CATAPULTA

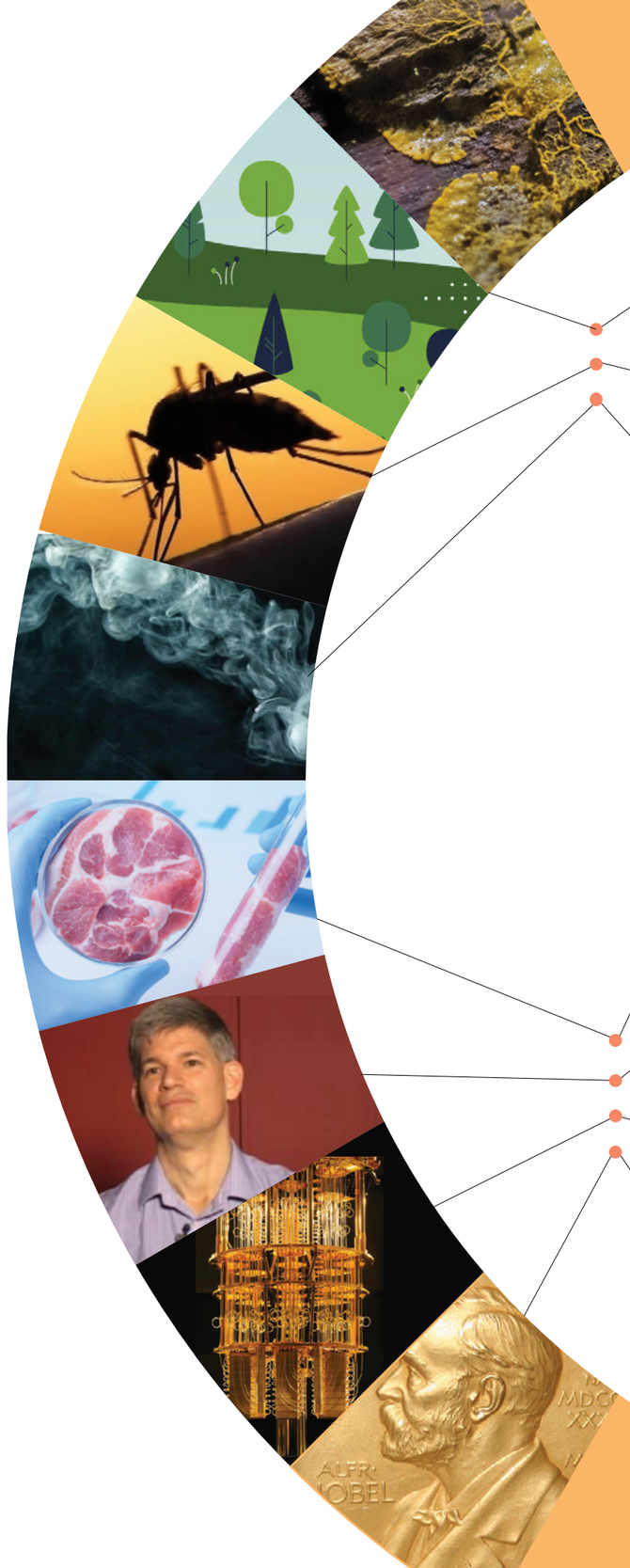
FALL 2019

TEAMTREES WITH MRBEAST

VAPING TREND AMONG TEENS?

INTERVIEW

WITH BLS ALUMNUS, GUY STEELE!



EDITORS' NOTE

AS ANOTHER SEASON OF DIFFICULT TERM TESTS, DREADED COLLEGE APPLICATIONS, AND FRUSTRATING PROJECTS COMES TO AN END, WE HOPE YOU TAKE A BREATHER AND ADMIRE THE PROGRESS AND DEVELOPMENTS OF SCIENTISTS FROM AROUND THE WORLD.

AS YOU READ ABOUT THEIR WORK, REMEMBER THAT EACH OF THESE SCIENTISTS WERE ONCE STUDENTS LIKE YOU. IN THE CASE OF GUY STEELE, HE WAS LITERALLY IN YOUR SHOES 50 YEARS AGO.

DOZENS OF SUBMISSIONS, HUNDREDS OF EDITS AND 20 PAGES OF LAYOUT LATER, YOUR EICS AND EDITORIAL BOARD PRESENT YOU WITH OUR FALL 2019 ISSUE.

...AND ALWAYS REMEMBER TO:
YEARN FOR
EDUCATIONAL
EXCELLENCE AT ALL
TIMES
(Source: Mr. Zou's screensaver)

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TEAM TREES

On October 25, 2019, Jimmy Donaldson, more commonly known as MrBeast, and Mark Rober launched Team Trees, a campaign to plant twenty million trees. The YouTuber duo has stated that their mission is to raise awareness and make a difference in the fight against climate change. Although MrBeast and Rober physically planted 1,700 trees with the help of volunteers, the bulk of the campaign has been done through fundraising on their website, teamtrees.org. The money raised will go to the Arbor Day Foundation, which pledges to plant one tree for every dollar donated.

Through photosynthesis, trees absorb the greenhouse gas carbon dioxide and release oxygen. Crowther Lab of ETH Zurich, a world-renowned Swiss university, published a study in the journal Science about the benefits of forestation. The lab claimed that 0.9 billion hectares of land, most of which had forests in the past, would be suitable for tree planting. This is about the size of the United States and does not include land used by humans for agriculture or habitation. The study estimated that if the trees were planted and allowed to grow to maturity, they would remove up to 205 billion metric tons of carbon, or two-thirds of all human emissions since the Industrial Revolution, from the atmosphere.

However, scientists like Eike Luedeling from the University of Bonn have warned that the study overestimates the potential of forestation. The lab used average temperature to determine planting potential, but this does not account for regions with a wide range of temperatures, including those inhospitable to trees. Moreover, some of the soil in deforested areas has been eroded, and the land estimates, which were based on satellite imaging, inaccurately included some rural villages and land used for pasturing animals.

Luedeling and others have also stated that curbing carbon emissions is key in fighting climate change. As of November 10, 2019, the campaign has raised money to plant over 14.6 million trees. While planting trees is not an antidote for climate change, the work of Team Trees will both raise awareness and have an impact.

THE FASCINATING 'BLOB' IN PARIS

In October 2019, the Paris Zoological Park added a new yellow 'blob' to its collection of many wild animals. This 'blob' is not exactly an animal, nor is it a fungus or a plant. It is simply a gooey mess of slime.

This unusual lifeform is known as Physarum polycephalum, which translates to "the many-headed slime." It is a unicellular organism that can grow up to a few square meters, has over 720 sexes and is found all over the world under leaves and trees, where it hunts bacteria.

It was first discovered in 1973 when a Texas woman found a blob rapidly multiplying in her backyard. However, the news surrounding it quickly died down, but scientists began to conduct more research on it in 2016. Even without a brain, P. polycephalum can solve problems, such as navigating through a labyrinth and following its slime trails back to a food source. It seems to be immortal except when exposed to light and drought, as it can regenerate after being cut and even fuse together.

This 'blob' is one of the many mysterious organisms in nature that we have yet to study intensively; there are countless others waiting behind the brushes of nature for us to discover.

P. POLYCEPHALUM'S SEX IS DETERMINED BY THREE POSITIONS OR LOCI ON ITS SEX CHROMOSOME. EACH OF THE LOCI HAS 3, 15, AND 16 POSSIBLE ALLELES, OR VERSIONS OF A GENE, RESPECTIVELY. THIS AMOUNTS TO 720 (3X15X16) ALLELE COMBINATIONS OR SEXES.

THE RISE OF EEE

Eastern Equine Encephalitis (EEE) virus, more commonly known as "Triple E," is a deadly virus with a thirty percent risk of death. It became particularly prevalent this past September within many of the suburbs and rural areas in the greater Boston area. There have already been twelve cases and four fatalities reported this season in Massachusetts alone, an alarming statistic when compared to the national average of seven cases.

What exactly is this virus and what does it do? The EEE virus, which belongs to the genus Alphavirus, is carried by mosquitoes and is transmitted to humans through their bite. Of those infected, only four to five percent usually show symptoms of the disease. According to the Centers for Disease Control and Prevention, there are two types of illnesses brought on by infection: encephalitic (of which the symptoms are fever, headache, anorexia, irritability, and coma) and systemic (of which the symptoms are chills and fever).

Unless their central nervous system is affected, those with the systemic illness generally make a full recovery in one to two weeks. Those with encephalitic illness, however, have a much more fatal prognosis. Symptoms generally manifest four to ten days after infection, and death can ensue two to ten days after symptoms occur. Those that survive are often left with severe neurological dysfunctions.

No specific cures or vaccines have been developed to fight EEE, due in part to both the expense of such an enterprise and the comparably low financial gain it offers. Perhaps some investors will take on such a project because of this recent uprise in cases and media coverage. For now, all we can do is avoid every known critical area and apply bug spray.

VAPING:

A NEW TREND AMONG TEENS

As of Thursday, October 24, there have been 1,604 probable cases and one new death from vaping-related respiratory illnesses, increasing the total death toll to thirty-four across the whole country. With vaping-related illnesses climbing to a new high, vaping has become a new epidemic in the United States, threatening public health, especially among young people.

THERE HAVE BEEN 1,604 PROBABLE CASES AND ONE NEW DEATH FROM VAPING-RELATED RESPIRATORY ILLNESSES, INCREASING THE TOTAL DEATH TOLL TO 34 ACROSS THE WHOLE COUNTRY.

So what is an electronic cigarette? An electronic cigarette is a handheld battery-powered device that heats a liquid into an aerosol for users to inhale. The liquid in the e-cigarette contains highly condensed nicotine, which is a toxic and addictive chemical. In addition to nicotine, there are other harmful ingredients, such as ultrafine particles, diacetyl, volatile organic compounds, and heavy metals, which have all been linked to permanent lung damage. The history of e-cigarettes goes back to the 1930s, but the modern e-cigarette was invented by a Chinese pharmacist named Hon Lik in 2003. It was invented with the intention of helping people quit smoking.

Vaping is still relatively new, and research on its long-term effects is scarce. However, according to one clinic study, the noxious chemical fumes or toxicity in vaping liquid is the main source of lung injuries. Doctors at the Mayo Clinic recently investigated more than 800 lung injury cases related to vaping and reported that, in many cases, the vaping products contained tetrahydrocannabinol (THC), the principal compound in marijuana and other cannabis products. The chemical has been associated with these products' psychological effects.

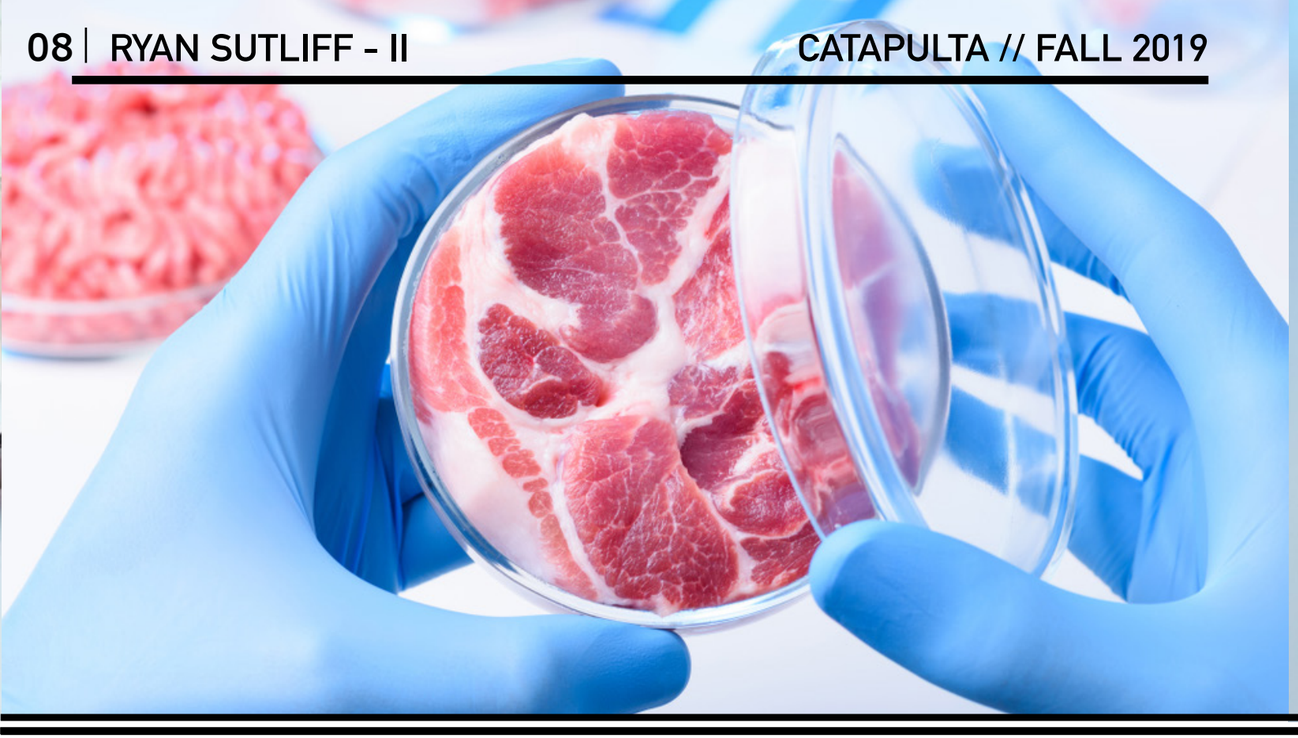
Based on data provided by the National Youth Tobacco Survey 2011-2018, e-cigarette use among young people has rapidly grown in the last five years. It is higher among high school students than adults. Peer pressure, the perception of a "safer option" to conventional tobacco, and unique flavors, including candy, fruit, and chocolate, may have contributed to the new trend among young people.

Vaping is also harmful to brain development, which continues until about twenty-five years of age. Studies indicate that nicotine can damage or slow down brain development, especially the brain's impulse control in young adults who are exposed to the chemical substance. In addition, nicotine can cause addiction. When the brain is in development, any new learning will stimulate brain nerves to cross each other so that the new learning can be strengthened and enforced. According to the U.S. Department of Health and Human Services, "addiction is a form of learning, adolescents can get addicted more easily than adults". Apart from that, nicotine raises blood pressure and spikes adrenaline, which increases the heart rate and the possibility of having a heart attack. With or without nicotine, the study suggests that e-cigarettes and other vaping devices are NOT risk-free.

Currently, given the increasing numbers of youth in the Commonwealth and across the country who have come down with respiratory illnesses related to vaping, Massachusetts Governor Charlie Baker issued an executive order to ban all online and retail sale of nicotine as well as flavored or unflavored, marijuana vaping products to consumers in the state for four months.

WHAT ARE SOME RISKS OF VAPING?

IT IS TIME TO TAKE ACTION TO PREVENT YOUTHS AND YOUNG ADULTS FROM USING E-CIGARETTES BY RAISING AWARENESS ON VAPING AND ITS RISKS.



CULTURED MEAT

CULTURED MEAT REFERS TO THE PROCESS OF HARVESTING AND NURTURING THE MUSCLE OF COWS AND OTHER LIVESTOCK TO MAKE ARTIFICIAL MEAT.

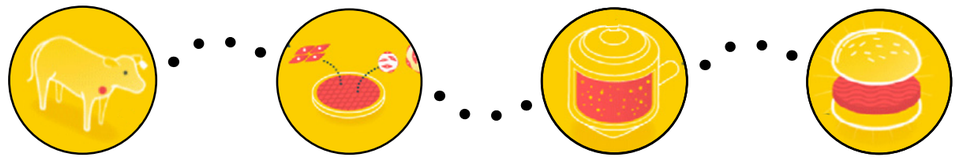
To make cultured meat, muscle tissue is first removed from the animal. Next, the muscle cells are separated from the fat cells and "cultured." Cell culturing is putting a cell in a favorable environment and providing it with everything it needs to survive and grow, such as nutrients and oxygen. With today's technology, this process takes four weeks on average.

Why should we grow our meat in a lab, when we already have animals that provide it? As we struggle to feed people every year in America, innovations in agriculture are a necessity. In 2018, The United States Department of Agriculture reported that over thirty-seven million Americans suffered from food insecurity. Cultured meat offers a solution to this far-reaching problem. Our current process of producing meat comes from slaughtering livestock, which is widely known to be inefficient and harmful to the environment. Livestock in a Changing Landscape, a study by Stanford biology professor Harold Mooney, found that livestock production uses up over twenty-five percent of Earth's arable land and accounts for about eighteen percent of manmade greenhouse gases. Cultured meat has been proven to use ninety-nine percent less land and could reduce greenhouse gas emissions by eighty-seven percent. In addition, this process is more humane than killing animals for their meat.

Furthermore, Maastricht University in the Netherlands demonstrated that the cells from a single cow can produce about 175 million quarter-pounders, which is much more efficient compared to conventional agriculture, which would need 440,000 cows for that same yield.
However, cultured meat still has many obstacles, such as mass production, cost, and acceptance by consumers. In an online survey conducted by Forbes, respondents' reactions to artificial meat varied. Some said that they would not eat anything that comes from a lab, while others noted the benefits of cultured meat and even said that they would pay more for it.

In addition, the tedious process has proven difficult to replicate on a larger scale, which would be necessary due to livestock production making up around forty percent of the global agricultural gross domestic product. The first sample of this meat cost 1.2 million dollars per pound in 2013, and it is still not cheap to produce today. Scientists say that the cost is what prevents it from being on the market today. They are confident, however, that the technology will catch up, and that cultured meat will be a more viable alternative to slaughtered livestock in every aspect.

Drawing support from philanthropists like Bill Gates and Richard Branson, cultured meat undoubtedly has potential. In the near future, lab-grown meats will be cheaper, faster, and more environmentally friendly, and we can expect to see lab-grown meats in our grocery stores as early as 2021.

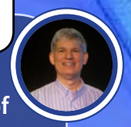


INTERVIEW WITH GUY STEELE

Guy Steele ‘72 is a Software Architect for Oracle Labs and the Principal Investigator of the Programming Language Research Group. He received his A.B. in applied mathematics from Harvard in 1975, and his S.M. and Ph.D. in computer science and artificial intelligence from MIT in 1977 and 1980. Prior to becoming a member of Oracle Labs, he was a Distinguished Engineer and then a Sun Fellow at Sun Microsystems Laboratories. He has received numerous awards including the 1988 ACM Grace Murray Hopper Award and has written extensively about the language Lisp. Steele led the team behind Fortress, an object-oriented language for high performance computing, and he has contributed to many languages including Java, several dialects of Lisp, and Fortran. Steele has served on several computer science award committees, and his other interests include chess, singing, and square dancing.

OUR FULL INTERVIEW WITH GUY STEELE ‘72 CAN BE FOUND AT BLSCATAPULTA.COM/INTERVIEWS/.

HOW DID YOU FIRST BECOME INTERESTED IN COMPUTER SCIENCE AND PROGRAMMING?



One day in November 1968, my buddy Al Swide ‘72 eagerly showed me a handful of punched cards: “This is a Fortran program!” Each paper card had holes encoding one line of the program, and the characters corresponding to the holes were printed along the top in dot matrix form. He explained to me what the program did and how it worked. I was hooked—I wanted to learn how to write programs too! I had read a bit about computers before but didn’t know much about how they worked. I was captivated by the idea that I could tell a machine what calculations to do, and it would automatically do them for me.

But where did Al get those cards, and what computer did he use to run his program? It turned out that BLS had a computer in its basement (for real, unlike the fictitious “fourth-floor swimming pool” often used to tease sixies). I later learned that T. Vincent Learson ‘31, vice president and later CEO of IBM, made that happen, and for that, I am eternally grateful.

I asked our math teacher, Mr. Wellings, about the computer, and he lent me some books, which I devoured over the Thanksgiving weekend. Soon I too had permission to use the computer.

WHAT IS UNIQUE ABOUT LEARNING AN ASSEMBLY LANGUAGE? DO YOU THINK IT GAVE YOU A STRONGER FOUNDATION OR UNDERSTANDING OF HIGHER LEVEL LANGUAGES?

In computer science we draw a distinction between “high-level” and “assembly” languages. High-level languages are intentionally somewhat abstract, so that programs can be run on many kinds of computers. Assembly languages are designed to express, in detail, what instructions can be executed by a given computer model—or family of related models. Learning an assembly language brings you “closer to the machine”; using an assembly language well requires you to know much more about exactly how the machine operates and what ways of doing things are more efficient.

I do think that learning an assembly language, and how a high-level language can be translated into assembly language by a compiler, can give you a much richer understanding of the high-level language.

In my own career, I didn’t stop there: I wanted to understand *everything* about how a computer works. So I took Physics and AP Physics at BLS, electromagnetism and quantum mechanics at Harvard, and electrical engineering, circuit theory, and graduate-level quantum mechanics at MIT. I can now say that I have a cursory understanding of how a computer works “all the way down”. One of the nicest compliments I ever got was from a hardware designer at Sun Microsystems. I would occasionally give him suggestions for new instructions for the SPARC (Scalable Processor Architecture) computer architecture: “You know, Guy, of all the suggestions I get from compiler writers asking for new instructions, yours are the least stupid.” I think this was his wry way of acknowledging that, because I had at least studied circuit design myself, I had some appreciation of what his design constraints were, and I had some knowledge of what is easily done in hardware and what is better done in software.

WHERE DO YOU HOPE COMPUTING WILL BE IN THE NEXT 10 YEARS?

I SEE THREE BIG TRENDS THAT INTEREST ME: PARALLEL AND DISTRIBUTED COMPUTING, MACHINE LEARNING TECHNIQUES AND THEIR APPLICATION TO “BIG DATA,” AND QUANTUM COMPUTING.

Parallel and distributed computing (use of multiple processors with and without shared memory, respectively) are necessary to tackle the largest problems now that individual processors are no longer getting faster every year. Quantum computing has two possible promises, both of which may or may not come true. The first is overcoming Moore’s Law by examining an exponential number of possibilities simultaneously, which might destroy the effectiveness of all the (non-quantum) encryption techniques currently in use to safeguard private data. The second is providing new quantum-based encryption techniques that really are, for physical and mathematical reasons, completely secure and unbreakable.

IN SIMPLE TERMS, WHAT IS THE AIM OF DIFFERENT DIALECTS OF A LANGUAGE LIKE LISP? IN A BROADER SENSE, WHAT FACTORS ARE CONSIDERED WHEN DESIGNING LANGUAGES?

In general, there are many languages, and dialects of languages, because the designers and implementers of those languages are trying to serve different communities of programmers with different expressive needs for different kinds of applications. In the case of Lisp, I helped design two different widely used dialects: Common Lisp and Scheme. Common Lisp was a rather large dialect (over 700 functions) aimed at developers of industrial strength artificial intelligence applications. It's still implemented in industry today, including in a widely used airline reservation system. Scheme, on the other hand, was designed to be small and to shine light on certain academic questions about programming language design. It was widely used in computer science education for decades but has been replaced to some extent by Python and Java. There are other dialects of Lisp that have other uses as well.

When designing a new computer language, I think it's always good to have a clear idea of what it will be used for and to talk to potential users. I worked on designing and documenting the Java programming language when it was first being introduced in the 1990s. An important intended use was to allow programs to be compiled on one computer before being sent across the Internet to be executed by other computers. Two of the most important design principles were "it must be safe to execute"—that is, you can circumscribe (limit) the actions taken by a downloaded program, in case you don't fully trust the computer that supplied the program—and "you get the exact same response no matter what computer it runs on."

IN YOUR OPINION, HOW HAS COMPUTING CHANGED FROM WHEN YOU WERE A STUDENT AT BLS TO NOW? WHAT ADVICE DO YOU HAVE FOR NEW PROGRAMMERS IN HIGH SCHOOL?

I've seen three big changes over the last forty years. First, when I was a student, I was one of the lucky few who had access to a machine that, adjusting for inflation, would have cost well over $300,000. As was typical in those days, I had to share it with many others. Today, computers and their programming languages are ubiquitous and cheap, so it's relatively easy to get a hold of them and try programming.

Second, when I was a student, the main memory of a computer was 8 kilobytes, or maybe 64 kilobytes for a big one, which is small enough that you could be familiar with the entire program, including the operating system, and the entire contents of memory. Today, memory is measured in gigabytes (1 gigabyte is 1 million kilobytes), and operating systems contain millions of lines of code. No one person can really know how it all works in detail, so you have to rely on documentation and trust that software will behave as promised.

NOWADAYS, MOST HIGH SCHOOL STUDENTS ARE TAUGHT JAVA OR PYTHON IF THEY TAKE A HIGH SCHOOL COMPUTER SCIENCE CLASS (THESE ARE THE TWO OPTIONS AT BLS AS WELL). WHAT DO YOU THINK THE BENEFITS OF LEARNING DIFFERENT LANGUAGES ARE?

Friends often ask me, "What programming language should I learn?" My usual answer is "Pick any three. It's less important which language you learn and more important that you understand its strengths and weaknesses, and the best way to do that is to compare it to two other languages."

Different languages have different ways of expressing things. Learning a new language gives you a new way to think. That's true of Latin and German and French and Spanish and Chinese and Japanese, but it's even more true of computer languages. After all, none of them are intended to cover all the expressive needs of everyday life. Learning a new language, spoken or computer, also gives you a way to connect with a new group of people with different cultures and concerns.

A trivial but illustrative anecdote: I took Latin and German at BLS and have used both to some extent since I graduated (I had an opportunity to give a short speech in German in Stuttgart). But I did let both languages get rusty. One time, before searching the Internet was really a thing, I was struggling to remember the German word that means "one and a half". I tried to look it up, but "one and a half" was not listed in my German-English Dictionary. After a few days, I remembered that while in Germany I had purchased a Latin-German dictionary on a whim. I looked up "sesqui", and bingo: "anderthalb!"

SINCE THEN I HAVE NOT REGARDED ANYTHING I LEARNED AT BLS AS WASTED EFFORT.

Third, over most of my career, computers were constantly getting smaller, faster, and cheaper, following exponential growth principles like Moore's Law and Dennard Scaling. Exponential improvements can't go on forever, and indeed Dennard Scaling flattened out about a decade ago. Since then pretty much all personal computers have clock speeds of about 3 to 5 gigahertz. So I was lucky in another way: more than once, when I faced a difficult computational problem, the easiest approach was to put it aside for several years until it was easy to solve on a computer that was 10 or 20 or 50 times as fast.

My advice for new programmers is: (1) Learn a lot, not just about programming. Programs, like essays, need to be about something. (2) Pick an application and write a program for it. Repeat as necessary. (3) Plan to learn at least three programming languages well enough to write one substantial program—a page or two—in each. Then your choice of "favorite programming language" will be intentional rather than accidental.

QUANTUM SUPREMACY

On October 23, 2019, Google announced its success in achieving quantum supremacy. This represents a massive leap in computer engineering and is the first step to applying quantum computers to solve real problems.

Quantum supremacy is the idea that at some point, quantum computers will be able to solve problems that classical computers find impossible.

The main difference between the two types of computers is not programming, but the hardware itself. Quantum computers use what is called a qubit. These qubits are similar to the bits used in classical computers, acting as a switch in either the on or off position. Qubits can also be in a superposition, where they are both on and off at the same time. The idea of superposition is fundamental to quantum computing.

To achieve quantum supremacy, Google used its very own quantum computer named Sycamore. Quantum computers often look nothing like a regular desktop and are usually quite beautiful to look at. Most of the structure itself is essentially a refrigerator, supercooling the quantum processor to near absolute zero in order to keep it stable. All the magic happens in one small computer chip, making quantum computers quite space-efficient besides the necessary cooling equipment.

The actual problem given to Sycamore was only a random set of instructions designed to test the speed and efficiency of a quantum computer. It took Sycamore about two hundred seconds to complete the task. Google's scientists hypothesized it would take almost ten thousand years for a classical computer to do the same, which is about one billion times slower.

Although the achievement of quantum supremacy did not solve any new problems, its implications are limitless. Given more time and resources, quantum computers might become more efficient and capable of completing a variety of applicable tasks.

One major use for quantum computing is modeling molecules. Although it is possible to model smaller molecules with classical computers, the margin of error increases too quickly with size for the measurements taken to be accurate. Quantum computers can be more efficient in the allocation of resources to model the system. Furthermore, the atomic particles that make up these molecules are known to experience superpositions in the same way qubits do. Quantum computers are perfectly equipped to model the uncertainty principle of atomic particles.

Quantum computers also pose a threat to cryptography companies around the world. Cryptography, the practice of using computers to reveal passwords and codes, becomes more dangerous as the efficiency and computing power of the user increases. New quantum computers, capable of solving new and formerly impossible problems, might also lead to the downfall of cryptocurrencies like Bitcoin without a proper increase of security.

With Google's achievement of quantum supremacy, modern computing is approaching an entirely new frontier.

"QUANTUM SUPREMACY IS THE IDEA THAT AT SOME POINT, QUANTUM COMPUTERS WILL BE ABLE TO SOLVE PROBLEMS THAT CLASSICAL COMPUTERS FIND IMPOSSIBLE."

WITH GOOGLE'S ACHIEVEMENT OF QUANTUM SUPREMACY, MODERN COMPUTING IS APPROACHING AN ENTIRELY NEW FRONTIER.

CHEMISTRY NOBEL PRIZE

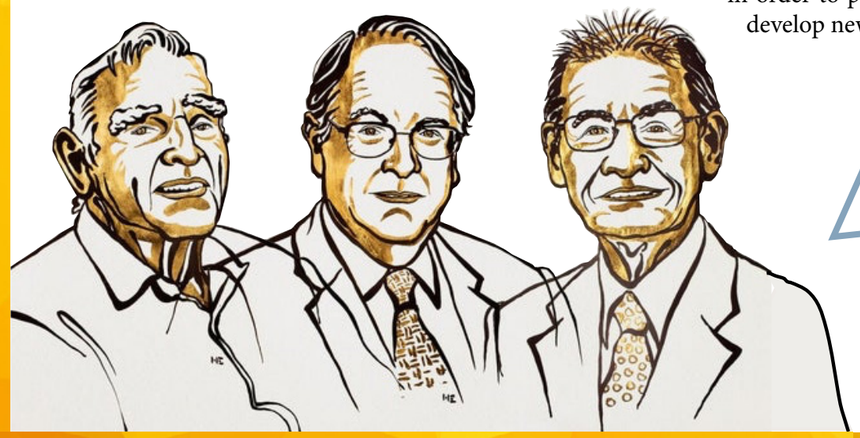
Researchers John B. Goodenough, M. Stanley Whittingham, and Akira Yoshino were awarded the 2019 Nobel Prize in Chemistry for their work in the development of lithium-ion batteries, which are used to power electric cars, solar panels, and cell phones.

Although the battery—first invented in 1800 by Alessandro Volta—has been around for over two centuries, the scientists vastly improved its mechanisms and expanded its applications. Until the lithium-ion battery was created in the 1970s, relatively few developments regarding batteries had been made since the end of the 19th century.

The fundamental idea of a battery is that electrons flow from a negative anode (a conductor through which electrons enter) into a circuit toward a positive cathode (a conductor through which electrons exit). As electrons travel through the circuit, it allows for devices, such as light bulbs, to be powered by the battery. Lithium's high reactivity as an alkali metal and its low atomic mass allows for a powerful and lightweight rechargeable battery.

Although Whittingham was the first to create a working lithium battery, Goodenough, and subsequently Yoshino, made crucial improvements in the cathode and the stability of the battery. Whittingham initially used titanium disulfide as his cathode because its structure was perfect for the reception of the lithium electrons. However, when charged too many times, the battery would short-circuit and explode—a problem that, albeit rarely, continues to exist in modern lithium-ion batteries. Goodenough tried to address this problem by replacing the titanium disulfide with cobalt oxide. This made the battery more stable and boosted its voltage. Finally, Yoshino improved the battery to the point where it no longer needed pure lithium—a development that was instrumental in increasing its safety.

Throughout history, Nobel prizes have not only been awarded to commend past discoveries but to also encourage future endeavors and to direct research. With this award, and particularly its emphasis on the role of lithium-ion batteries in environmental sustainability, the Nobel committee is making a statement to the scientific community. They are calling attention to the climate crisis in order to push future scientists to develop new solutions.

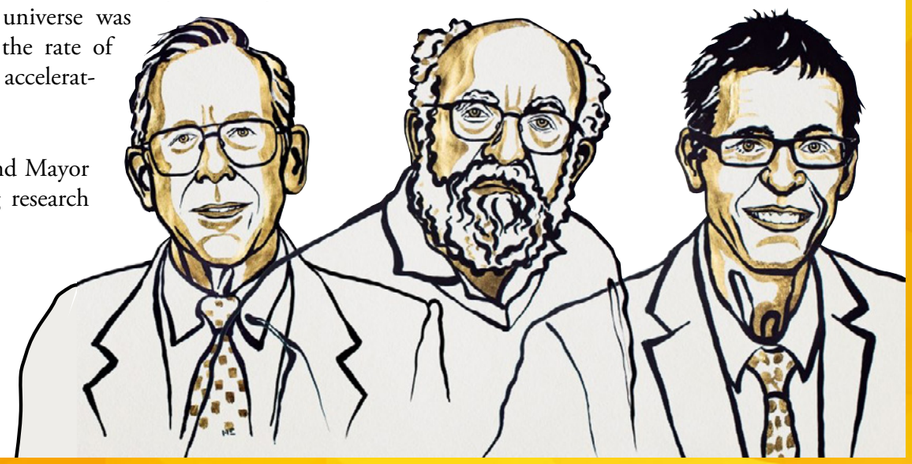


PHYSICS NOBEL PRIZE

What happened in the infancy of the universe? Could there be other planets out there, orbiting other suns? James Peebles, a cosmologist and Princeton professor, was awarded the 2019 Nobel Prize in Physics along with astronomers Michel Mayor and Didier Queloz. Peebles came up with ideas about the universe's structure, and Mayor and Queloz discovered an exoplanet orbiting a star similar to our Sun.

Peebles created a more mathematical approach to measuring the distances and age of our universe after finding that the microwave radiation from 400,000 years after the Big Bang had faint fluctuations. These fluctuations reveal the locations where matter clumped together to form stars and galaxies. In the 1980s, Peebles proposed the existence of cold dark matter, particles that pulled other matter together to form galaxies. Peebles also used Einstein's cosmological constant, known as dark energy, to show that the universe had much less mass than previously thought. He claimed that five percent of the universe is ordinary matter, while ninety-five percent is dark matter and dark energy. In 1998, astronomers confirmed Peebles's theory; they found that the universe was expanding, and the rate of expansion was accelerating.

While Queloz and Mayor were conducting research in the 1990s, there was little hope for finding an exoplanet able to support life. To search for exoplanets, the two astronomers looked for shifts in the color and wavelength of light from the planet's star, which were caused by the planet's gravitational pull. This technique, known as Doppler spectroscopy, is effective enough to detect a planet the size of Jupiter. Queloz soon discovered a solar-type star in the Milky Way, 51 Pegasi, which is 51 light years away. It had a planet as big as Jupiter, and the planet's orbit was short, lasting only four days and making it easy to pinpoint. However, the planet's proximity to the star made its existence doubtful, even to Queloz. After half a year of checking data, Queloz informed Mayor of his discovery. In 1995, they made a public announcement. Although the planet was too close to the star to be habitable, scientists now had a method to discover and study planets similar to Earth. Since then, over four thousand exoplanets have been found in the Milky Way alone. The laureates of the 2019 Nobel Prize in Physics have transformed our view of the cosmos and of the world, and scientists are now closer to finally answering the question of how rare life is in the universe.



MEDICINE NOBEL PRIZE

For years, high school biology teachers have taught the importance of oxygen for sustaining life, but now, more is known about the mechanisms behind it. Not much was known about the ability of cells to adapt to oxygen availability before the research of three scientists. This October, Gregg Semenza, William Kaelin, and Sir Peter Ratcliffe were awarded with the 2019 Nobel Prize in Physiology or Medicine.

Oxygen is an important component for cellular respiration, a process during which cells convert glucose into adenosine triphosphate (ATP). Hypoxia is the condition of oxygen levels dipping too low. This typically occurs at high altitudes, during exercise, or after receiving a wound. When hypoxia occurs, kidney cells produce and release a glycoprotein hormone called erythropoietin (EPO). This is known as an erythropoietic response, and it aids in the formation of new red blood cells, which compensate for the decreased oxygen levels.

Hypoxia Response Element (HRE), the genetic region that is responsible for these responses, was discovered by Semenza. Within the HRE, Semenza discovered the Hypoxia Inducible Factor (HIF), which is made up of two DNA-binding proteins, HIF-1a and ARNT. HIF-1a is dependent on oxygen levels whereas ARNT is not.

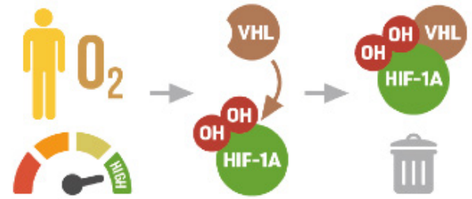
While Semenza and Ratcliffe were studying oxygen regulation, Kaelin was studying von Hippel-Lindau's (VHL) disease. VHL causes tumorous growth of blood vessels, and although the tumor itself is usually benign, the growth may cause complications. The VHL gene is a tumor suppressor gene which encodes a suppressor protein named pVHL. Mutations in the VHL gene can prevent proper function of the suppressor protein and are associated with VHL disease. Kaelin observed that cancer cells with the mutant VHL gene had higher levels of genes affected by hypoxia inducible factors (HIF). This suggested that there were also higher levels of HIF.

Later, Ratcliffe found more evidence that, through a process called proteasomal degradation, the VHL protein was responsible for identifying the oxygen-dependent protein HIF-1a to be destroyed by proteasomes. Proteasomes are protein complexes that degrade specific proteins. They concluded that, in high oxygen conditions, the HIF-1a is constantly destroyed by the proteasome after it interacts with the VHL protein.

Kaelin and Ratcliffe later completed their research when they discovered that oxygen regulated this entire process. When oxygen levels are high, the HIF-1a hydroxylates or gains a hydroxyl (OH) group. It is then recognized by the VHL protein and gets destroyed. When oxygen levels are too low, the HIF-1a protein is prevented from being destroyed, and consequently, oxygen-dependent molecules, including EPO, are activated. In other words, the presence of HIF-1a indicates low oxygen levels and triggers hypoxic responses.

Initially, Semenza's team thought that EPO was involved in very specific responses. However, they found that HIF-1a was present during low oxygen conditions in both animal and human cells. Ratcliffe noticed that the hypoxia-induced responses occurred not only in kidney cells, where EPO is generally produced, but also in almost all cell types. This means that these hypoxia-induced responses are universal, and the presence of EPO could further affect expression of related genes throughout the body. These genes could play important roles in processes such as homeostasis and immune defense.

Combining all the research about EPO, hypoxia, VHL, and oxygen, the researchers finally discovered the components behind the oxygen-sensing mechanism. The discoveries of these three scientists can be applied in cases of anemia, heart disease, and many other life-threatening diseases.



With information about EPO's composition and oxygen sensitivity, EPO and HIF-1a can be used to help patients who are unable to produce EPO, which is essential for red blood cell formation. The ground-breaking research of these three laureates opens up new possible solutions for treating these diseases and for further research. In the near future, a drug that increases HIF activity and EPO levels may become a reality.

PUZZLE

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YOUR FRIEND FILLS UP THE BOARD WITH THESE PIECES AND THEN TAKES THEM OUT. THEY CHALLENGE YOU TO FILL UP THE BOARD IN THE EXACT SAME WAY. RATHER THAN LEAVE YOU TOTALLY CLUELESS, THEY MARK EVERY LINE WHERE A 1X2 HITS A 2X1 AND WHERE A 1X3 HITS 3X1. CAN YOU FIGURE OUT HOW THEY FILLED THE GRID?

1x3 hitting 3x1