STEM

MAGAZINE

Space Elevator

Science Fiction Becomes Science Fact?

The Wonder of it All

More International Women on Campus

August 2016
\\193v

CLASS STEM LESSON

Recipe for one person:

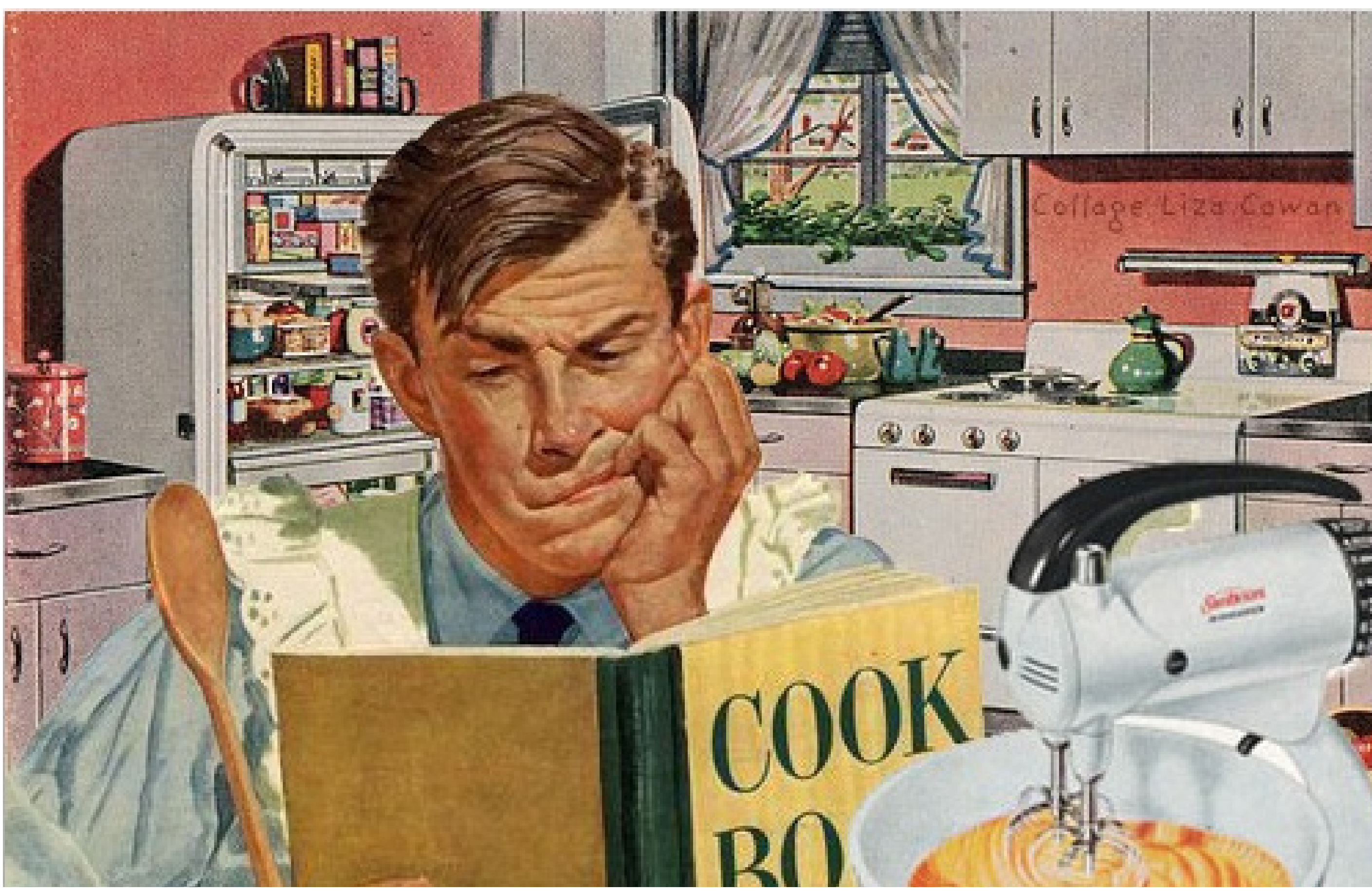
- 1/2 cup sugar
- 2 1/4 cups flour
- 1/8 tsp. all spice
- 2 cups water
- 3 eggs
- One Cornish Hen
- 2 tsp. salt
- 1/2 tsp. pepper

Math I use everyday.

Assignment:

4 people are coming for dinner.

- Re-calculate recipe



Yes, you will use math (usually easy math) everyday. Don't be afraid of it. Your brain is actually wired for it.

A warm welcome to our newest readers in Ghana at the Juaben SHS / Charity Aid Educational Foundation.

July Articles

STEM Magazine is a non-profit monthly education publication for teachers, students, their parents. The example and inspiration of individual educators carries tremendous weight on a daily basis, greatly impacting the quality and effectiveness of the classroom environment.

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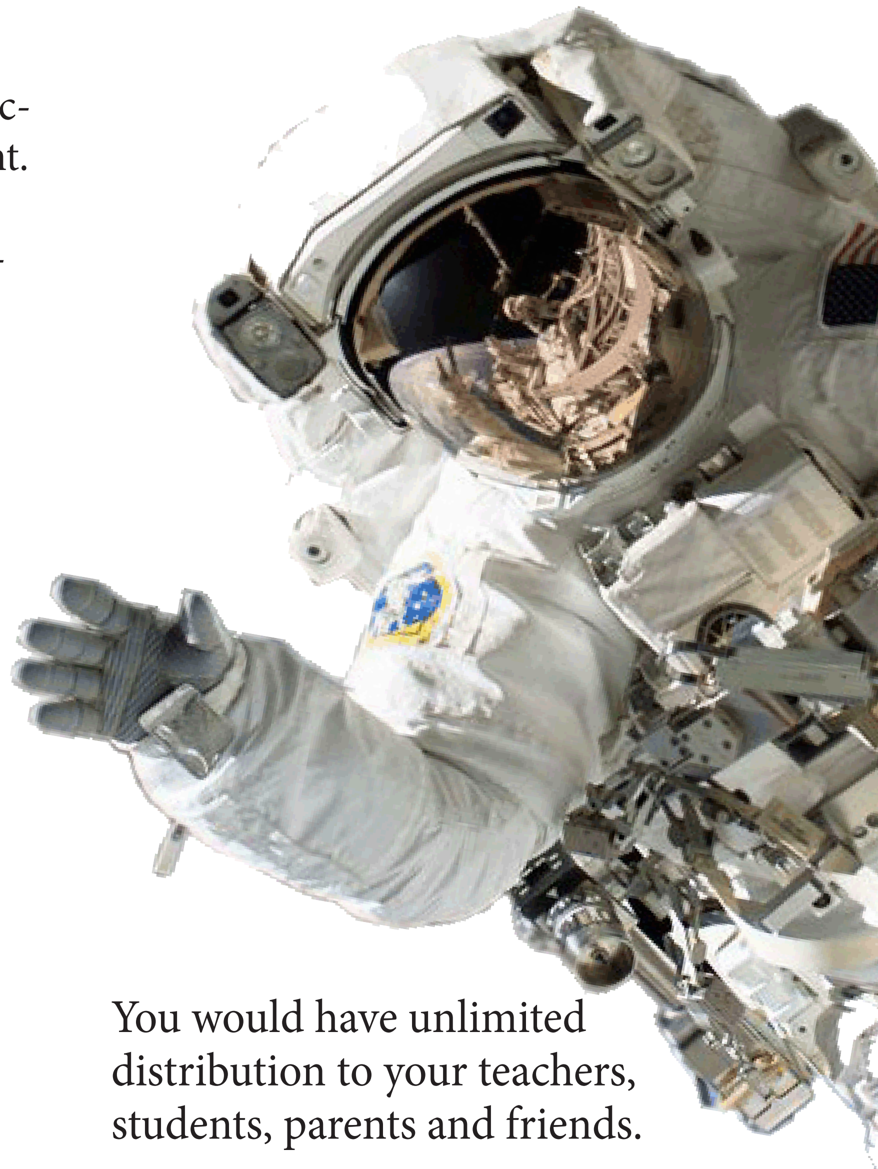
We believe that the key to success in seeing higher graduation rates, improved testing results, student inspiration, creativity, excitement and career satisfaction rest in the hands of the teacher. The example and inspiration of individual educators carries tremendous weight on a daily basis, greatly impacting the quality and effectiveness of the classroom environment.

Our mission: Encourage curiosity, inspiration and creativity, the foundations of every career passion.

Wayne Carley
Publisher
STEM Magazine
STEM for Women Magazine
STEAM Magazine



School, district, county and state "customized versions" are available.

To find out more, simply send your E-mail request to:

wayne@stemmagazine.com

You would have unlimited distribution to your teachers, students, parents and friends.

STEM Magazine is also PDF printable and mobile device friendly.

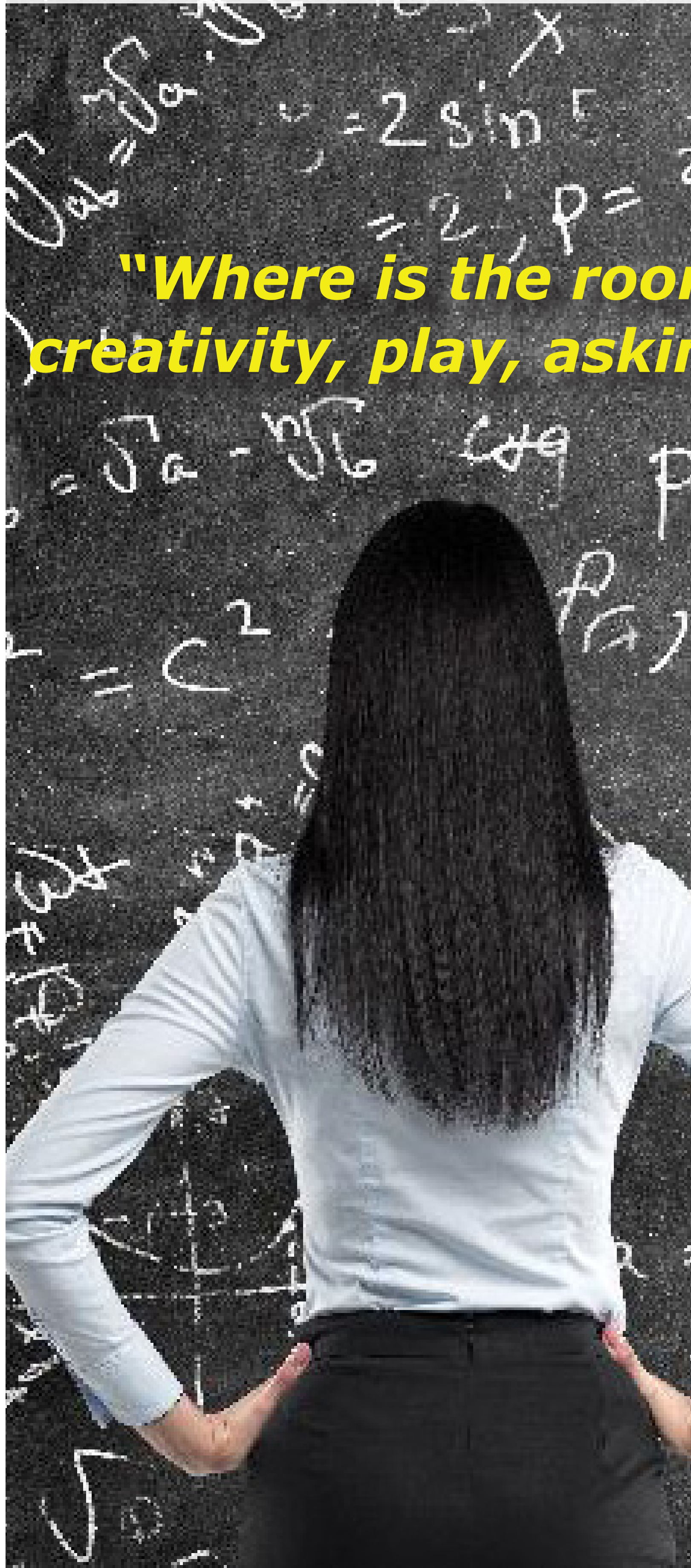
STEM: The ***Wonder*** of it All!

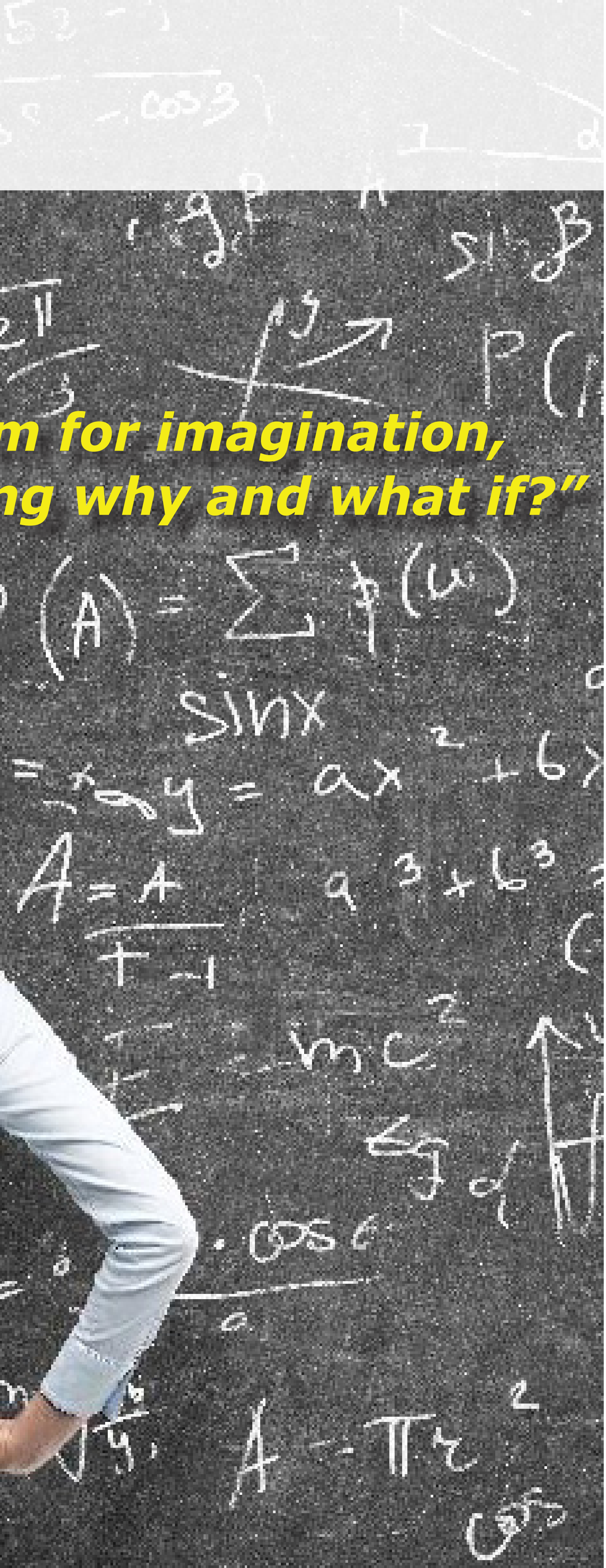
by *Richard C. Larson* / MIT

STEM means so many distinct things to different people. Some think of robot competitions, not exactly an inviting image for many young people. Others think of AP tests in math and sciences. Another downer for many! Still others may think of myriad items to memorize and parrot back on tests – math formulas, multi-syllabic biology terms, Newton's Laws of Physics, the Periodic Table, etc. Not exactly what you leap out of bed for in the morning!

I'm not saying that students should not know the fundamentals. They should. They must. But in today's education environment, where is the room for imagination, creativity, play, asking why and what if? And doing this may be much harder than any of the items listed above. But also much more enjoyable and satisfying.

Last month I learned that two friends of mine are pregnant, with due dates March 12 and March 17. The March 12 pregnancy is the 2nd for the Mom-again-to-be, whereas the March 17 event will be the first birth for that Mom-to-be. So, motivated by the fact that my 7-years younger "baby sister"





was born on my own birthday, I asked myself this question: What is the likelihood that both babies will be born on March 12? On March 17? And, more generally, what is the probability that both will be born on the same day, any day?

This is an example of ***playing*** with mathematics in the everyday world. It’s not a textbook assignment, nor will it be tested. But to identify it requires inquisitiveness about math and the world around us. We should not feel intimidated by a problem we have not seen in a textbook. In fact, we should eagerly pursue it! And what if it takes us a week to frame, formulate and solve it?

Timed tests may make us think that if we cannot solve a math problem in 20 or 30 minutes, we are failures! The reverse is true. On the job, as an adult professional, if one is confronted with a new math problem, “the boss” is not likely to care whether you solve it in 10 minutes, one day, one week or perhaps even one month. Just solve it and move the project forward!

I decided to pursue the pregnancy problem and create an MIT doctoral exam question around it! The data required to address the problem are available on the web, for instance in the Boston Globe – “Get ready. Your baby is coming Early.” And, yes, the probabilities related to day of birth compared to Due Date depend on whether the baby is the first for a mother or not the first.

But I don’t think one needs to be a Ph.D. student to solve this! One just needs patience and a careful step-by-step approach, perhaps aided by an Excel spreadsheet. Try it yourself! Work with some illustrative simple numbers to start, to test your ideas. If you are successful, you can generalize the problem: Say the due dates are X days apart (X = 0, 1, 2, …): Plot the probability that both babies will be born on the same date as a function of X.

We need to encourage our young people to explore the wonder of math and science. To ask questions that relate to their everyday lives. Why not operate a STEM class where periodically one of the assignments is just that: Frame, Formulate and attempt to Solve some math or science problem that awakened in you as a result of something you saw, experienced or dreamed about?

And add your proposed solution to your Portfolio of Accomplishments, and later submit that portfolio to your college of choice, along with your SAT, ACT and AP scores! In my view, such a portfolio is much more important than any of those test scores.

Students may not be able to solve every problem they identify as interesting, but building up that portfolio will also help them discover what kinds of every-day, real-world problems are of particular interest to them – and lead them in the direction of fields of study that will help them to address those types of problems! Match making of interests and careers!

What’s the probability of me becoming a professional athlete?

What’s the probability of me becoming an astronaut?

What’s the probability of being hit by lightning?

What’s the probability of winning the lottery?

What’s the probability of me becoming rich or famous?

It not luck or the roll of the dice.....it's math. What's interesting is you already ask this type of question all the time.

The answer is there and it a math problem. Do you want to know answers?

Do the math !

Status of the Space ELEVATOR Concept

During the Summer of 2016 / Part I

Peter A. Swan, Ph.D., and Cathy W. Swan, Ph.D.

This isn't the first time science fiction was on the verge of becoming science fact. Multiple companies and organizations are currently building or researching the reality of a space elevator.

One such group is The International Space Elevator Consortium who has chosen to describe the space elevator from the top level to help readers understand its status as of the summer of 2016.

One of the first steps is to describe the three concepts of space elevator infrastructures that are sufficiently refined to be seen as ***"real."*** To accomplish this task, the authors present their views starting with the questions:

- Why are we going to build a space elevator infrastructure?
- What is the range of missions enabled by space elevators?
- What are the three concepts for modern day space elevators?

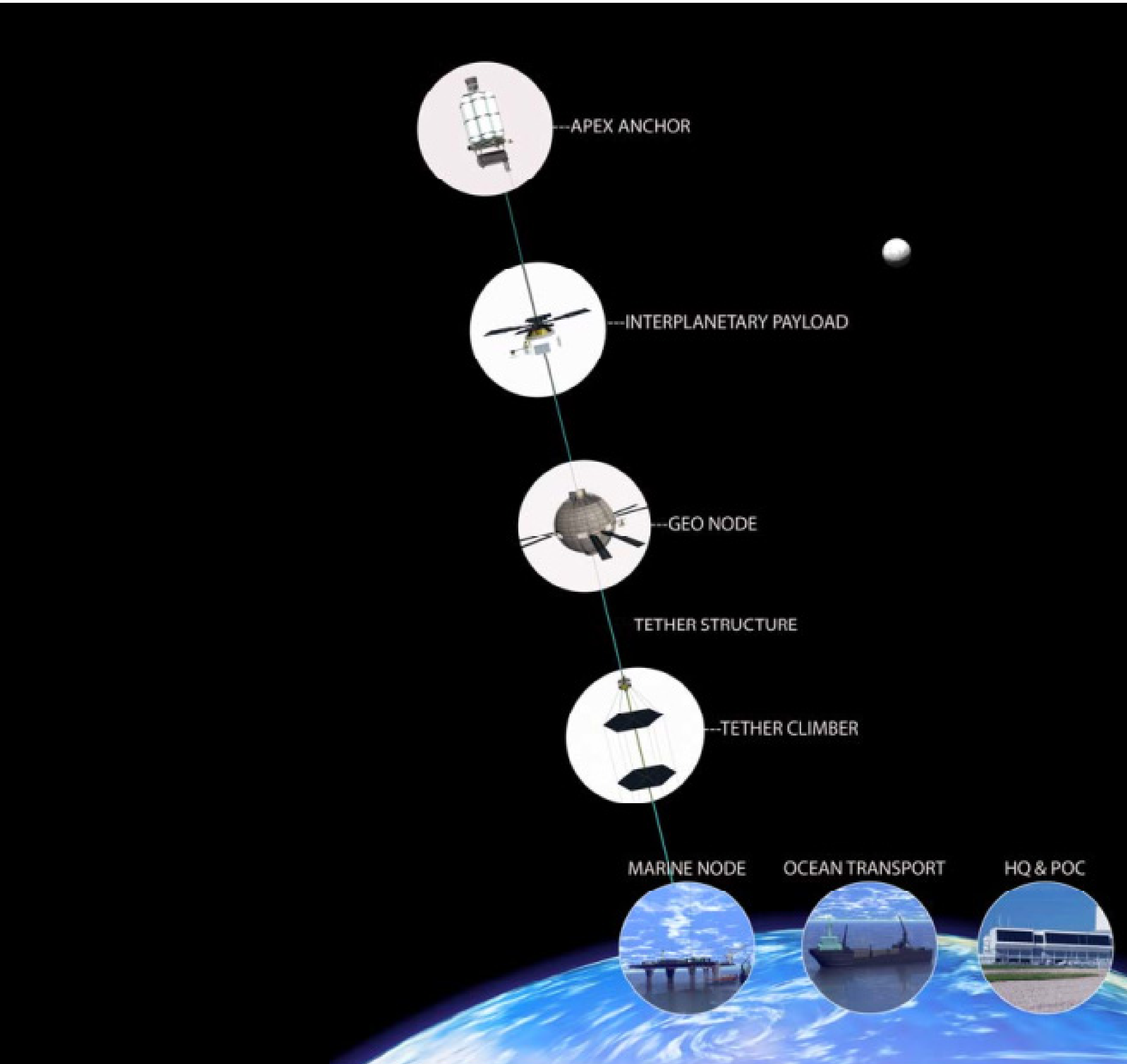
- **Reason:** Routine, inexpensive, and safe access to space.

- **How?** Thin ribbon 1-meter wide, 100,000 km long, with climbers using opposing wheels pressing upon the ribbon, driven by electricity, they rotate and friction enables movement up the ribbon, it works!

- **Why?** Space access and solutions for Earth based problems are limited by current launch size and cost. Humanity must move off Earth and space elevators will enable it.

The Space Elevator will be a transformational transportation system. It will move objects, systems, material and (eventually) people from the Earth to Space. The Space Elevator will be incredibly more efficient than today's launch systems.

It will be safe. It will be environmentally friendly, and most importantly, it will enable a wide range of revolutionary activities in space. Because of a Space Elevator, we will do today's space missions better than ever before. It will enable us to do missions in space that we have only dreamt of. One goal is to show the space elevator community's expectations for future missions leading towards an intermediate and then future destinations.



Geostationary orbit:

A geostationary orbit, geostationary Earth orbit or geosynchronous equatorial orbit (GEO) is a circular orbit 35,786 kilometres (22,236 mi) above the Earth's equator and following the direction of the Earth's rotation.

An object in such an orbit has an orbital period equal to the Earth's rotational period and thus appears motionless, at a fixed position in the sky, to ground observers. Communications satellites and weather satellites are often placed in geostationary orbits, so that the satellite antennas (located on Earth) that communicate with them do not have to rotate to track them, but can be pointed permanently at the position in the sky where the satellites are located.

Using this characteristic, ocean color satellites with visible and near-infrared light sensors (e.g. the Geostationary Ocean Color Imager (GOCI)) can also be operated in geostationary orbit in order to monitor sensitive changes of ocean environments.

Note: It's only about 60 miles to space, but you have to orbit at about 19,000 miles per hour to stay in that orbit. A GEO orbit requires you to continue out to about 22,236 miles from Earth so Earths gravity does not pull you down....thus the ability to keep your position as the Earth rotates.

A geostationary orbit is a particular type of geosynchronous orbit, the distinction being that while an object in geosynchronous orbit returns to the same point in the sky at the same time each day, an object in geostationary orbit never leaves that position.

The space elevator concept is nothing new. There were three historic concepts about space elevators that were systems reasonable for each of their times.

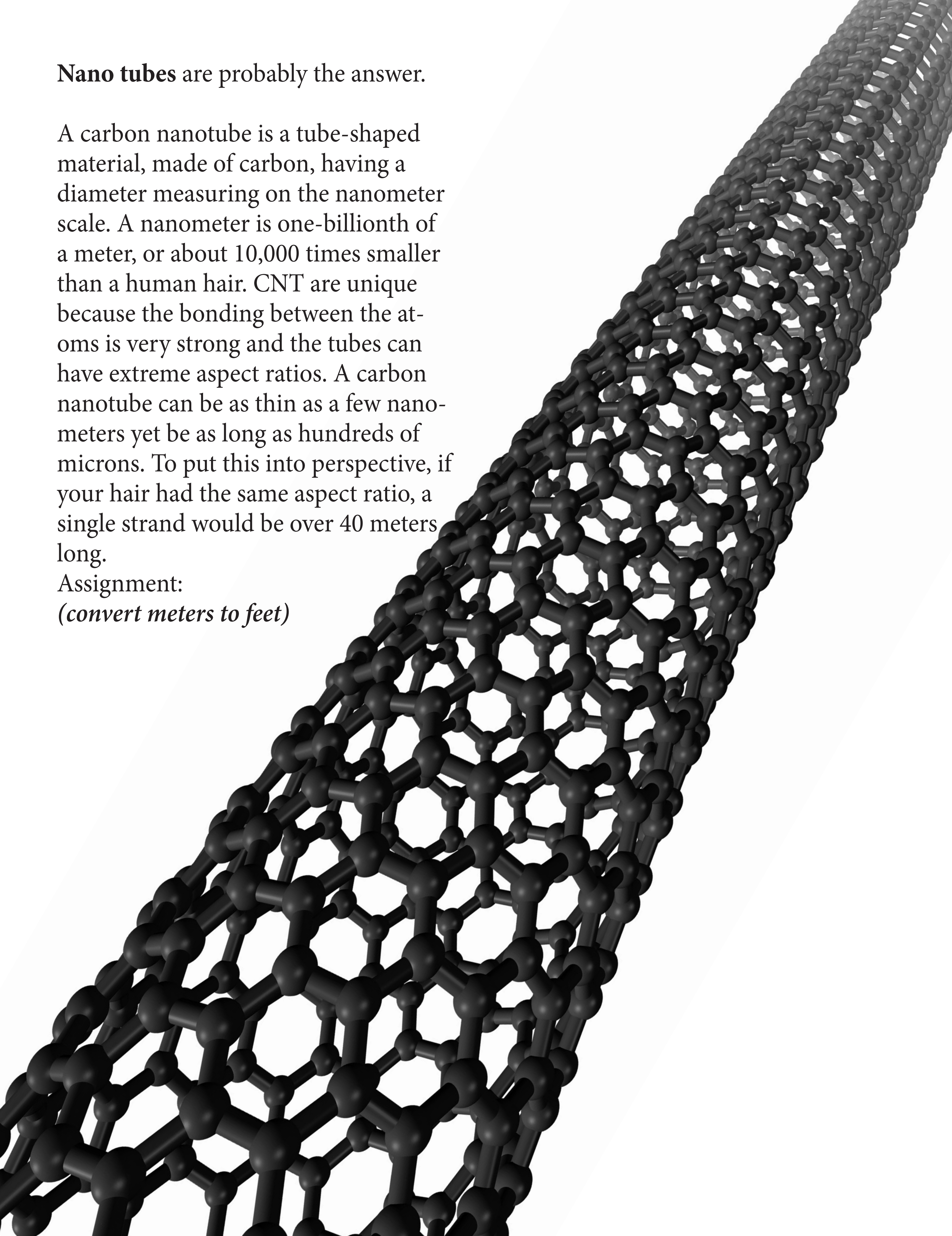
• Konstantin Tsiolkovsky, a Russian rocket scientist pioneered astronautics' theory and conceptualized a building growing to GEO orbit, in 1895. He wrote about building a tower on the equator in his essay.

• The first player in the field to really deal with cables and layout a real concept was Yuri Artsutanov, who showed that you could stretch a cable from GEO down if the strength and lightness was significantly better than materials that existed in 1960.

• In 1974, Jerome Pearson published his engineering calculations showing that the space elevator could be stable and built from a GEO orbit .

Nano tubes are probably the answer.

A carbon nanotube is a tube-shaped material, made of carbon, having a diameter measuring on the nanometer scale. A nanometer is one-billionth of a meter, or about 10,000 times smaller than a human hair. CNT are unique because the bonding between the atoms is very strong and the tubes can have extreme aspect ratios. A carbon nanotube can be as thin as a few nanometers yet be as long as hundreds of microns. To put this into perspective, if your hair had the same aspect ratio, a single strand would be over 40 meters long.
Assignment:
(convert meters to feet)



There are many different types of carbon nanotubes, but they are normally categorized as either single-walled (SWNT) or multi-walled nanotubes (MWNT).

A single-walled carbon nanotube is just like a regular straw. It has only one layer, or wall. Multi-walled carbon nanotubes are a collection of nested tubes of continuously increasing diameters. They can range from one outer and one inner tube (a double-walled nanotube) to as many as 100 tubes (walls) or more. Each tube is held at a certain distance from either of its neighboring tubes by inter-atomic forces.

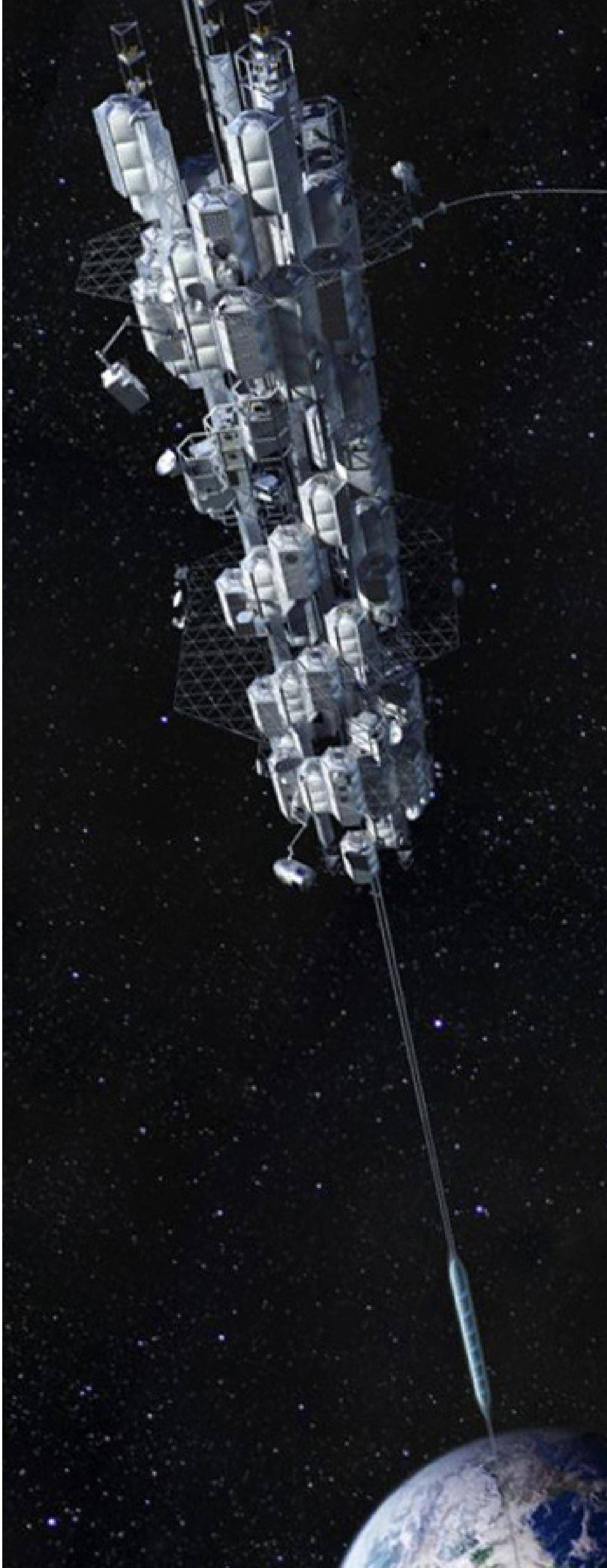
The discovery of carbon nanotubes (CNT) in 1991 opened up a new era in materials science. These incredible structures have an array of fascinating electronic, magnetic and mechanical properties. CNT are at least 100 times stronger than steel, but only one-sixth as heavy, so nanotube fibers could strengthen almost any material. Nanotubes can conduct heat and electricity far better than copper. CNT are already being used in polymers to control or enhance conductivity and are added to anti-static packaging.

The potential global impact of the space elevator is drawing comparisons to another great transportation achievement -- the U.S. transcontinental railroad. Completed in 1869 at Promontory, Utah, the transcontinental railroad linked the country's east and west coasts for the first time and sped the settlement of the American west. Cross-country travel was reduced from months to days. It also opened new markets and gave rise to whole new industries. By 1893, the United States had five transcontinental railroads.

The idea of a space elevator shares many of the same elements as the transcontinental railroad. A space elevator would create a permanent Earth-to-space connection that would never close. While it wouldn't make the trip to space faster, it would make trips to space more frequent and would open up space to a new era of development.

Perhaps the biggest factor propelling the idea of a space elevator is that it would significantly lower the cost of putting cargo into space. Although slower than the chemically propelled space shuttle, the lifters reduce launch costs from $10,000 to $20,000 per pound, to approximately $400 per pound.

You may have a job waiting !



The Future is STEM

CCRM Commercializing Living Therapies

By *Stacy Johnson*

Chloe Titus is five years old. She loves arts and crafts and board games, and hates spinach and bedtime. When she grows up, Chloe will be an ideal candidate to make a meaningful contribution to Canada's knowledge-based economy.

While that could arguably be said of any bright young Canadian, Chloe has an ace in her pocket; actually two: mother Emily and father Steve are both engineers, each making their own significant contribution to Canada's innovation productivity growth.

Chloe is growing up in a country that values STEM education: science, technology, engineering and mathematics. From governments to educational institutions to professional associations to the private sector and private foundations, ScholarshipsCanada.com estimates there are hundreds of groups across Canada creating programs and providing millions in scholarships to encourage students to pursue degrees in STEM.

While a 2015 report commissioned by the Council of Canadian Academies (CCA), STEM Skills and Canada's Economic Productivity, "found no evidence of a current imbalance between the demand for and supply of STEM skills at the national labour market level," that conclusion is counter to what many other STEM labour reports and media outlets are claiming. On the ground, regenerative medicine is one field that is discovering that good talent is hard to find.

Emily Titus is a project manager and product and process development scientist at the Centre for Commercialization of Regenerative Medicine (CCRM), a federally funded Centre of Excellence in Toronto focused on developing and commercializing cell therapy and regenerative medicine technologies. Dr. Titus has been able to successfully hire scientists and technicians for cell reprogramming and fee-for-service projects, but it's a frequent worry at CCRM that certain positions can only be filled by going outside of Canada.

Photo: Emily, Chloe and Steve Titus

"Part of CCRM's mandate is to provide good jobs to Canadians and to grow the economy," says Michael May, President and CEO, CCRM. "Cell therapy and regenerative medicine are still so new that a skilled workforce is difficult to find. We take highly educated university graduates and train them for their roles, but when it comes to finding seasoned professionals, we have a harder time."

Joanne Thomsen, Vice President Talent at MaRS Discovery District in Toronto, echoes this sentiment. "When we post jobs for senior roles for CCRM and similar organizations who rely on experienced STEM professionals, we get hundreds of CVs, but only a small number have the specialized expertise we're seeking."

For private companies like Aercoustics Engineering Limited, where Steve Titus serves as President and CEO, internships provide a built-in system for finding new employees. Aercoustics specializes in acoustics, vibration and noise control so Mr. Titus ends up hiring a lot of engineers from Canadian universities. He's an enthusiastic proponent of taking on interns and then hiring the best ones.

According to Mr. Titus, "Recruiting young talent takes time, so we use our internships to help streamline the hiring process. Interns should not be seen as free labour. By creating a meaningful program, we can assess how our interns work on projects and how they fit within the company before they become employees."

The report from the CCA acknowledges that predicting which skills and knowledge will be needed in the future is not possible. "However, it is clear that STEM skills are central to a variety of education and job opportunities." Further, "Investments in STEM literacy are crucial for developing a skilled society that is prepared to respond to an uncertain future."

For Canada to remain competitive globally, governments, educators and business leaders should keep encouraging kids like Chloe to follow in her parents' footsteps.

Stacey Johnson is the Director of Communications at CCRM and the editor of Signals, where she has blogged about women in STEM.

CCRM Commercializing Living Therapies

STEM INTEGRATION

by *Wayne Carley*

Since this continues to be a challenge for many and a point of "push back" for other educators, let me suggest the perfect opportunity to inject a very brief and effective STEM integration mini-lesson.

By far, the *"classroom disturbance"* continues to be the most distracting moments in the flow of knowledge and lesson presentation. Hardly a day goes by that our limited time of learning impact is broken by having to "call someone out" for their behavior, thus creating a fracture in the focus and concentration of the other students.

Rather than directly addressing the student in question, *(I've used this very successfully by the way),* say this:

"Since Bobby has decided to interrupt me and the class, it's important to point out that in every career field you choose, STEM or not, there are strong employer expectations regarding self-control, discipline, team work and maturity. If this behavior was presented in virtually all jobs, the employee would face possible termination, demotion in responsibilities resulting in financial fines or salary reduction and most importantly, the loss of respect of the [boss] and all of the other employees."

There you go! You've turned the average and unfortunately common lesson interruption into a learning experience and reminder that there is more at stake in skill building than just a good grade. Everyone profits....and hopefully Bobby too. You'll have to get creative tomorrow if Bobby acts out again....

STEM Magazine has a lot more to say about classroom discipline strategies, so we realize the example given is simplistic and temporary.....but it's a start to our conversation.

More Female International Students Pursue STEM Degrees at U.S. Universities

By *Anayat Durrani*

As a sick child suffering from severe asthma, Indian national Tvisha Gangwani says her parents never pressured her to focus on academics. She got by with average grades – except in math and science, where she excelled. One math teacher, who became her mentor, saw Gangwani's potential and encouraged her to pursue science, technology, engineering and math, the so-called STEM fields.

She followed this advice and enrolled at the University of Southern California, where she is now pursuing a bachelor's in electrical engineering with a minor in math. Gangwani is among the growing number of female international students pursuing STEM degrees at American universities.

"I wanted to be a part of USC Viterbi because besides being a very good engineering school, it is known for having strong women in the engineering community. This year's freshman engineering class is almost 40 percent female," says Gangwani. She says the many research opportunities available to undergrads also attracted her to the school.

According to the U.S. government's Student and Exchange Visitor Program, the total number of active female international students studying STEM in the U.S. increased more than 68 percent from 76,638 students in 2010 to 128,807 in 2015, with the largest increase at the master's degree level. The majority of those students were from India and China.

While researching schools, Gangwani says she realized that the U.S. "...had the most liberal system when it came to choosing your major." She says she liked that she could take a variety of classes, add a minor and change her major. In contrast, in India, once students decide their area of study, they can't make changes.

USC isn't the only school seeing an increase in female international students pursuing STEM. Katepalli R. Sreenivasan, dean of the New York University Tandon School of Engineering, says the number of female international students at NYU has more than tripled in the last decade.

He says one reason is because the U.S. is acknowledged worldwide as a leader in higher education and stands out for its "can-do attitude, the hands-on experience that is usually incorporated in it and a culture of confidence it instills." Some of this hands-on experience, he says, includes students working alongside entrepreneurs to learn firsthand what it takes to establish a successful company.

Japanese national Kasumi Kanetaka has enjoyed similar hands-on experience through the University of California—Davis, where she is double majoring in aerospace and mechanical engineering.

Last summer, Kanetaka completed a 10-week mechanical engineering internship at Technical University of Dresden in Germany. She says this wouldn't have been possible if she were in Japan, since the internship program was open to college students studying STEM in the U.S., U.K. and Canada.

"Studying and getting a STEM degree in the U.S. is clearly expanding my possibility to learn more about the world," says Kanetaka, who received the UC Davis Provost Award, a $13,250 per year renewable scholarship given to high-achieving freshmen from outside California.

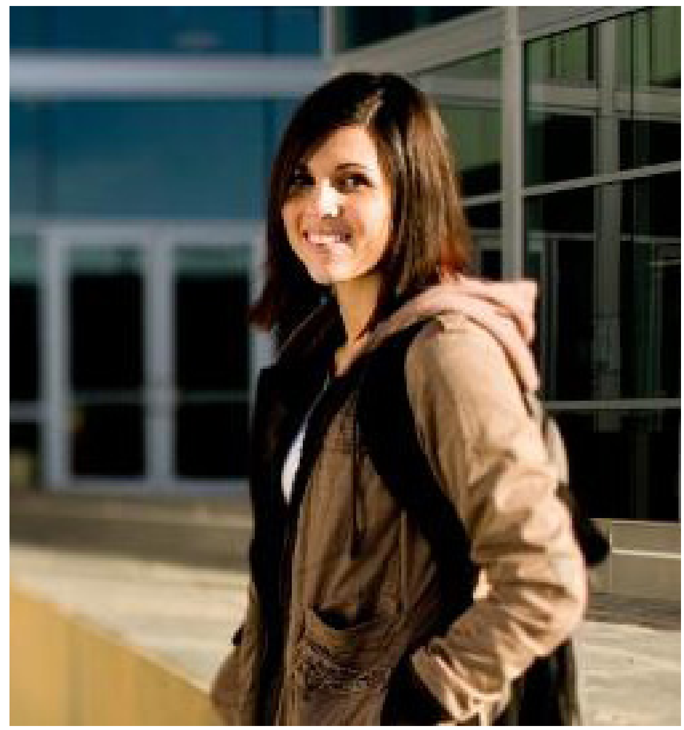
As a member of the UC Davis Advanced Modeling Aeronautics Team, she helped build a radio-controlled airplane from scratch. The team then competed in Houston for the SAE Aero Design West competition and won first overall in the advanced class category in 2014. "Designing, planning and creating an airplane is such a good way to learn the aerospace materials from real experience," says Kanetaka.

Through their exposure to American innovation and entrepreneurship, international students attending U.S. schools can increase their competitive edge as job applicants, says Jennifer Sinclair Curtis, dean of the UC Davis

College of Engineering. She says U.S. companies, which are starting to proactively recruit those who are traditionally underrepresented in STEM, seek employees with entrepreneurial backgrounds who "are used to working in environments that are both highly competitive and evolving."

Curtis says female international grads from U.S. universities "with both a STEM degree and some exposure to innovation or entrepreneurship will be highly sought as an employee by global companies large and small." International exposure as well as the prestige of American schools and research opportunities attracted Italian national Flavia Tauro to study in the U.S. Funded with a scholarship from the Italian government, she graduated in 2009 with a master's in civil and environmental engineering from the Massachusetts Institute of Technology.

In 2014, she also received a joint doctorate in philosophy, hydraulic engineering from the Sapienza University of Rome and mechanical engineering from the NYU Tandon School of Engineering, which a U.S. professor and an Italian scholarship partially financed.



"It is an extremely enriching experience from a professional point of view. But also from a human perspective, you learn a lot in a multi-ethnic environment," says Tauro, who is now assistant professor at the Department for Innovation in Biological, Agrofood and Forest Systems at the University of Tuscia in Viterbo, Italy.

Following their positive experiences studying STEM in the U.S., students like Gangwani from USC are working to recruit other female students to the primarily male-dominated field. Gangwani, who is currently in Germany for a summer internship with multinational software corporation SAP SE, started a program to host a panel for 35 girls, ages 16-17, where she discussed established women in tech, including spotlighting two of her colleagues' careers. She plans to host similar STEM panels and workshops at her former high school in Mumbai, India, this December.

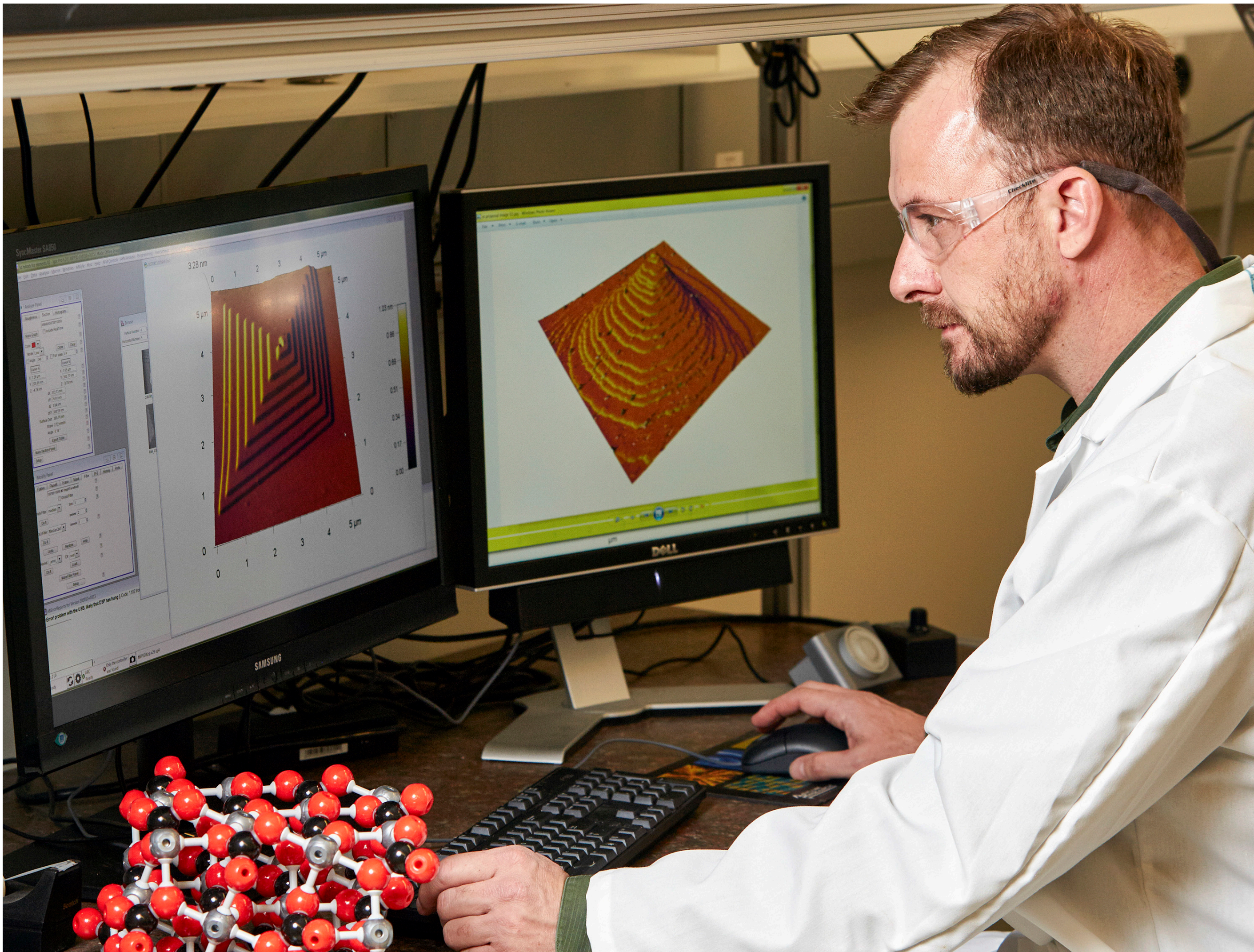
"I feel like a lot of women are afraid to take up STEM fields because they believe they won't be successful. I want to change that," says Gangwani, "..and show them how awesome science, tech, engineering and math can be."

The Making of a Geochemist:
Q&A with Andrew Stack

Interview by Dawn Levy

When fields collide

Oak Ridge National Laboratory researcher pioneers discoveries.



Today, Andrew Stack conducts geochemical research on problems related to energy as a research scientist at Oak Ridge National Laboratory.

He performs experiments at high powered neutron and X-ray sources, uses atomic force microscopy, and conducts molecular simulations and other routine chemical analyses.

Scientists who bridge disciplines often take research in new directions. Andrew Stack of the Department of Energy's Oak Ridge National Laboratory calls on his expertise in geology, chemistry and computing to advance understanding of the dynamics of minerals underground.

Working in the Geochemistry and Inter-facial Sciences Group of ORNL's Chemical Sciences Division, he investigates chemical processes that take place on mineral surfaces at scales ranging from individual atoms to entire rocks. These processes can trap contaminants, such as nuclear waste, carbon dioxide and toxic by-products from hydraulic fracturing.

Fundamental knowledge of chemical transformations is crucial to many DOE missions and serves as a basis for developing ways to lessen the environmental impacts of energy use.

Q: How did your multidisciplinary career begin?

A: I was good at science in intermediate school and went to a high school that specialized in it (Thomas Jefferson High School for Science and Technology). It probably helped my interest in science that my parents worked for the Food and Drug Administration in Washington, D.C. (I have my Dad's old balance in my office).

One summer in high school, I volunteered at the Smithsonian National Air and Space Museum, helping to preserve their space suit collection and creating a file of space shuttle missions for their research library.

What an amazing experience that was! That alone would get somebody interested in science. In my senior year I really liked an Earth science course in which we read a novel by John McPhee (Rising from the Plains) about a geologist in Wyoming. Just when I was starting to think about a career path, my mother arranged for me to talk to a paleontologist at the Smithsonian National Museum of Natural History for a couple of hours.

The novel Jurassic Park had just come out, and I wanted to talk to him about the feasibility of resurrecting dinosaurs. I thought that whole concept was really cool, and we talked about problems with the novel and what careers in geosciences were like.

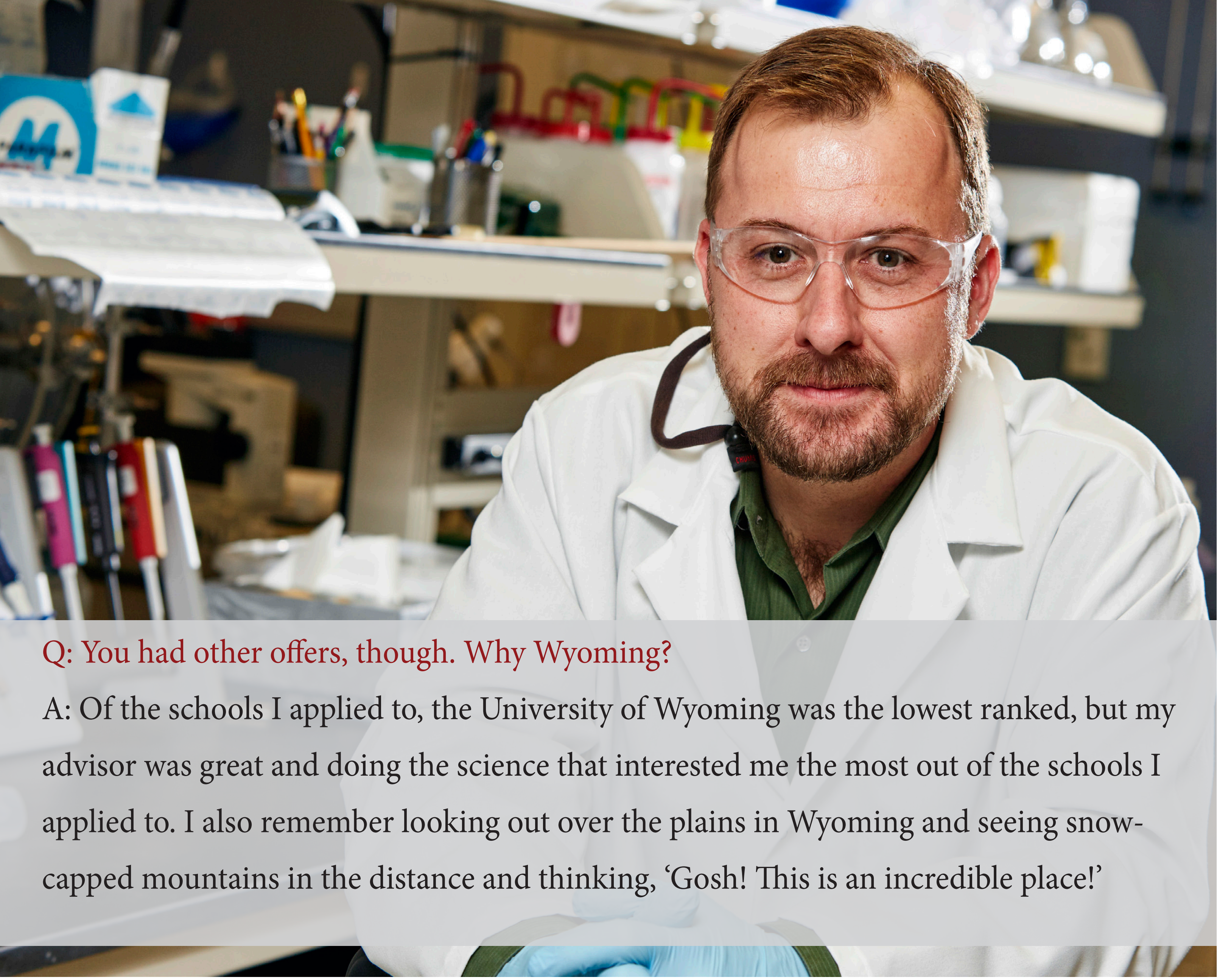
Q: What was your college experience like?

A: I got into Virginia Tech in 1993 and decided to major in geology. I liked geology because you could work outdoors as well as do high-tech science. But freshman year I also discovered that I liked chemistry—so much so that I was agonizing about whether to change majors when my department offered this new geochemistry degree, geology with a chemistry minor. I thought, hey, that solves my problem!

I got a job during summers and breaks in the Water Resources Division of the US Geological Survey with a geochemist who needed a computer programmer with some geochemistry sense.

What he got was me, a geochemist who had taken a computer programming course and liked computers. It turned out—and this was random luck— that my supervisor was a famous geochemist, Niel Plummer.

My mineralogy and geochemistry professors at Virginia Tech, Mike Hochella and Don Rimstidt, were also really good and opened my eyes to how interesting minerals and their reactions are. I ended up deciding to go to graduate school with one of Mike's former students, Carrick Eggleston, at the University of Wyoming.



Q: You had other offers, though. Why Wyoming?

A: Of the schools I applied to, the University of Wyoming was the lowest ranked, but my advisor was great and doing the science that interested me the most out of the schools I applied to. I also remember looking out over the plains in Wyoming and seeing snow-capped mountains in the distance and thinking, 'Gosh! This is an incredible place!'

Q: How did graduate school go?

A: I did both my master's and doctoral degrees with Carrick in Wyoming. The master's degree was on a laser technique called second harmonic generation. I used it to look at the surface charge of a mineral called corundum, which is aluminum oxide. Rubies and sapphires are made of corundum.

The difference between them is they have some different impurities that give each of them their nice colors. The surface charge of minerals is important in groundwaters and soils because similar minerals affect the transport of contaminants, such as toxic metals.

If the dissolved metal ion has a positive charge and the mineral ion has a positive charge, too, the like charges repel and you don't tend to get a lot of adsorption.

Q: What big scientific question were you exploring?

A: A big question that geochemists want to answer is whether the minerals present in a rock or in a soil are going to be positively or negatively charged in groundwater. The laser technique allowed us to isolate a specific crystal surface of that mineral to see how charge might change from crystal face to face. What I found was that the surface charge might change a lot, and you should account for this.

Q: How did you decide on a PhD topic?

A: I decided to stay for a PhD with Carrick but on a different subject, scanning tunneling microscopy of surfaces of hematite, a common iron oxide mineral. When you look at the Grand Canyon, its redness is due to hematite.

For the first part of my degree, Carrick and I wanted to know what the structure of this mineral looked like at the atomic scale, specifically whether the surface was covered in iron or oxygen atoms. We found that the mineral could have mixtures of both. For the second half of my PhD, I was interested in an organic compound chemically similar to those that might be used by bacteria to transfer electrons to hematite.

There are several species of what are known as iron-reducing bacteria. Similar to the way we breathe in oxygen and breathe out carbon dioxide after transferring electrons to the oxygen, these organisms transfer electrons to iron minerals.

So they're essentially "breathing" on the iron minerals. The mineral becomes unstable and dissolves during this process, and I wanted to understand the reaction mechanisms that were controlling it. I found that the electron-transfer process was much faster than the rate at which the minerals dissolved and couldn't be controlling the dissolution.

Q: Where did your career take you after you received your doctorate?

A: I obtained a postdoctoral research position at the University of California–Davis to look at reaction mechanisms of water that's bound to mineral surfaces. One can synthesize molecules that have similar chemical structures as minerals but that are easier to characterize.

My advisor, Bill Casey, and I were interested in understanding how quickly water molecules bound to a mineral surface exchange with each other, with the idea that this process is connected to how fast the mineral reacts generally.

When you expose a mineral to water, one water molecule will be bound to a metal site on the mineral surface for a little while, and then it will get pushed out by another one; or it will leave and another one will come in. I simulated that process using quantum chemical calculations.

I knew what the answer was on this particular molecule because it had been measured by someone else in my advisor's group. If I could simulate the reaction on the molecule correctly, then I could simulate the same thing on a mineral surface and be confident that I got the right answer.

I found that I could get mostly the right answer, but I needed to simulate many more water molecules than we could do at the time to get a better answer.

Q: What other topics did you explore as a postdoctoral researcher?

A: I also did some work related to the National Ignition Facility (NIF), where they use lasers to create fusion. They were having trouble growing crystals of potassium dihydrogen phosphate to use as optics in the lasers.

I was doing fundamental work to understand how that type of crystal grew. NIF researchers needed to grow crystals several feet wide, and it takes a long time to grow a crystal that big.

They wanted to grow them more rapidly but with a low number of defects in the crystal. Defects make the crystal not last as long, and too many defects make it useless. I found that, while I couldn't determine what they were precisely, the atomic-level mechanisms for reaction on the crystal surface were important for determining the shape of the crystal and how fast it grew.

Q: What job opportunities were available to you next?

A: In 2005 I decided to take a position at the Georgia Institute of Technology as an assistant professor. I felt I could do more advanced science there as opposed to my other job offers. Whenever I've been faced with a career decision, I have always picked the path that lets me do the science that's the most interesting.

Q: What science interested you most at Georgia Tech?

A: Regarding those iron-reducing bacteria that I had mentioned from my PhD, I started working on the bacteria themselves, trying to understand more about what controls how much of the iron oxide mineral they can access. I also continued working on simulating water exchange. This time, instead of working on an idealized molecule, I was simulating the water exchange on the mineral surfaces themselves.

Finally, I kept working on the atomic scale mechanisms for crystal growth to find out what they really were. I started working on barium sulfate, which is called barite, and calcium carbonate, which is calcite.

Barite is not as common geochemically as calcite, but it is important because it precipitates in wells and pipes during the production of oil and natural gas, and people are thinking about using it to stop radium from contaminating the flow-back water from hydrofracturing operations.

Q: Did following your scientific curiosity bring you to ORNL in 2010?

A: Yes. DOE's Office of Science has been very supportive of research on the kinds of atomic-scale mineral reactions that I am interested in.

Another thing is that collaboration with other scientists at the national labs is so much easier than at a university. At a university you might talk to your friend or somebody across campus and get a collaboration going between two or three of you. At ORNL, papers often have a whole bunch of co-authors, even from other national labs or universities, because the labs are about large, collaborative projects. The scope of the problems that you can tackle or that you can try to understand is larger at a national lab than what you can do by yourself at a university.

The really amazing thing to me about the lab is that the opportunities for research topics are so diverse. I've got five projects right now, and they include things like neutron and X-ray scattering, which I had never done before I came to ORNL. We're working now on rare earth element minerals, geologic carbon storage, hydraulic fracturing, mineral reactions during nuclear waste disposal and other things. The lab has helped me realize my potential and allows me to work on important problems for society.

Interview by Dawn Levy

ORNL–Historic Oak Ridge National Lab Facility

Calvin Roosevelt Bell, III

National Youth Leadership Forum: ***Explore STEM***

Washington, D.C. – Outstanding middle school students such as Calvin Roosevelt Bell III, from across the nation took part in a unique academic development experience, the National Youth Leadership Forum: Explore STEM.

The forum's mission is to inspire scholars to explore career possibilities in the fields of science, technology, engineering and mathematics (STEM).

"STEM fields are the fastest growing areas of study, and STEM professionals are in high demand in the United States and throughout the world," said Jan A. Sikorsky, Ph.D., the Vice President of education for NYLF Explore STEM.

"These students, who have already proven themselves academically, were challenged to apply math and science skills as they work on real-world, student created projects to bring their studies to life." Students who attended the program participated in a broad range of interactive simulations, hands-on workshops and educational site visits to discover the work of today's professionals in fields such as engineering, health care and environmental science.

Scholars of the program also learned to develop critical success skills such as time management, conflict resolution, information analysis, collaboration and public speaking.

Calvin, a 14 year old 8th grader who recently graduated from the City School Christian Private School located in Philadelphia, PA, and will be attending Moorestown Friends School in Moorestown, NJ, where he will be taking college prep and honors classes to further his education and prepare for his post-education career.

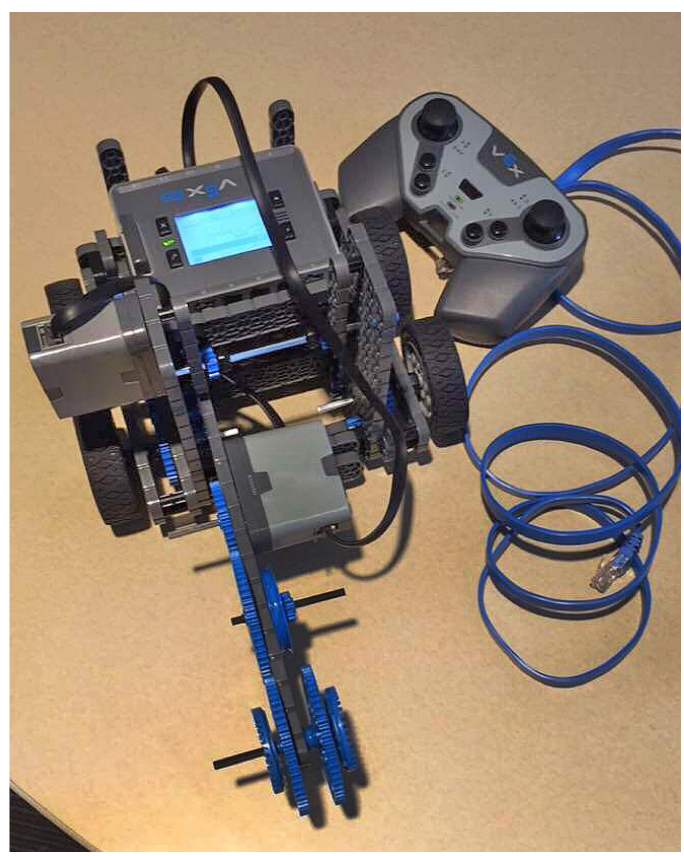
This year Calvin had the honor of receiving the following awards:

- Co-Valedictorian
- Head of School Award
- Music Class Award
- High Honors (4.0 GPA)
- Academic Effort Award
- President's Education Awards Program

Retired Astronaut Jerry M. Linenger and Calvin Roosevelt Bell, III.

NYLF Explore STEM is a unique learning experience for bright, forward-thinking middle school students who will evolve into our next generation of innovators, engineers, doctors, software developers, mathematicians, and physicists.

Calvin has a passion for robotics and having been nominated to attend the Explore STEM summer program, his excitement for this opportunity could hardly be contained. Best wishes to Calvin Roosevelt Bell, III in his STEM journey.



Plumber

A great STEM

This is a great example of a STEM career with:

- limited education requirements,
- apprenticeship opportunities
- self-employment future
- no gender restrictions and,
- a great salary.

By *Publisher*

Career

Having been an apprentice plumber in college for a time, I can attest to the STEM applications and career opportunities.

We will ALWAYS need plumbers.

Plumbers are primarily responsible for installing and maintaining various types of piping systems and fixtures. The exact responsibilities of a plumber depend on the particular project type. All plumbers must be able to follow blueprints, work with plumbing tools, and know what types of materials are required for each job. Plumbers may also design piping systems for new construction projects. During plumbing jobs, you may need to perform:

- basic carpentry to access pipes inside walls or brace pipes to keep them in place.

- You will also weld, solder, and attach fittings together when necessary.

Once a piping system is installed, you'll:
- install fixtures, such as bathtubs, showers, toilets, water heaters, and dishwashers
- gas lines
- specialized in-floor heating systems
- customized plumbing applications for unique projects
- the list is long

The Science of plumbing:

"A systematically organized body of knowledge on a particular subject."

There is a lot to learn about plumbing and as the associated tools, technology, pressures, regulations, laws, safety requirements, enviromental concerns, material specifications and demands change, the plumber must continue to learn, apply and imagine.

The Technology of plumbing:

What is new in plumbing? Technology comes up with new things all of the time, but there are some latest developments that are piquing people's interest. One of these things is epoxy pipe lining. This is actually a new trend in repair. It used to be when a pipe was becoming worn and developing holes, it needed to be completely replaced. With epoxy pipe lining, instead of replacing a pipe, the plumber sandblasts the inside of the pipe to remove corrosion and rusting, then fills it with an epoxy lining that seals it and makes it function good as new.

You will need to know about new synthetic plastics, electronic sensors, laser sighting, metering systems and remote controls, chip technology, new metal alloys, copper innovations, monitoring devices, and a good old wrench.

The Engineering of plumbing:

Since the engineering method, a decision making process, is critical to plumbing layout and design, thinking ahead and problem solving will be a daily routine and expectation.

Following the blue prints is important, but they are often in error when it comes to actually laying out the design. You will have to use your imagination, creativity (the Arts), and experimentation to find solutions to unexpected challenges.

The Math of plumbing:

It's not difficult to figure out that there is a lot of measuring involved.

Be ready for a little geometry, basic measuring calculations, a bit of physics and some three dimensional visualization.

Plumbers and the related trades of pipe fitters and steamfitters, who often work in commercial and industrial settings, earned median pay of about $49,000 a year nationally, well above the $35,000 average for all occupations, according to 2012 data from the Bureau of Labor Statistics.

Earning potential can be much greater once you start your own business and find the best city or state to set up shop. Resort areas are a fantastic place to make it big.

SCHOOL...

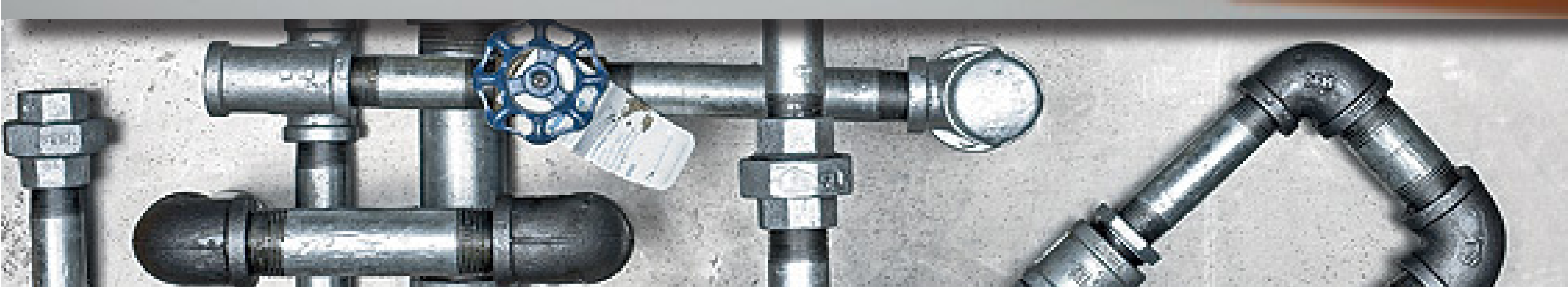
While a formal training program may not be required, it can aid advancement and teach students useful skills that can come in handy on the job. Many trade or technical schools and community colleges offer formal training programs for those individuals who want to become plumbers.

These are typically short certificate training programs that last about one year. Coursework covers water supply and drainage systems, as well as piping, venting, fittings and valves. Students can expect to learn plumbing skills and maintenance. They can use this training to begin an apprenticeship as a plumber or go on to earn an associate's degree.

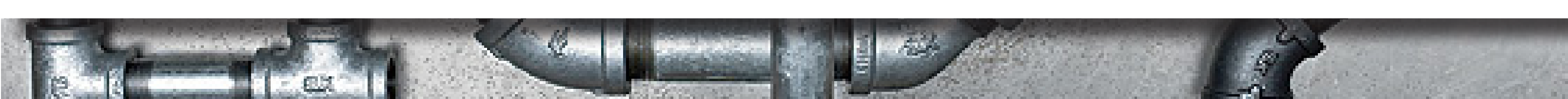
Apprenticeship programs are provided by local unions and their affiliates, as well as by non-union contractors. These programs last from 4 to 5 years and combine paid on-the-job training with classroom instruction, which can be either paid or unpaid.

On-the-job training should total anywhere from 1,700 to 2,000 hours per year, according to the U.S. Bureau of Labor Statistics. Apprentices learn local plumbing codes, as well as all types of plumbing procedures, from primary installation of plumbing fixtures to repair and maintenance of water pipes. Trainees also gain special plumbing skills, such as choosing materials and plumbing fittings, identifying grades and types of pipes and using the tools of their trade.

There is always a shortage of plumbers.

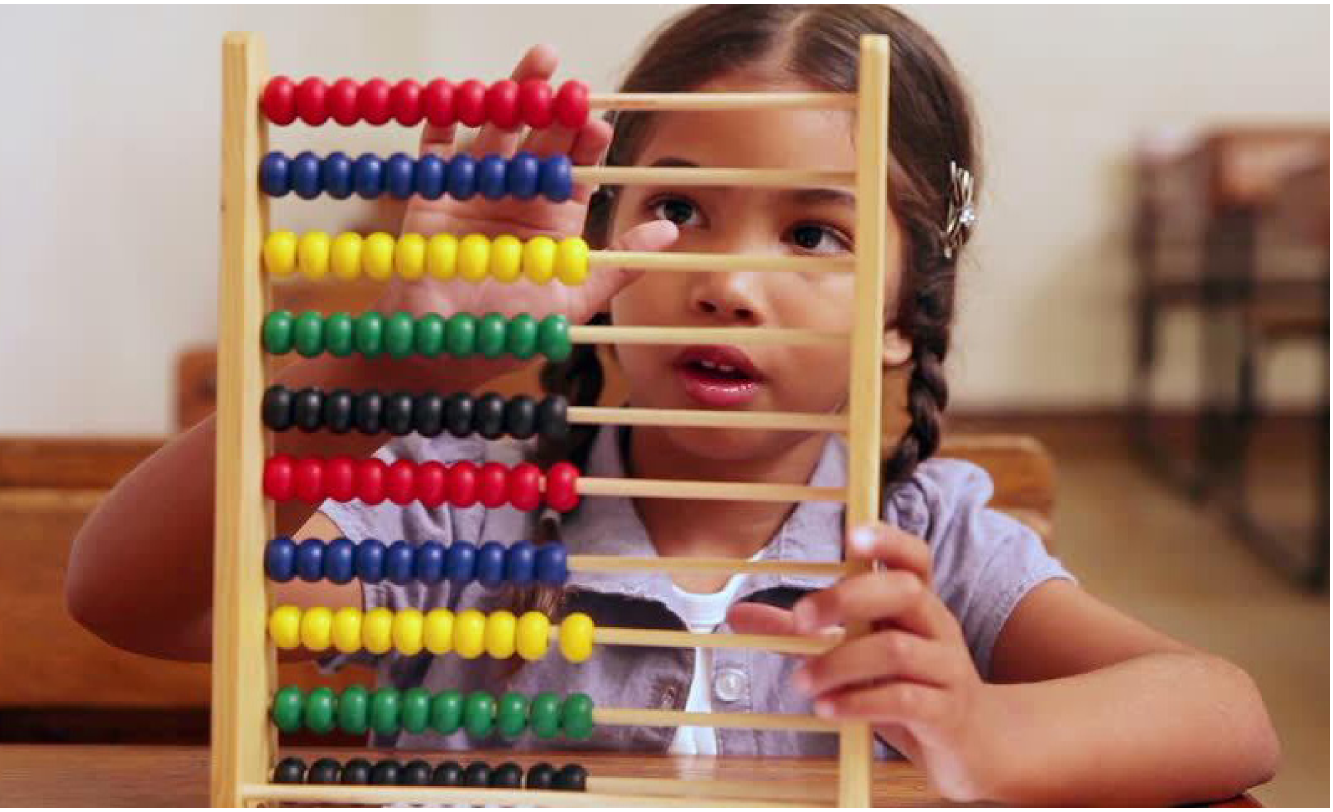


Ladies welcome. Show us how it's done!



Seeds of STEM

aims to provide preschoolers with the foundation for STEM careers and lifelong learning



In an effort to address the national need to guide more students to careers in science, technology, engineering, and math (STEM), Worcester Polytechnic Institute (WPI) researchers are developing curriculum which introduces STEM principles during the formative preschool years.

“The ability to apply STEM concepts to solve a variety of problems is key for students’ future success as well as the nation’s competitiveness in the global economy,” said Martha Cyr, principal investigator of Seeds of STEM: The Development of an Innovative Pre-Kindergarten STEM Curriculum; and executive director of The STEM Education Center at WPI.

"Despite the evidence that introducing STEM during the pre-kindergarten years supports children's cognitive development and positive attitudes toward learning and inquiry, there is very little STEM instruction in pre-kindergarten classrooms. Through this initiative we aim to increase STEM instruction practices in preschool classrooms, increase children's exposure to STEM, and ultimately improve children's curiosity, knowledge, and skills in STEM."

STEM education is often perceived as complex and challenging—too sophisticated for preschool, but Cyr and Mia Dubosarsky, co-principal investigator of Seeds of STEM and director of professional development at The STEM Education Center at WPI, contend that the fundamental core of STEM concepts is simple; ***problem solving.***

Supported by a $1.5 million grant from the U.S. Department of Education's Institute for Education Services (IES), over the course of four years the Seeds of STEM initiative will involve the creation and testing of six clusters of related lessons—referred to as units—that introduce young children to the problem-solving process through popular storybooks, play, and classroom authentic problems.

"The actual subject matter of STEM in preschool classrooms will be basic," Dubosarsky said. "Lessons focus on the problem solving process, not concepts and theories. The idea is to provide fundamental knowledge of the problem solving process, to help children and teachers internalize the process and use it to address any problem they have inside and outside of school."

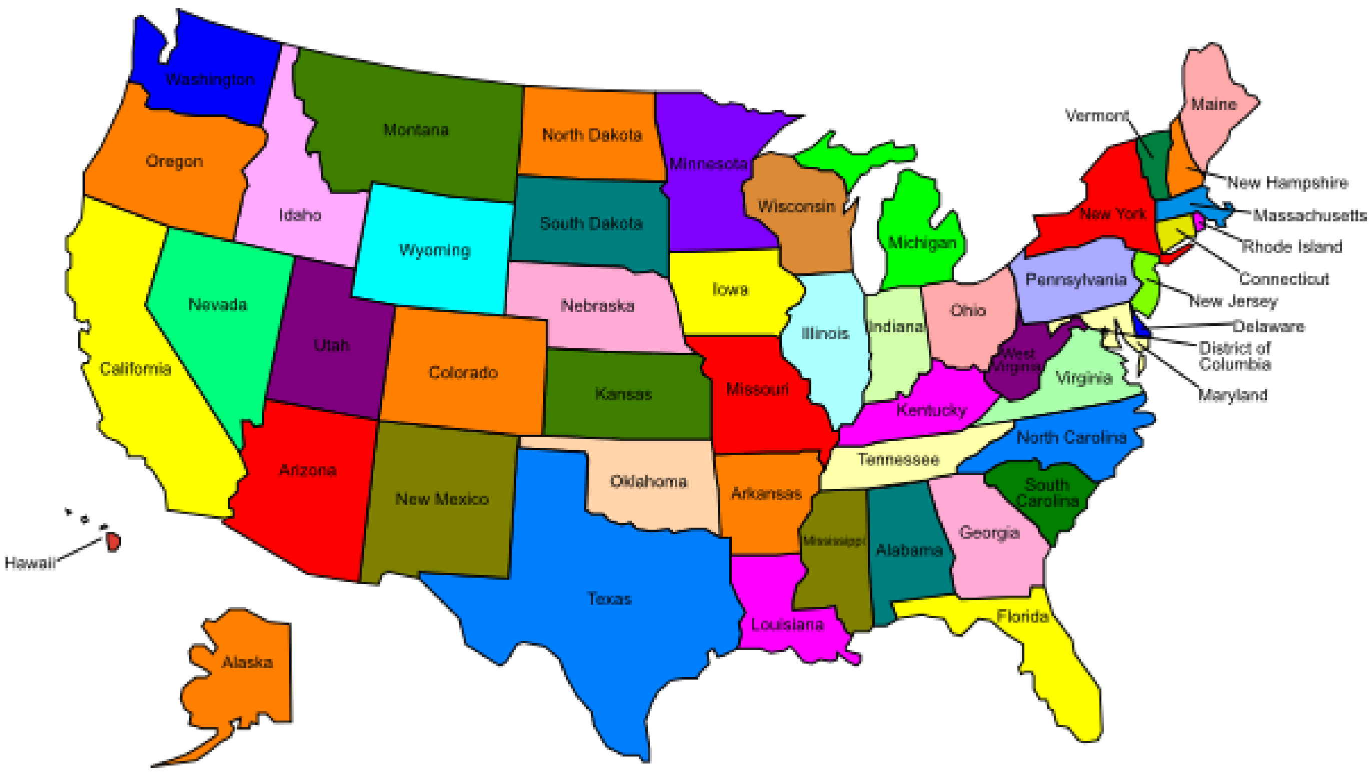
Seeds of STEM also aims to address the lack of people from socioeconomically disadvantaged backgrounds in STEM fields by partnering with the early education program for low-income children, Head Start of Worcester, to develop, test, and evaluate Seeds of STEM lesson plans.

An advisory board including co-principal investigators Melissa-Sue John, a specialist in developmental psychology from WPI, and Florencia Anggoro, a specialist in developmental psychology from The College of the Holy Cross, seven Head Start teachers, and early education and psychology specialists from Clark University and Quinsigamond Community College, are also aiding in curriculum development and evaluation.

"It's exciting to see such a dramatic evolution of their understanding," Sherbourne said. "We were delighted to see that in just a short period of time using these lesson plans, we are already seeing an improvement in the extent of development teachers are able to cultivate in these young students.

A pilot test of the entire curriculum is planned for September 2017 in Montachusett Opportunity Council preschools.

STEM Magazine would like to begin producing “Personalized State Versions” monthly, free to every educator, student and parent K-16 in the state. If you know of an organization or state education department who is interested, please let us know.



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