flying. My son is a helicopter pilot. I do and don't love that. I don't know a lot about flying a helicopter. A few things, but not enough to keep one in the air. But I do know fixed wing flying. And one thing, of many, that all fixed wing aircraft have in common is take-off speeds: V1, Vr, & V2.

Whether it's a small Cessna or a jumbo jet, the definition of speed is the same. Speed is defined as the change in position, x, divided by the change in time, t.

In science, the phrase "change in" (or "change of") is written by the symbol Δ. Its pronunciation is delta. Δ is the 4th letter of the Greek alphabet.

We're all familiar with many terms of speed: mph, miles per hour, for example. Let's talk about fixed wing aircraft take-off speeds. (From now on, in this article, I will be writing only about fixed wing aircraft.)

There are 3 take-off speeds that pilots have to know. And they differ, of course, per type of aircraft.

V1, abort decision speed, is the speed, beyond which, the take-off should not be aborted. If the pilot experiences any trouble with the aircraft before reaching V1, the take-off could be immediately aborted and the pilot will apply all means necessary to bring the aircraft to a halt. If pilots experience any serious

$$\text{Speed} = \frac{\textit{change in } (\Delta) \textit{ position}(x)}{\textit{change in } (\Delta) \textit{ time } (t)}$$

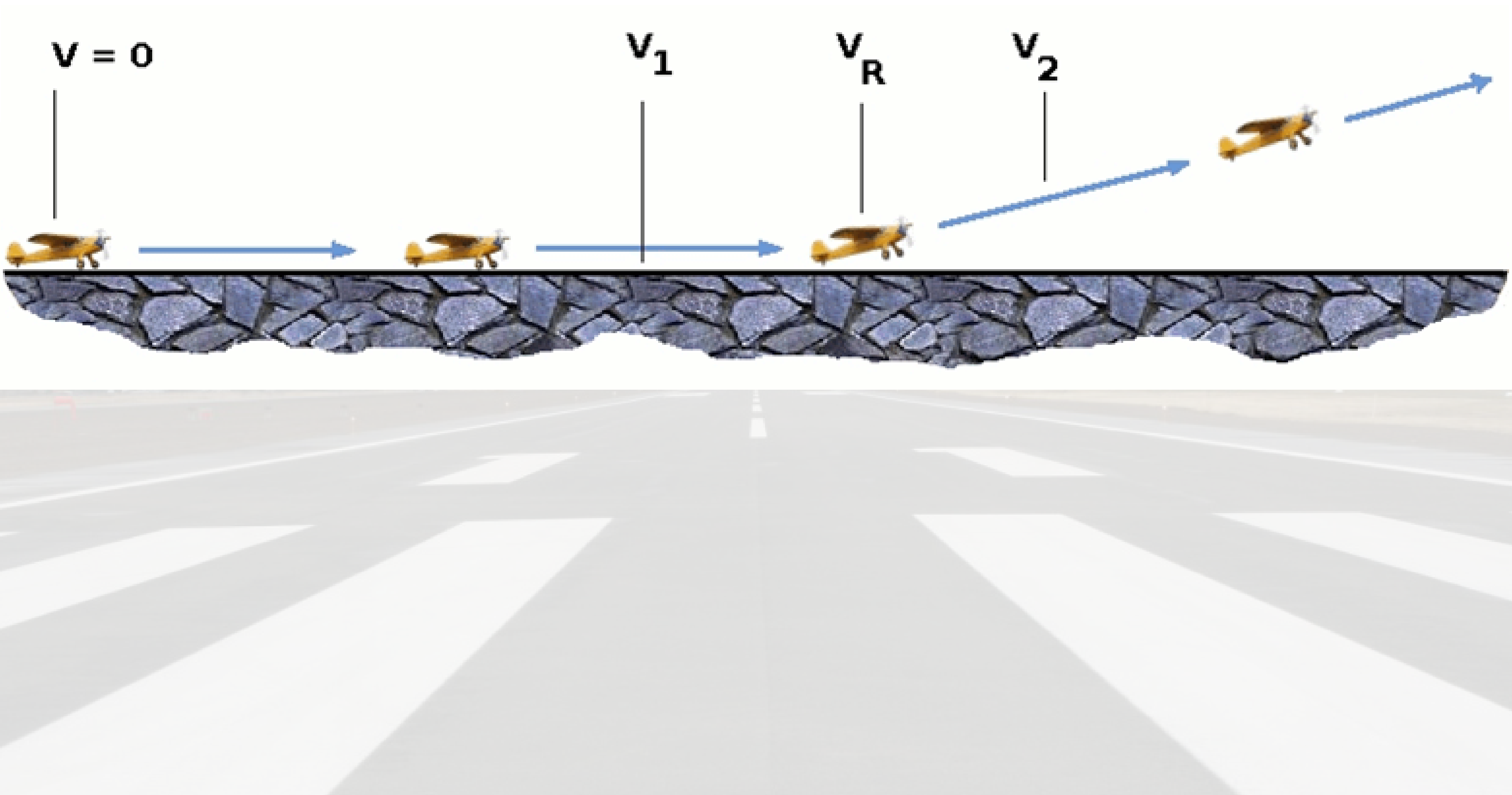
$$\text{Speed} = \Delta x / \Delta t$$

malfunctions after V1, the take-off will have to continue. Any aborted take-off after V1 will lead to a runway overrun that could seriously damage the aircraft.

Vr, rotate speed, is the speed at which the pilot begins to apply control inputs to make the nose gear (wheel) leave the ground. Also, at Vr, is when the wing tips create vortices, which rotate behind the aircraft. Moreover, the point where the main gear leaves the ground is called Vlof, or lift-off speed.

V2, safe climb speed, is the speed at which the aircraft can safely climb with one engine inoperable. This speed is nicknamed the take-off safety speed. It is the speed an aircraft, with only 1 engine operative, that must be attained in order to leave the runway and get 35' off the ground by the end of the runway and maintain a 200 ft/min climb thereafter. This is the lowest speed at which the aircraft complies with the handling criteria associated with a climb after a take-off, followed by an engine failure.

I can go more deeply into the mathematics and physics of these speeds if anyone if interested. I know so little about helicopter flying. I wonder if they have something equivalent to take-off speeds. I'll do some research.



Plutonium-238 to help power Perseverance on Mars

Produced by Oak Ridge National Laboratory

By Kristi L Bumpus / ORNL

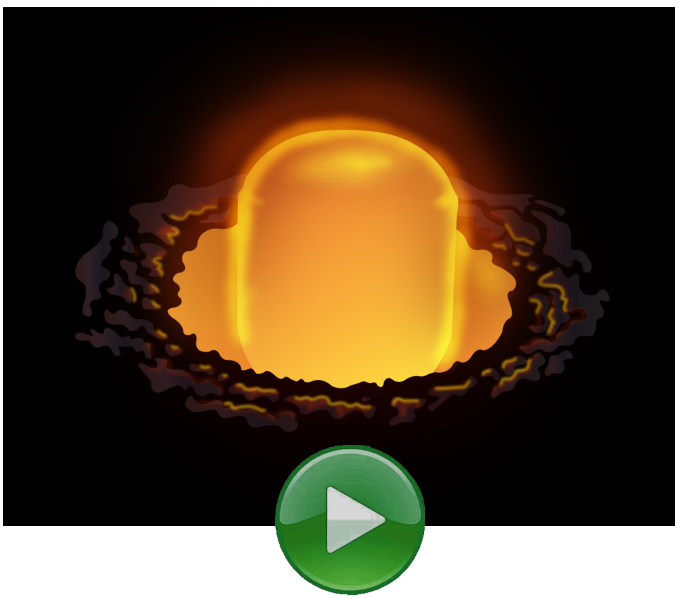
After its long journey to Mars beginning this summer, NASA's Perseverance rover will be powered across the planet's surface in part by plutonium produced at the Department of Energy's Oak Ridge National Laboratory. "Mars 2020 will be the first NASA mission that uses ORNL-produced plutonium-238," said Alan Icenhour, associate laboratory director for nuclear science and engineering at ORNL. "This accomplishment represents countless hours of work by dedicated ORNL staff, and it's rewarding to see this work come to fruition. Helping NASA in its mission to Mars is a significant moment in the history of the lab."

Like other rovers on deep-space missions, Perseverance's traveling power on Mars comes from thermoelectric generators that create electricity from heat generated from the decay of plutonium-238 in the form of oxide ceramic pellets. Pu-238 produces heat as it decays, and the rover's multi-mission radioisotope thermoelectric generator converts that heat into electricity to charge the lithium-ion batteries that move the rover and power the instruments it will use on the surface of the Red Planet.

Pu-238 is ideal for deep-space travel because of its long half-life of nearly 88 years, but it has been in short supply. Previously, the U.S. stockpile consisted primarily of Pu-238 produced at the Savannah River nuclear plant in the late 1980s, which has since been decaying away. But U.S. production of Pu-238 ended more than 30 years ago.

That's why 2015 was a milestone for ORNL: the first new stateside production of Pu-238 in nearly three decades. Since that initial success, the lab has been consistently increasing its Pu-238 production capabilities, aiming to produce 1.5 kilograms per year by 2026.

"We have a 50-year history of irradiating targets and producing radioisotopes," said ORNL's Robert Wham, Pu-238 Supply Program manager. "Having the resources we have right here makes ORNL well suited to produce the nation's supply of Pu-238. We have a lot of scientists and engineers all across the lab involved with this effort, and it's very exciting to them to be contributing to space exploration."



It's not an easy process, and ORNL, DOE's Office of Nuclear Energy and NASA have invested time, money, research and bright minds into improving it. ORNL receives neptunium-237 feedstock from Idaho National Laboratory, which stores the nation's inventory. Once at ORNL, the neptunium oxide is mixed with aluminum and pressed into pellets. Next, the pellets are put into tubes and irradiated in ORNL's High Flux Isotope Reactor, which causes the neptunium to transmute into Pu-238.

The pellets are moved to shielded hot cells in ORNL's Radiochemical Engineering Development Center. There, the Pu-238 is separated from the neptunium through a series of chemical processes, converted to an oxide powder, and then shipped to Los Alamos National Laboratory for fabrication into ceramic pellets for the thermoelectric generator. Leftover neptunium is recycled to make more Pu-238.

HFIR can irradiate up to 6,800 grams of neptunium per year in batches that stay in the reactor for two to three months. INL's Advanced Test Reactor is also irradiating small quantities of neptunium on a limited basis and is slated for a makeover next year that will increase its capability to produce Pu-238 as well.

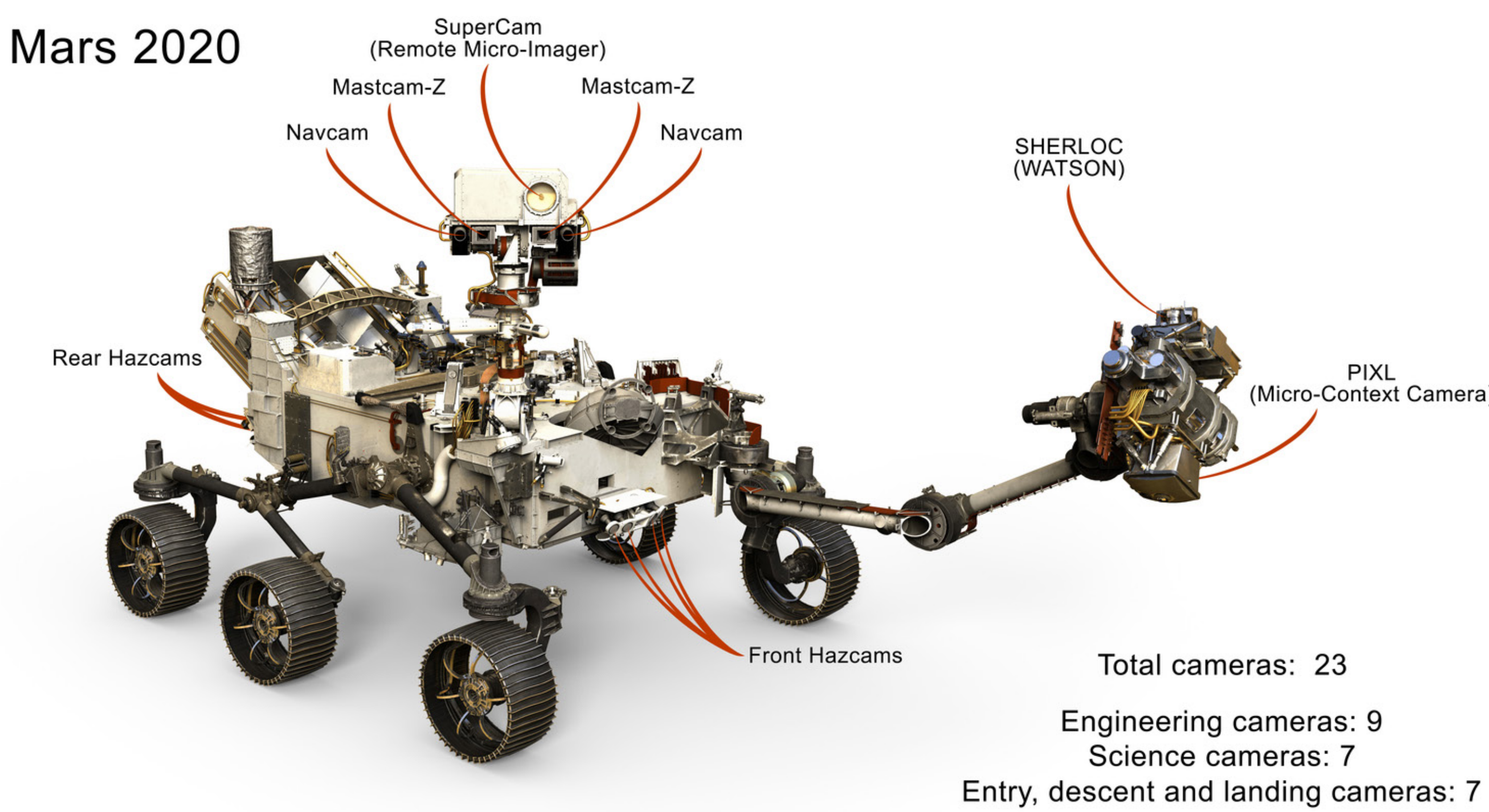
The program has installed automated systems to press and measure the Np-237 target pellets. Wham said automating the entire process has allowed the lab to increase the production of pellets significantly, helping to more than triple the output of Pu-238. Researchers are looking at ways to use monitoring on the line to test and evaluate chemical processing steps in the hot cells, saving time and materials involved with taking samples out of the hot cells for analysis.

Additionally, new equipment is being made to improve fabrication of the targets that are irradiated in HFIR. ORNL is staffing operations so that the process can continue 24 hours a day.

Some of ORNL's Pu-238 was combined with Los Alamos's existing supply for the

Mars 2020 mission. ORNL has contributed additional elements to Perseverance, including producing the rover's iridium alloy clad vent sets, which are virtually indestructible metal cups that contain the Pu-238 fuel, and the carbon-bonded carbon fiber insulation that surrounds the fuel cladding.

UT-Battelle manages ORNL for the Department of Energy's Office of Science, the single largest supporter of basic research in the physical sciences in the United States. The Office of Science is working to address some of the most pressing challenges of our time. For more information, please visit energy.gov/science.



Perseverance

by Wayne Carley

noun
per·se·ver·ance |
Definition-

: continued effort to do or achieve something despite difficulties, failure, or opposition : the action or condition or an instance of persevering : steadfastness, determination, endurance

Examples of perseverance in a sentence:

"The middle school student continued in their perseverance of math and science, despite daily challenge, so they could pursue their dream of becoming a doctor".

"Scientists were determined to persevere in their pursuit of innovation for the Mars 2020 flight and exploration".

This is a great word and applies to any number of challenges faced by people of all ages on a daily basis. From tryouts for the high school basketball team, to the long awaited promotion at work, and the construction of innovative technology for the exploration on Mars, the decision to persevere and never give up on your dreams and goals is an excellent character quality everyone should include in their life.

For those in school, any variety of homework assignments or classes may challenge you to decide to either "persevere" or quit. How bad do you really want your dreams to come true?

To our educators I plead, "Do your best to persevere through these challenging times in education, for the sake of your students".

“I quit 4 times”

I have lived long enough to experience successes through years of difficult perseverance and I have also quit numerous times on other projects after making a decision to ‘not” persevere. I can say without a doubt that the reward, both in my self-esteem of accomplishment and lifestyle freedoms, has far outweighed the decisions to quit.

Some years back, I arose early, about 2am, climbed out of my tent, strapped on my pack and started my assent of Long’s Peak on Colorado’s front range. My solo climb of the 14,259 foot mountain was number 18 in my pursuit of the coveted Colorado 14er’s challenge. I had trained and climbed for years of course, but Long’s was certainly the most challenging to date for me. To be clear and put this in context, I quit 4 times on the climb that day.

I quit in the ‘Bolder Field” because of a cramp in my calf and the constant looking up toward the summit that was far beyond my reach. I sat for 20 minutes, gathered my thoughts about how much I wanted this one, and set off again toward the “Keyhole” passage.

I quit the second time a few hours later as I looked through the ‘keyhole formation’ into the next valley and the rocky scramble ahead that merely traversed the south face along “the Ledges”, with little progress on the ascension. Another 30 minutes of discouraging contemplations about being only halfway was followed by anger over my lack of commitment to the goal.

Here followed the steepest portion upward through the very vertical and loose footing of the “Trough”. Up, up, constantly up through the loose and jagged rocks of this portion that strained my balance, my energy reserves and at this altitude, my lung capacity. My perseverance to this point had become multi-layered and at about the half way point in the Trough, I quit for the third time.

My brain was exhausted, as well as my body, and I began to rationalize the quitting by saying, “I’ll try this again another time, when I’m in better shape”. I remembered that 60 climbers had died on this route and more than 50% of the attempts had resulted in failure. I found a good reason to quit. I looked down into the Trough and saw 2 younger adults working their way up slowly below me. “No way I’m going to let them pass me by,” I said out loud. I continued on, foot by painful foot toward what I knew would be the most frightening portion of the climb for me called the “Narrows”.

As I reached the high point of the trough and the beginning of the Narrows, I looked over the edge to see the endless drop-off and the narrow ledge I was expected to navigate. It was so high, and windy and narrow. I quit again. I didn’t just decide to take a break - I really did quit this time.

But wait, it’s not over.

After another 30 minutes of reflection, overcoming 3 previous "quits" and knowing I was nearing my goal, I chose to deny my fears, ignore my pain and persevere all of this by pressing on to the summit.

It wasn't determination that drove me on, but rather the choice to surpass the obstacles, face the challenges, ignore the good reasons to quit and the looming dangers all around - to persevere and continue this effort, despite the difficulties, and the momentary failures while remaining steadfast in my personal endurance.

Did I make it? Yes, all the way to the summit where I stood proud, cold and incredibly satisfied. Not just satisfied in reaching my goal, but in pushing past the "quits, and momentary failures", and continuing on when my mind was telling me I could not do this.

This lesson of personal perseverance has stayed with me for years in business, relationships, sports, health challenges, and continuing education.

Choose to persevere.

Wayne Carley / Summit of Long's Peak, Sept. 1989

Smell .

.... The Most Unsung Sense

by Andrea Rothman

The first time I ever smelled mulch was ten years ago. I was sitting out on the porch in my pajamas on a Sunday morning, watching my husband tear open a bag on the lawn. The geraniums, which he'd recently planted, could use a little help, as could the peach tree and the apple tree. The stuff inside the bag was of a rich dark chocolate color, and from a distance looked like ordinary fertilizer, the one he had used the previous spring, when we'd moved out of the city with our children. A year had passed and I worried that I would never get used to living in a house, let alone Long Island.

Shards of bark were mixed with the soil inside the bag, a multitude of them, so that there appeared to be as many woodchips as there was soil, and there was a strange reddish tinge to the mix being spaded out of the bag and spread on the flower bed at my feet, that felt as un-graspable to me as the smell that had begun to permeate the air: an odor of earth and sawdust laced with acid and decay.

I'd smelled these individual odors before, but never together, as a whole. Together they didn't make sense; nothing about the smell in the air made sense to me. It felt entirely alien.

As a former research scientist in olfaction, I understood why I felt the way I did, because it was my first time smelling mulch. I had nothing to compare it to...nothing to ground me in the moment. My primitive brain, where memories associated with smell are made, was a blank slate to mulch.

Until then that is, which might explain why the experience felt as wondrously strange as seeing a new color in the spectrum of light. More than that, it was a historical moment in my life and in the life of any adult: a new smell-associated memory was slowly taking root inside of me.

The human nose can detect thousands of odors, but given our mostly sedentary lives and limited smelling lifespan (our capacity to smell tends to decrease with age) it is likely that we will only experience a fraction of these odors in our lifetime. Moreover, most of the smells we encounter every day are archetypal of the modern world, and therefore tend to have collective rather than personal associations.

And yet smell is our most powerful means of accessing the past. Because the nerves that signal smell information, unlike those that signal vision and sound, connect directly to the hippocampus and amygdala in our primitive brain—involved in memories and emotions—our response to odors, in particular odors associated with significant events in our lives, is strong and immediate. We don't just remember who we were and how we felt; we actually experience it, we relive the moment.

The smell of steamed cabbage for instance will immediately transport me to my paternal Jewish grandmother's kitchen in Brooklyn New York where she taught me how to cook stuffed cabbage. I remember the smell of melted wax at the church in lower Manhattan where my maternal catholic grandmother used to take me as a child while both of us knelt at the pew after lighting a candle by the door.

My grandmothers are long deceased, but smell allows me to conjure that early period of my life and what it felt like to grow up with two very different heritages. While the odors of steamed cabbage and melted wax are universal, the memories they unlock in me are uniquely mine like no one else's in the world.

Most of us take our sense of smell for granted, but if we were to lose it tomorrow, we would also lose our most faithful sensory portal to the past. We would still be able to recall significant events in our life, but not as vividly. We would, in a sense, irretrievably lose touch with who we were.

My husband never bought mulch again. In the end, it didn't do very much for the garden. But I recently drove to Melville, not too far from where we live, and visited a mulch supplier. I got out of the car and stood for a moment contemplating the dune of organic matter through the rusted gate, and gradually I was transported back to that early spring day on the porch of our house, where being new to Long Island, was yet unaware as of its sensory magic.

Andrea Rothman

Andrea Rothman is a former research scientist at the Rockefeller University in New York with a PhD in neurobiology, where she studied the sense of smell. Awarded two grants from the National Institutes of Health to study olfaction, Rothman knows her subject matter intimately, crafting her debut following the age-old adage of "write what you know." She is also the author of The DNA of You and Me which is available now anywhere books are sold. Learn more about Andrea at www.andrearothman.com.

Computer Science: A Revelation from a Crow

By Song-Chun Zhu, PhD
Professor of Statistics and Computer Science, UCLA
Founder and Chairman, DM Group

Compare a crow and a parrot, birds of similar size.

Parrots have a strong language imitation ability; they learn to mimic words by hearing them repeatedly. Repeat words and short sentences to a parrot enough times, and the bird will start talking back. This behavior resembles the data-driven chatbots of today; both can speak, but neither can understand semantics nor the context of speech. They cannot utter words that respond to the physical world, or to social objects, scenes, and characters. They cannot speak to logical cause and effect.

In contrast, consider the common crow. Crows can create tools, develop new physical skills, and engage in social activities that require common sense. In other words, crows are far more clever than parrots.

If you were to watch any number of YouTube videos of crows interacting with humans in urban environments, you would see why I believe that any AI research group would be wise to have a crow as its mascot. This is an animal that can teach us about the very nature of intelligence.

Observing the Crow

The following figures are taken from the study conducted by Nihei Yoshiaki (Tohoku University) and Higuchi Hiroyoshi (The University of Tokyo) in the publication, Tohoku Psychologica Folia. In Japan, carrion crows have been observed to use cars to crack nuts since the 1990s.

Above is a crow in the wild, untrained by man. It must rely on its faculties of observation, perception, cognition, learning, reasoning, and execution to make its way in life. If it were a robot, its explicit day-to-day goal would be to survive. In the city, this means managing the uncompromising urban environment.

Our crow's first task is to acquire food. Luckily, it finds a nut; but to eat it, it must crack its shell, a task beyond the crow's physical ability. Other animals use tools: to crack a nut, a gorilla will knock it against a hard surface, such as a stone. Our crow tries to crack the nut by dropping it from elevation to the ground, but this strategy does not work, despite repeated attempts. But then a new idea emerges.

This photo shows the crow using a new trick: it puts the nut in the middle of a road where passing cars crush its shell – what we might call a "bird-machine interaction." But there's a new challenge: how to retrieve the cracked nut from the middle of a busy thoroughfare? After some gentle trial and error, the crow quickly realizes that attempting to retrieve its prize from traffic could result in its death.

Note how different the process of the crow learning to avoid traffic is from machine learning today. There is no dataset, no supervised learning, and no learning cycle; the crow does not run through the nut retrieval scenario multiple times to see exactly how it can go wrong. The crow has only one chance at life.

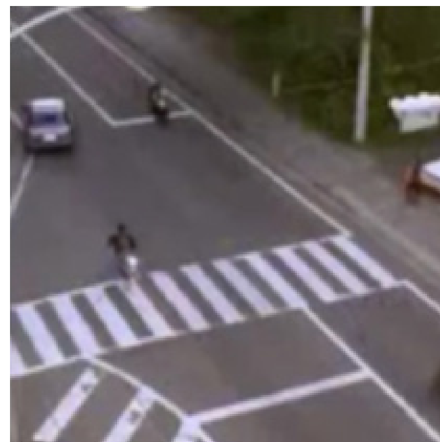
This image shows the crow beginning to observe how cars and people sometimes stop at the intersection near the red and green lights. To fully understand why, it must comprehend the complex causal relations between the traffic lights, crosswalk, pedestrian lights, and cars. It must understand how all of these impact cars' speed and stopping, and how this information is relevant to its goal of retrieving its cracked nut.

It must even understand, in some small way, how which lights in which direction will influence which object.

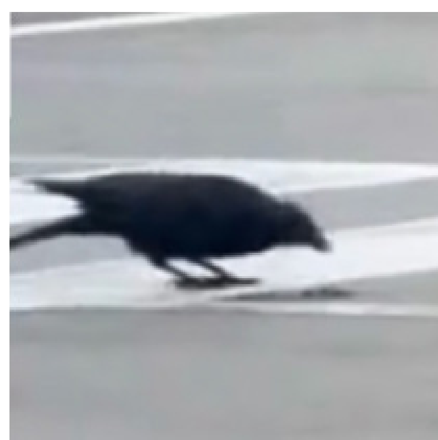
The following photo shows the crow choosing to observe from a wire just above a crosswalk at a different location from where it observed and learned about the relationship between all the variables of the intersection.

It generalizes and transfers the causal relationships between these variables from one location to another. Current machine learning models cannot accomplish this; some reinforcement learning methods may teach robots how to engage with fixed objects, such as building blocks or toys, but the methods learned in this way can be "brittle" -- they fail once an object's position changes slightly.

The crow drops a nut onto the crosswalk and waits for a car to drive over it.



Once the nut is cracked, the pedestrian lights turn on, and the cars come to a stop, the crow can finally…



…fly down and walk leisurely over to eat the cracked nut off the ground while the cars are stopped at the red light.

The Crow, the Nut, and the Intersection

You may be surprised by the crow's cleverness. But this is the level of intelligence I have come to expect from AI. Below is an example of intelligent behavior exhibited by a crow. The task is to safely crack a nut and eat the kernel inside its shell.

(A) A common crow is identified by a researcher. It has no prior training.

(B) The crow discovers how to open nuts by placing them on a street to be driven over by a car.

(C) The crow finds that cars sometimes stop moving at intersections, creating periods of safety in crosswalks.

(D) The crow intentionally chooses a wire over the crosswalk to get the best view of the scene.

(E) The crow throws the nut on to the crosswalk and waits for a car to drive over it and the pedestrian lights to come on.

(F) The crow retrieves the nut safely.

"Speaking in metaphor, we are looking for a crow mode of intelligence, rather than a parrot mode of intelligence."

This metaphor shows that a solution exists for the kind of AI we want to build. At the same time, I certainly do not claim that this simple analogy clarifies every issue about intelligence. Meanwhile, not all aspects of intelligence need to be replicated in machines to be useful; we can appreciate that the parrot mode of intelligence is commercially viable for some vertical applications, and should by no means be discarded.

Three critical takeaways about crow intelligence:

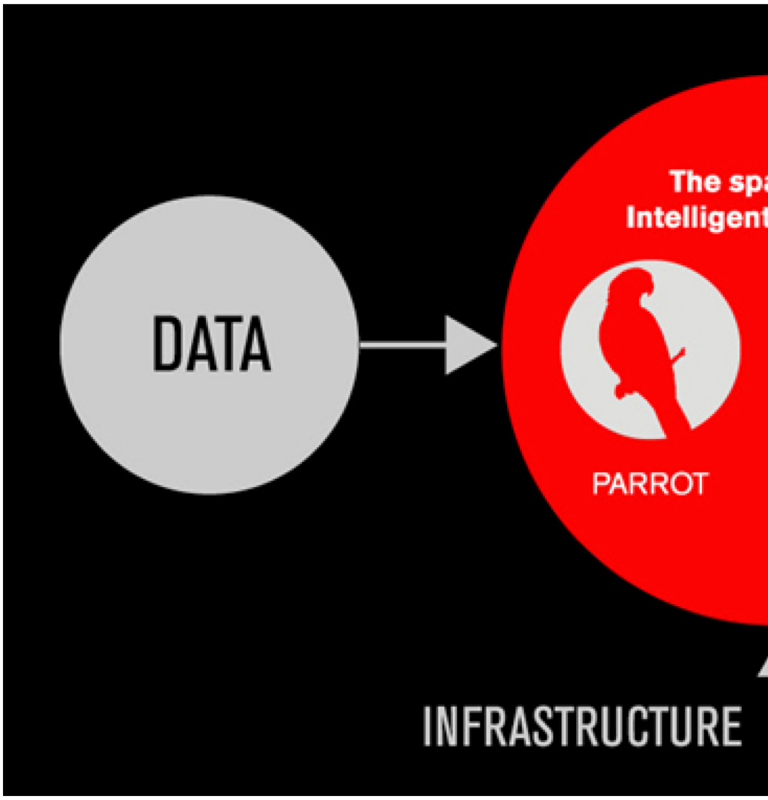
1) ***It is entirely autonomous.***
It has perception, cognition, reasoning, learning, and execution. We noted earlier that general cognition is a problem that can't be solved by the world's top scientists; the crow proves that a solution exists.

2) ***It does not need big data.***
A crow does not have millions of annotated inputs and outputs to analyze. It solves problems through a small amount of data and without any supervision from a teacher. The crow cannot try random solutions in dangerous situations to see what could go wrong; this is the crow's only life.

3) ***It is efficient.***
A crow's brain consumes only 0.1-0.2 Watts of power, while the human brain consumes between 10-25 Watts of power. The size efficiency of the human brain shows hardware chip designers what is possible.

The goal of scientific research is, of course, to look beyond immediate commercial value, to look deeper, to work towards advancing what is possible.

Unified: The "Small Data, Big Task" Paradigm and Cognitive Frameworks

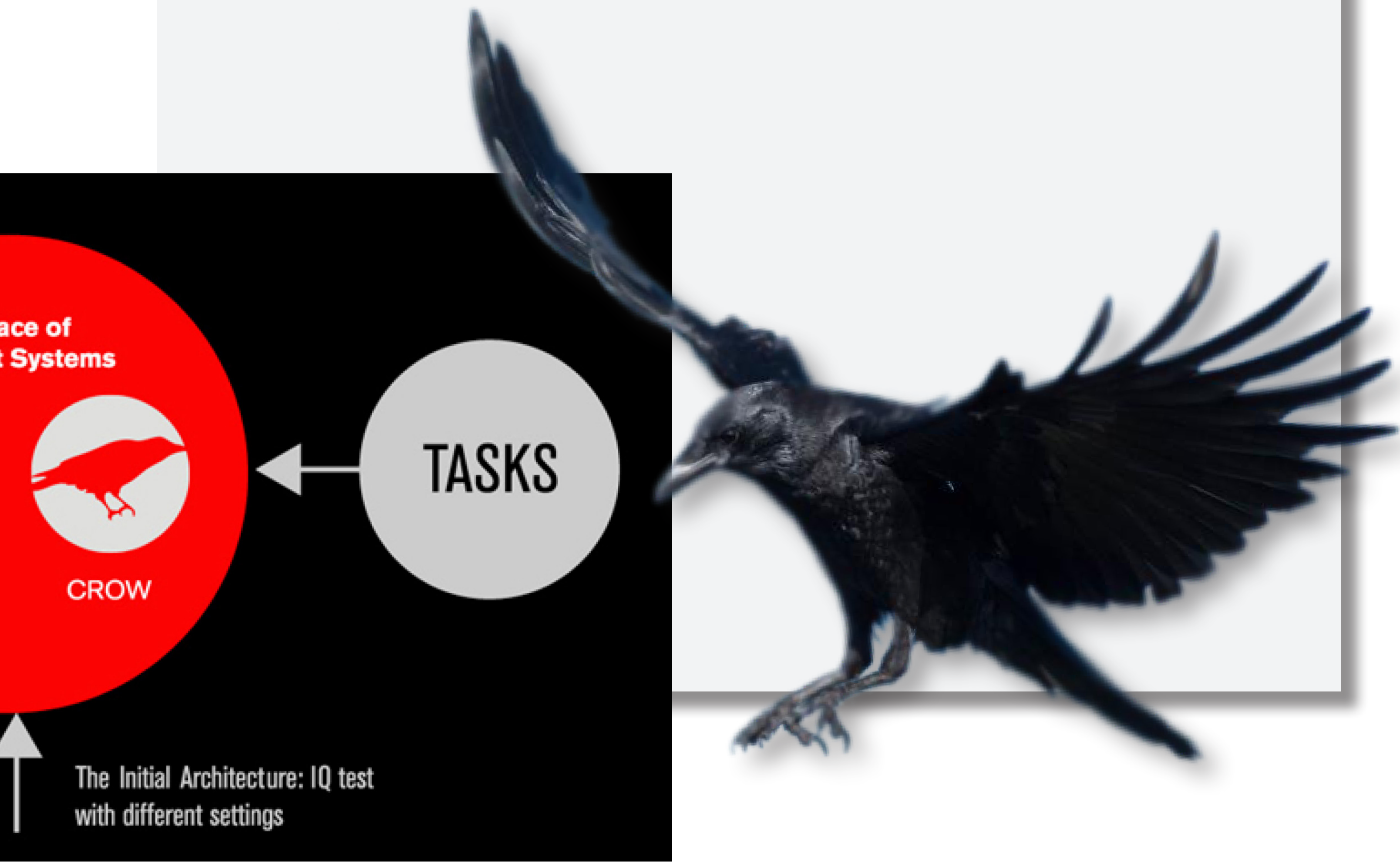


Intelligence is a phenomenon that manifests itself in the behavior of individuals and social groups. In the case of crows, intelligence is molded by two basic forces.

1) The physical environment and chain of causal events.

The boundaries of a crow's physical existence profoundly shape its intelligence; if it had evolved in different environmental conditions, its intelligent abilities would have developed differently. Any intelligent machine must understand and adapt to its physical world.

2) The internal values shaped by tasks that must be performed by the species to survive and thrive.



Survival demands that an individual solve the problems of how to acquire food and ensure safety against various environmental threats. In addition, the survival of the species necessitates procreation through the finding of mates, which in many species requires social activity. Many tasks arise from these foundational problems; these tasks drive behavior.

Behavior aimed at completing these tasks is represented in a host of value and decision functions. These functions were formed in the evolutionary process and are modulated by chemical compounds in the brain such as dopamine (pleasure), serotonin (pain), acetylcholine (anxiety, uncertainty), norepinephrine (novelty, excitement) and many others.

Song-Chun Zhu is a Chinese-American computer scientist and applied mathematician known for his work in computer vision, cognitive artificial intelligence, and robotics. Zhu founded DMAI as an AI startup to lift humanity by developing cognitive AI assistants and platforms that make personal connections to individuals. He is widely recognized as a global thought leader and innovator within the field of artificial general intelligence.

The STEM of Teaching

#2 in our series of "What Most Americans Do".

by Wayne Carley

Teachers are number 2 on our list of careers that “most Americans do”, following retail sales. With nearly 4 million public and private school educators, this group of professionals has the responsibility of not only presenting curriculum throughout the school year, but possibly as important, influencing students in a variety of ways.

For educators who understand what STEM *really* means, they realize that every teachers in every subject and every grade uses STEM, as defined in every issue of this magazine. Let’s take a closer look as to how every teacher is a STEM teacher in application regardless of curriculum.

The science of Teaching

By definition, science is the “systematic accumulation of knowledge”. I cannot name one subject in school at any grade level that does not require this systematic accumulation. By definition, all teachers use this form of science daily as well as their students. Memorization, testing, homework, research and assignment completion all require this gathering of facts, theories, historical data, and personal experiences in preparation for a testing evaluation of how well this knowledge has been gathered or accumulated.

The Technology of Teaching

As defined, technology is the "practical application of science". Practical application is the use of something for a reasonable purpose. The age old question posed by students remains relevant; "How am I going to use this in the real world?"

An example of practical application is using a school math lesson to figure out the total cost of items while grocery shopping. Calculating percentages, discounts, simple math or more complicated geometry used by carpenters on a daily bases are good examples. Simply following a recipe while cooking is a great math example of how we use this every day.

The technology or practical application of knowledge accumulation in English class is used in all career fields since communication's, writing skills, grammar, and spelling are all included in your chosen job.

This would be a good topic of discussion at home between students and parents (with life experience) to consider and evaluate the practical application (use) of school subjects such as:

- Math
- Social Studies
- Geography
- History

- Earth Science
- Language Arts
- Foreign Language
- Music
- Health Class
- any other subjects you are taking.

The Engineering of Teaching

This feature of education is one of my favorites to discuss and probably the least understood by most teachers. Engineering is one of those words that has hundreds of practical applications and hundreds of career definitions, but must be specifically defined in order to be discussed.

Engineering is a process defined by the engineering method that is used to "solve problems". Engineers are problem solvers, and problem solvers are engineers, regardless of their education or career field. The process of solving problems remains the same, even for teachers.

- ASK: What is the problem?
- IMAGINE: What are some possible solutions? Has anyone else had to deal with this problem?
- PLAN: Make a list of possible solutions to the problem?
    - Financial cost
    - Available resources or supplies
    - Time line for solution
    - Other needs such as people or a location needed
- TRY IT: Pick a single solution and try it out.
- EVALUATE: Did it work? Why or why not?

If your choice and evaluation fails to solve your problem, you simply go through the process again until something works. This is a fun process that offers challenges, deep thought and imagination. I personally find deep gratification is solving problems of all kinds. The reward is very satisfying and boosts your self-esteem too.

That being said, teachers are solving problems daily in class and at home using this method…often without their knowledge of the steps. Some experts are exploring our natural ability to solve problems this way. Is it already wired into many brains? Is it common sense? Life experience?

The Math of Teaching

Math is the "science of numbers and their operations". Once again we see the systematic accumulation of knowledge mentioned in the definition of mathematics as a science. We have to build our stored knowledge of numbers operations for future use.

How does "non-math class" teaching use that? In all subjects, students are individuals but also numbers in the broader picture of education as a whole. Student performance is tracked using numbers, evaluated numerically and charted using graphs, percentages, and statistics. The total number of class periods projected for a school year is considered with the total amount of information needing to be taught by the teacher. These calculations are constantly revised numerically throughout the school year as unexpected delays or interruptions occur.

Grading is the obvious use of math as well as tracking those numbers for each student and the combined data of the class as a whole and then as a school. This application of math usually involves the use of mathematical statistics, a widely needed area of math in industries worldwide.

So here we have a Language Arts teacher who suddenly realizes the use of STEM in their class and personal life on a daily basis. This "ah-ha" moment can provide great influence in the lives of their students as to the practical applications of STEM in every school subject as well as every career field. It can be life changing for all involved.

To conclude, there is a national and global shortage of teachers in all grade levels. Even though teaching is the second most populated career in America, the shortage is severe. Teachers is all 50 states are quitting faster than the student dropout rate.

Over the years I have asked hundreds of students in all grade levels;

"Would you like to have your teachers job?"

With very few exceptions, the overwhelming response was, "No way. These students would drive me crazy."

Under paid, over worked and usually unsung, teachers remain the most influential in the lives of students. If your passion is to shape lives and influence the future with less regard for yourself than others, teaching may be a good fit.

The best educators have a broad understanding of the interrelationship between subjects and curriculum which is why a more complete understanding of STEM skills and their career paths is so important. It's my hope that this brief overview of teachers and STEM has sparking questions to consider and the desire to know more about STEM skills on behalf of our students and their families.

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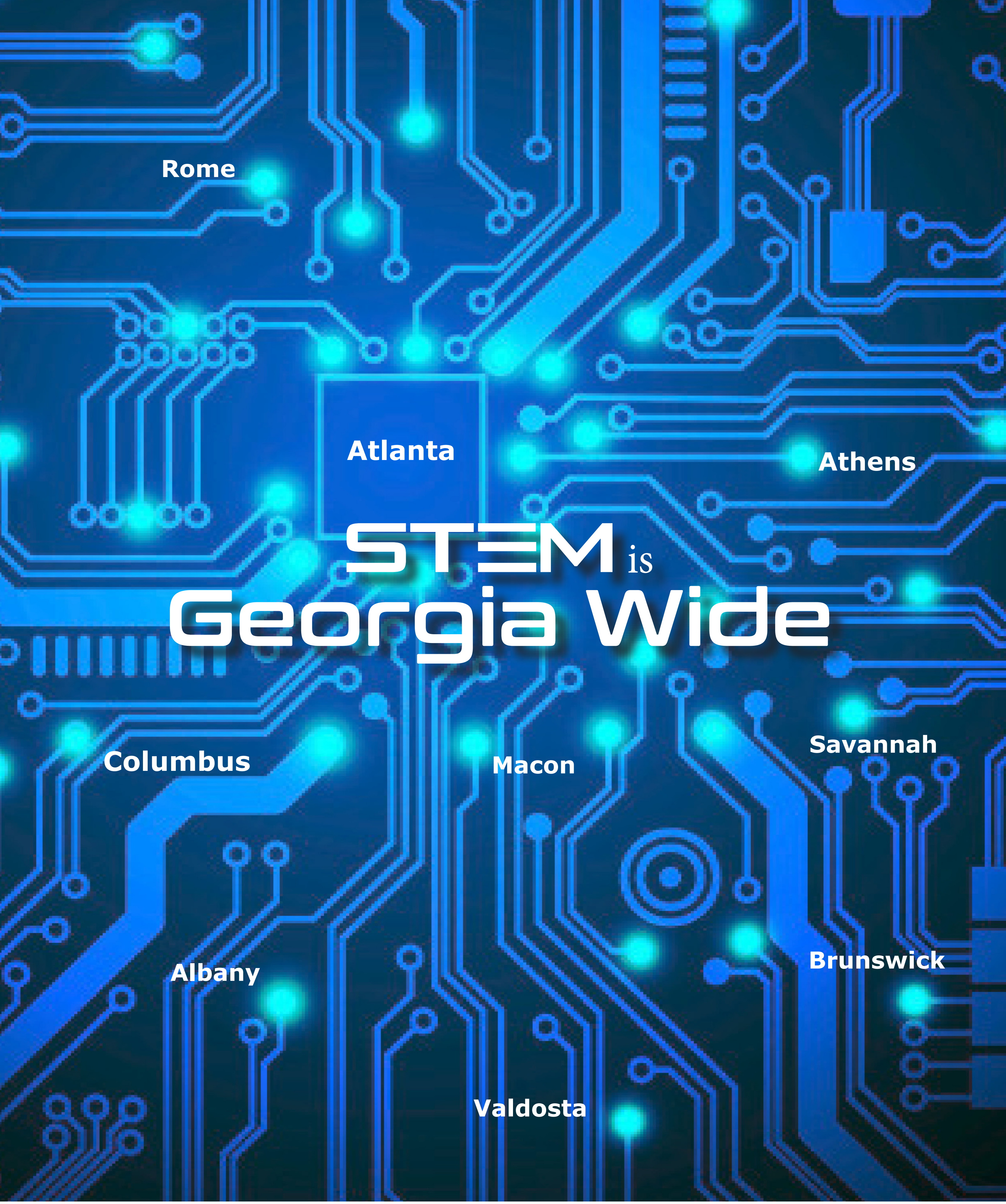

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