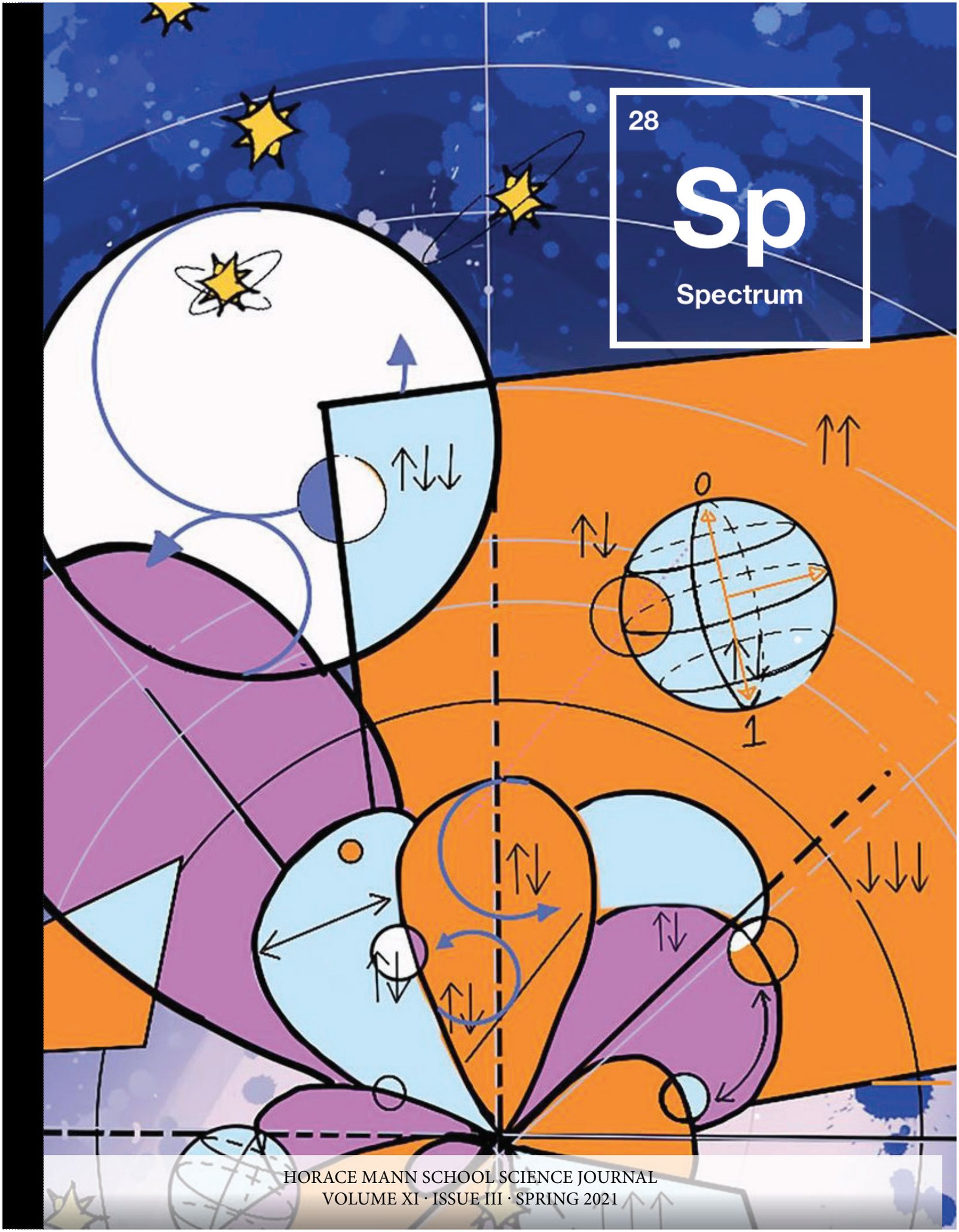

HORACE MANN SCHOOL SCIENCE JOURNAL
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LETTER FROM THE EDITORS

Dear Readers,

Almost all of the information that dominates our daily lives is stored according to the binary machine logic of zeroes and ones. But what if computers could use not only zeroes and ones but also a third state that represents *both* a one and a zero at the same time?

This idea of coexisting states is known as *superposition* and captures the essence of the world's most efficient machines, known as quantum computers. These computers' ability to represent multiple states at the same time results in exponentially faster data processing.

Consequently, today's quantum computing revolution is providing us with more processing power than ever before. The problems that modern computers will take thousands of years to solve, quantum computers can address in a matter of mere seconds.

Our Features topic, "The Future of Computing," explores the revolutionary impact that quantum computing will make on computers' ability to execute some of the world's most daunting computational tasks. Features articles focus on the fundamentals of quantum computing, the technological competition surrounding the development of the most powerful quantum computers, and applications to artificial intelligence and machine learning.

In addition to the Features section, this issue will showcase articles in Biology, Chemistry, and Physics focused on the challenges of mental health and illness, the future of green chemistry, and the promising implications of particle physics, respectively.

We would like to extend our most sincere gratitude toward all of the writers and editors who contributed to this issue. We are also deeply appreciative of Spectrum's faculty advisor, Dr. Christine Leo, and would like to thank her for her constant support, guidance, and advice.

Sincerely,

Danielle Paulson

Sam Singer

Danielle Paulson
Editors-in-Chief, Volume XI

Sam Singer

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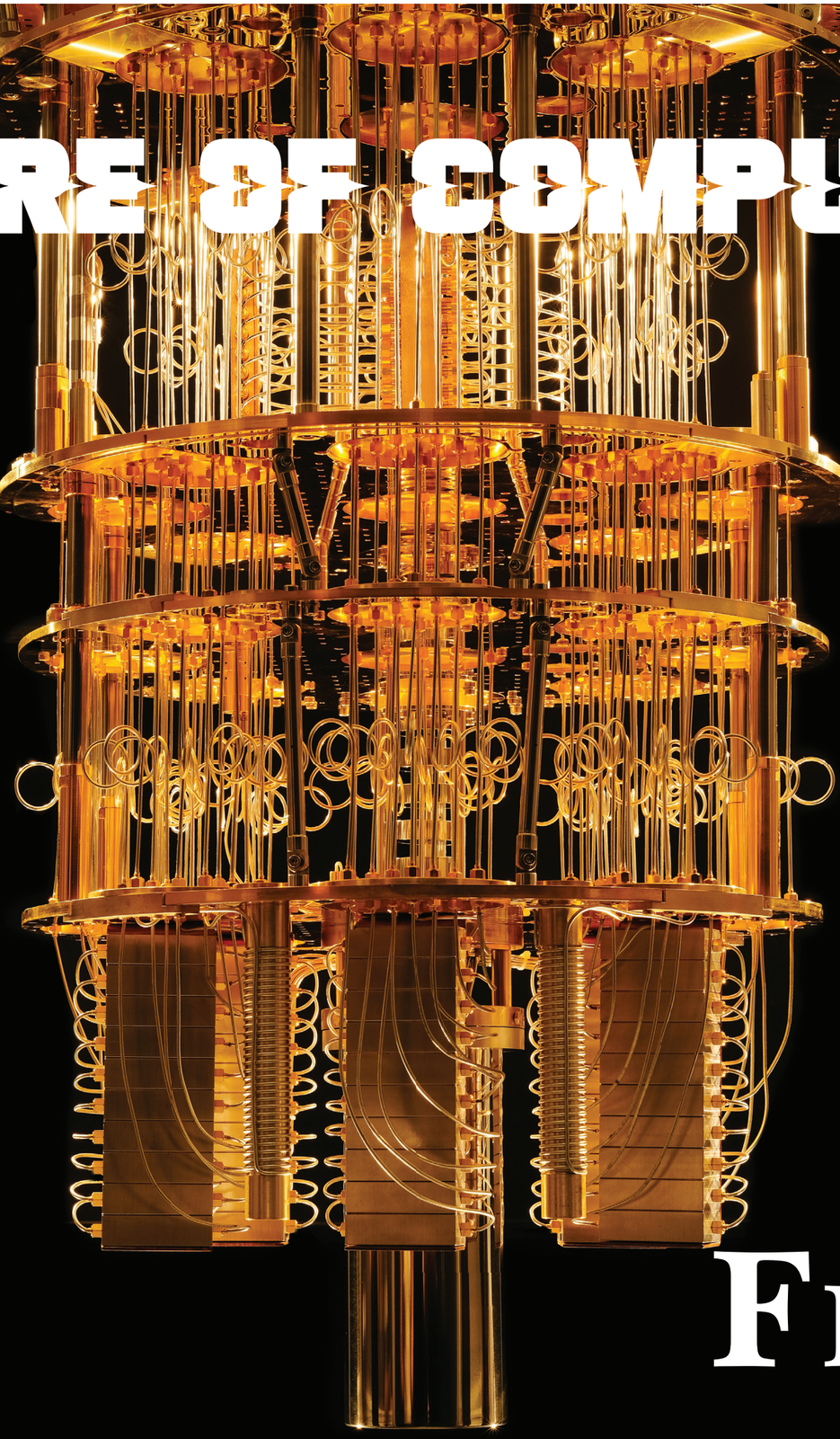
FUTURE OF COMPUTING



FEATURES

The Fundamentals of Quantum Computing

Giselle Paulson
Staff Writer

Although it may seem that major and complex automatic feats have already been accomplished, the realization of technology's true potential has only just begun. Research in the field of quantum computing is revealing faster, more advanced ways to solve problems that would take classic computers approximately 10,000 years to crack. Quantum computing is an area of computer programming based on quantum theory, also referred to as quantum mechanics or quantum physics.

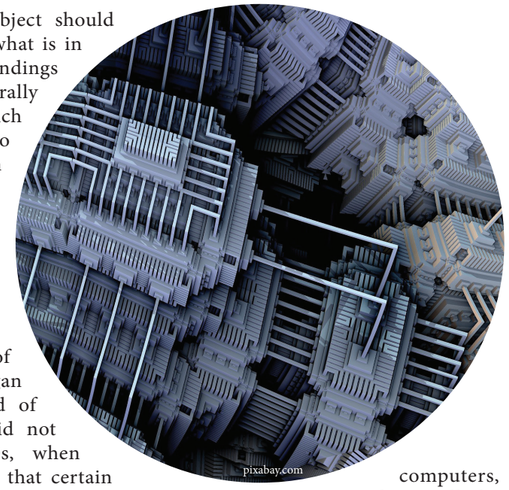
Quantum computers, also called supercomputers, are far more efficient than classical ones and also require far less energy. Classical computers can only encode and store information in bits that have a value of either 1 or 0. These strings of 1s and 0s are essentially like a language that only the computer understands. The computer then translates this binary language into words, images, or files when actually expressing the content to the person using it. However, the specificity of a bit being a 1 or a 0 restricts the computer's ability. Quantum computers, on the other hand, store their information in quantum bits, otherwise known as qubits. In addition to being able to be a 1 or 0, a single qubit can have a value of 1 and 0 at the same time. This is called superposition, a phenomenon in which a subatomic particle has the unique ability to exist in more than one state. Quantum computing takes advantage of this ability, and the result is that it has far more capabilities. For example, since a qubit can have two values at one time, it can hold twice the information and accomplish tasks–like solving complex computational problems–twice as fast. In addition to superposition, entanglement is another feature of quantum theory on which supercomputers are based. However, in order to understand this term and the fundamentals of quantum computing, one must first understand the basis of quantum theory.

Quantum theory refers to how energy and matter behave at atomic and subatomic levels. More specifically, it is based on the concept of quanta: the minimum amount of any specific type of material involved in a given interaction. For example, the quantum (quantum is just the singular form of the word "quanta," hence the name "quantum theory") energy of an atom would be the minimum amount of energy it can absorb; if the amount of energy available was any smaller, the atom would not absorb any of it.

The equations used in quantum mechanics are fairly complicated. While classical mechanics deals with objects of everyday sizes that are always in a given place at a given time, quantum mechanics involves objects so small that they only exist in a region of probability. For example, it is impossible to detect the location of an electron in an atom at a given time because the very act of taking that measurement would cause the electron to move from its natural position. Thus, the position of electrons in an atom is represented using a region of possibility–where the electrons are most likely to be. Thus, the equations of classical mechanics cannot be applied to quantum mechanics because that is essentially the same as expecting the concept of certainty to define that of probability.

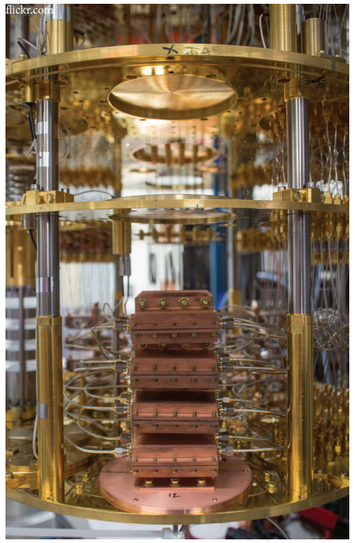
"A problem requiring approximately 10,000 years for a classical computer to calculate could be solved by a supercomputer in seconds."

In addition to equations, many other features of quantum theory are fairly complex and strange. For example, entanglement is when certain characteristics of two objects can only be described in reference to each other even though they are entirely separate and belong to different systems. One example of entanglement is when one particle is observed to be spin-up, the other will always be spin-down (the particles always spin in opposite directions). The concept of entanglement has triggered major philosophical discussions about quantum mechanics because the theory of Local Realism states that the characteristics of an object should only be influenced by what is in the immediate surroundings of its system. It generally defined the way in which researchers work to explain changes in objects. Entanglement contradicts this theory because an object seems to be influenced by another object in an entirely different system.

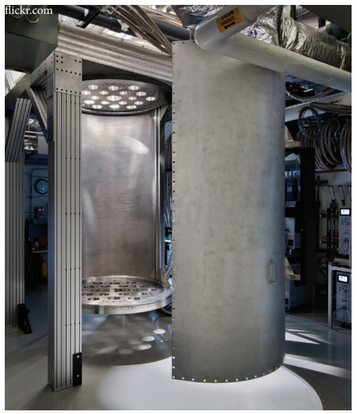


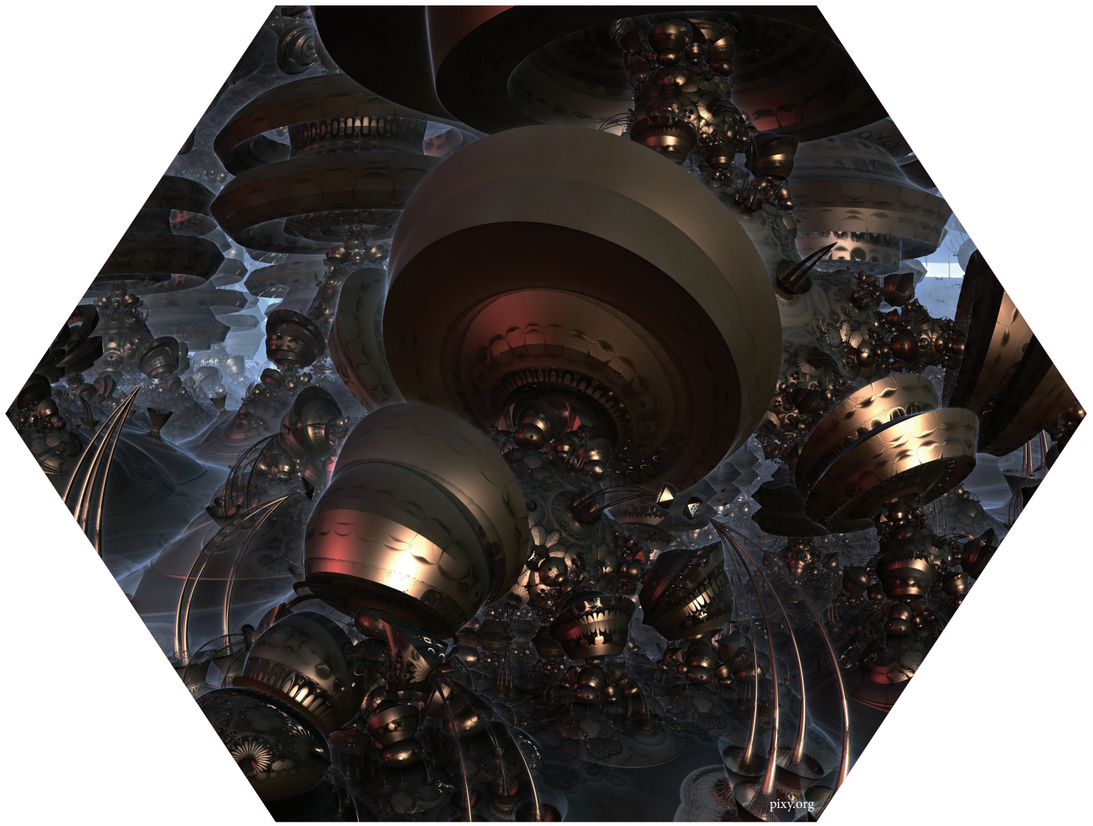
While the study of quantum theory began in the 1920s, the field of quantum computing did not begin until the 1980s, when people began to realize that certain computational problems could be solved more efficiently with quantum algorithms than with traditional ones. Today, some of the world's largest corporations are engaged in an arms race of supercomputers. Some of these companies include Microsoft, Google, Alibaba, HP, Intel, and Nokia.

"Since the machine learning problems required for truly precise AI are too difficult for classical computers to handle, supercomputers are starting to be used instead."



Google, in a partnership with NASA, has made significant progress in developing supercomputers used for artificial intelligence (AI). The process of "giving" a computer artificial intelligence is called machine learning. The algorithms that are coded into the computer are fairly simple, and the computer learns by trial and error. Since the machine learning problems required for truly precise AI are too difficult for classical computers to handle, supercomputers are starting to be used instead. Furthermore, molecular modeling is a likely critical future use of quantum computing. Creating models for specific configurations of chemical reactions is so complex that classical computers can only analyze the simplest molecules. However, given the efficiency and advanced problem-solving capabilities of quantum computers, they will be able to depict the most advanced molecular interactions. Cryptography is also a great future use of quantum computing. Most online security measures involve searching through every possible factor for large numbers and converting them into prime numbers, and this tedious process performed by digital computers is incredibly expensive. Thus, the computational potential of quantum computers would make cracking these codes far more practical. Beyond these applications, quantum computing has many uses in other fields such as finance, military affairs, intelligence, nuclear fusion utilities, and digital manufacturing. All in all, quantum computing will clearly play a dominant role in the technology of the future.





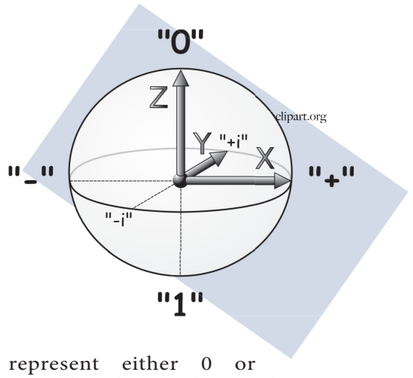
Quantum Error Correction

Luccas Correia
Staff Writer

This article provides a basic overview of quantum error correction code in the world of quantum computing. Quantum computing has many revolutionary benefits; however, for quantum computers to operate at their full potential, scientists need to devise methods for fixing errors, or quantum error correction (QEC).

Qubits–quantum particles representing a 1, 0, or both simultaneously–are fragile by nature. They are made from substances such as individual atoms, electrons trapped within tiny chunks of silicon, or superconducting materials. When the qubits interact with their environment, errors can easily occur, and the information stored in them can be lost. Quantum computers must run near absolute zero at temperatures around –273.15°C (–459.67°F) or in an ultra-high vacuum chamber. Near absolute zero, the vibrations and thermal fluctuation present are negligible, and therefore, the information contained within the qubit is preserved. It is due to this fragile nature of qubits that quantum computers are prone to errors. Scientists need to devise methods for detecting and correcting errors. This field is known as quantum error correction (QEC).

In classical computing, bits



represent either 0 or 1. Therefore, the only error that can occur is a bit-flip that changes a 0 to a 1 and vice-versa. When this occurs, correcting the errors is straight forward. The basic principle behind classical computing error correction is to use redundant coding, which means sending multiple copies of each bit. If the bit is a 1, just copy that three times, resulting in 111. Likewise, a 0 becomes 000. If one of the three bits is accidentally flipped, 111 turns into 110, and the bits will no longer match, indicating that an error occurred. By reviewing the altered three-bit sequence, whichever state is the majority is the correct state.

Similar to classical error correction, QEC is used to protect quantum information from errors. However, given the complex nature of qubits, error correction for quantum computing is far more difficult than the use of the majority rule method used to solve classical errors. Decoherence and other quantum noise are two examples of errors that can disrupt a quantum algorithm. Decoherence is the interaction of qubits with their environment that results in the decay and loss of qubit quantum properties. Unlike classical computers, which only have bit-flip errors, quantum computers also have phase flip and bit-phase flip errors.

QEC schemes attempt to use redundancy like classical computing error correction. However, there are two principles of quantum computers that make this difficult. First, the no-cloning theorem says that it is impossible to copy a quantum state, so qubits cannot be duplicated. Second, in quantum mechanics, it is impossible to measure a qubit without destroying its quantum properties of superposition and entanglement, which are responsible for how quantum computers work. QEC schemes get around this problem by spreading qubit information over multiple entangled qubits, collectively known as a logical qubit. The idea is to combine multiple physical error-prone qubits to form a more reliable logical qubit that is used in the computations. To measure the value of a qubit, scientists perform indirect measurements by checking if two qubits have the same value.

The first QEC code was discovered in 1995 by Peter Shor, a mathematician at the Massachusetts Institute of Technology. Shor's 9 qubit code mapped 1 qubit onto 9 entangled qubits to ensure a single qubit was protected from errors.

One QEC scheme that is being studied is the surface code, which works well on superconducting quantum computers, like the ones being built by Google and IBM. The algorithm is designed to be used with qubits that are arranged in a 2-D grid, where each qubit has a different job. Data qubits are used to store information, and ancilla qubits are used as helper qubits. The ancilla qubits can be measured to check and correct quantum errors without affecting the information stored in the data qubits. The more data and ancilla qubits used to make up the logical qubit, the more errors that can be detected and corrected. Other forms of QEC used are The Bit Flip Code, The Phase Flip Code, and The Shor Code.

Due to the two fundamental principles of quantum mechanics, superposition and entanglement, a quantum computer can process numerous calculations simultaneously. Parallel processing of data is what allows quantum computers to solve certain problems–such as factoring large prime numbers and sorting large random lists–far more efficiently than any classical computer. Quantum computers could be used in the military to break security codes or search large data sets at lightning speed. To put things into perspective, Google's quantum computer performed a task in 200 seconds that would have taken the world's fastest supercomputer 100,000 years!

While scientists are currently creating prototypes for quantum computers, useful ones that will outclass ordinary computers remain years or decades away. However, companies like IonQ, IBM, and Google are closer than ever to making effective quantum computing a reality. IonQ has already made headlines, claiming that they will soon "Release New 32 Qubit System with Record-Breaking Performance and Accuracy," and IBM is promising a 1000-qubit quantum computer by 2023!

"Due to the two fundamental principles of quantum mechanics, superposition and entanglement, a quantum computer can process numerous calculations simultaneously. Parallel processing of data is what allows quantum computers to solve certain problems, such as factoring large prime numbers and sorting large random lists, far more efficiently than any classical computer. "

The World's Most Powerful Quantum Computers

Avi Kumar
Staff Writer

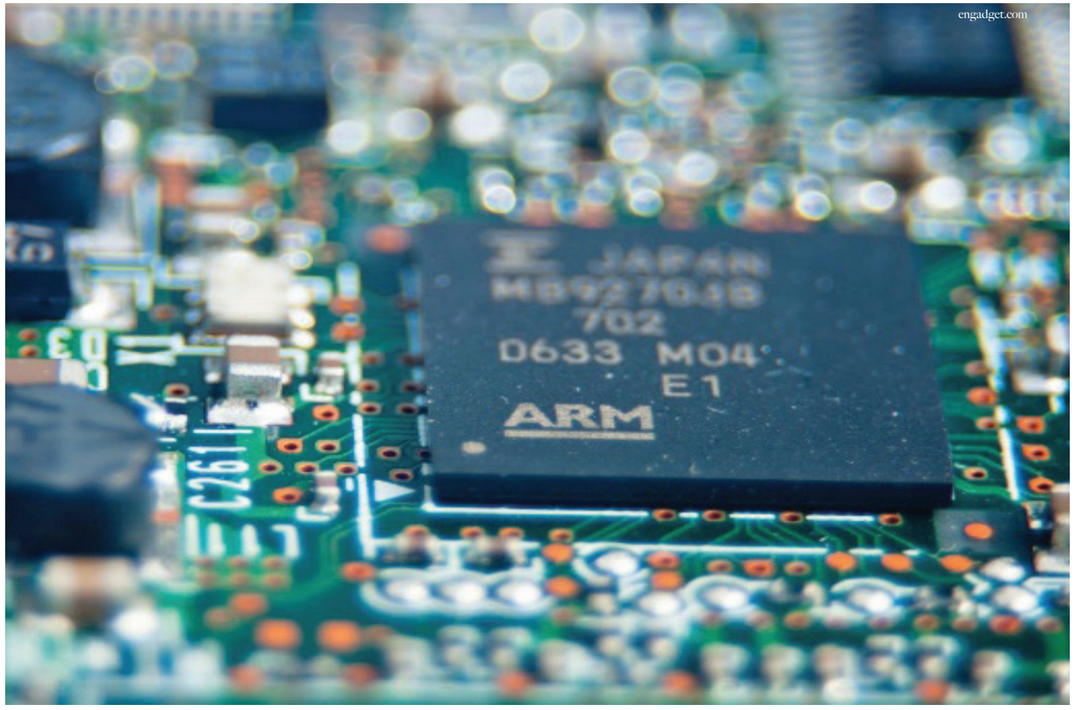
Whether it is NASA vs. the Soviet Space Program, competition between consumer technologies like smartphones and laptops, or even the race between car companies to build a successful electric car, technology today is increasingly advancing because of the intense competition. Now, there is a race for the most powerful quantum computer.

Quantum computers can process much more data faster than any other computer could because they allow for more possibilities. Quantum computers could be revolutionary. One of three biggest uses for these computers is in pharmaceuticals. Biogen, a pharmaceutical research company, 1QBit, a quantum software company, and Accenture Labs, a R&D group for infrastructure and technology, are collaborating to use quantum computing to lower the amount of time it takes to produce a new drug. By analyzing and comparing large scale molecules, these three companies believe they can treat and cure neurological diseases and rare genetic disorders.

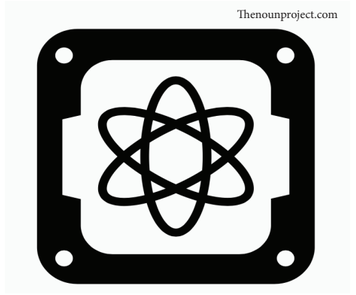
As one might expect, technology like this is in high demand for different businesses and individuals, and this fact has triggered the race to build the most powerful supercomputer. To measure a quantum computer's performance, a metric developed by IBM, known as Quantum Volume, is used. Three main factors go into determining the Quantum Volume. The first is the number of qubits. Similar to a 16-bit or 32-bit computer, the greater the number of qubits a computer has, the faster the computer can process data and solve equations. The next variable we must consider is the error rate. This is simply the percentage of time that a quantum computer makes an error. One important type of error is decoherence, which occurs when the exposure of a qubit to a certain environment causes the superposition of the qubit–or the ability of that qubit to be both 0 and 1 simultaneously–and its subsequent decay. Decoherence is a major obstacle for quantum computing companies because it can heavily affect how well a quantum computer can process data. The final factor that affects Quantum Volume is the connectivity of qubits. Entanglement of qubits occurs when qubits are connected, which allows for the quantum computer's efficiency to exponentially increase, as there are more qubits for each quantum state. Therefore, the more connected qubits, the better the Quantum Volume. These three factors allow the Quantum Volume to effectively represent the performance of a quantum computer when comparing different quantum computers.

> "Now, there is a race for the most powerful quantum computer."

One of the prominent companies in the "quantum computer race" is Honeywell. Honeywell is a multinational conglomerate focusing on aerospace, cybersecurity, health care, safety, and innovation for the future. Honeywell's quantum computer has a Quantum Volume of 64, which is high for today's standards. Honeywell's computer can also avoid decoherence by a unique feature known as the mid-circuit measurement, which can reuse qubits throughout a calculation. Most other quantum computers would automatically decohere when doing this. This means Honeywell can go a long time without decohering, allowing algorithms to be longer. Honeywell is in the lead for the most powerful quantum computer and is on track to reach the one million qubit threshold necessary for quantum computers to have some practical use.



Honeywell's computer is an example of a Trapped Ion Quantum Computer, where atoms are "trapped" in an electromagnetic field on a silicon chip. IonQ is another company using similar technology. IonQ claims its quantum processor has a quantum volume of 4,000,000. While this number may seem high, it is only an estimation. It is also crucial that these processors are error-corrected. Ion traps are popular for quantum computers, but they can limit the number of qubits trapped. This triggers the need for flying qubits, meaning they can be sent over long distances without decohering. Honeywell wants to create a quantum version of the technology in a traffic camera. Traps can allow ions to move between them to share quantum information within qubit groups, meaning the ions are the flying qubits. IonQ has a similar approach, but it relies on the "conversion between ion qubit and photons" to move between adjacent traps, making distance no longer an issue. IonQ's new quantum computer also has better error-correction techniques, which is necessary for these quantum computers to be used by consumers. Its system will be available as a private beta, meaning at first it will only be available to companies. The companies include Amazon and Microsoft Azure Quantum Cloud.



As good as IonQ may say its error-correction techniques are, many are skeptical about whether quantum computers are worth it. Many companies have invested heavily in this technology, but the computer's processing noise, or the errors it makes, may be tough to get rid of. Gil Kalai, a professor at Hebrew University in Jerusalem, has studied the noise of quantum computers and suggests that noise levels may not be able to be reduced sufficiently.

The question behind quantum computers is whether we should be putting time, energy, and money into these technologies. It is only possible for quantum computers to improve the world if the technology can and will be economically efficient, accessible, and practical.

Applications of Quantum Computing to Artifical Intelligence & Machine Learning

Alexandra Yao
Staff Writer

A man from Texas uses his card to withdraw a million dollars in Hawaii. A classical computer looks at the location, looks at the amount withdrawn, and immediately assumes the transaction is fraudulent and freezes the card. In an ideal world, the computer would look at many more factors to get a fuller picture of the situation. Why couldn't it do so? One fatal flaw: speed.

The first "computer" was invented by Alan Turing in the 20th century. It was the size of a room, with gigantic tubes representing bits of 0 or 1. Since then, computers have shrunk to the size of a pocket. Tiny silicon transistors act as switches to either block or amplify a flow of electricity: 0 or 1. As transistors became smaller and smaller, more of them could fit into tinier spaces, and the increased number of bits allowed more tasks to be executed at once. Currently, transistors are thousands of times smaller than red blood cells. However, when scientists tried to make them even smaller to increase the speed even further, they ran into a few problems: when the objects being manipulated were that tiny, the rules of classical mechanics began to break down and those of quantum mechanics, which deals with the very small and the very cold, took over.

The first problem classical computers ran into was quantum tunneling, which occurs when transistors are so small that flowing electrons can phase straight through, preventing the electricity from stopping when it needs to. To address this issue, scientists turned away from classical bits, which can only be 1 or 0, and towards quantum bits, also called qubits.

> "This ability to be exponentially faster—or rather, to do exponentially more things at once—is especially helpful for computing that requires multiple iterations, so many that it would take classical computers far too long to finish."

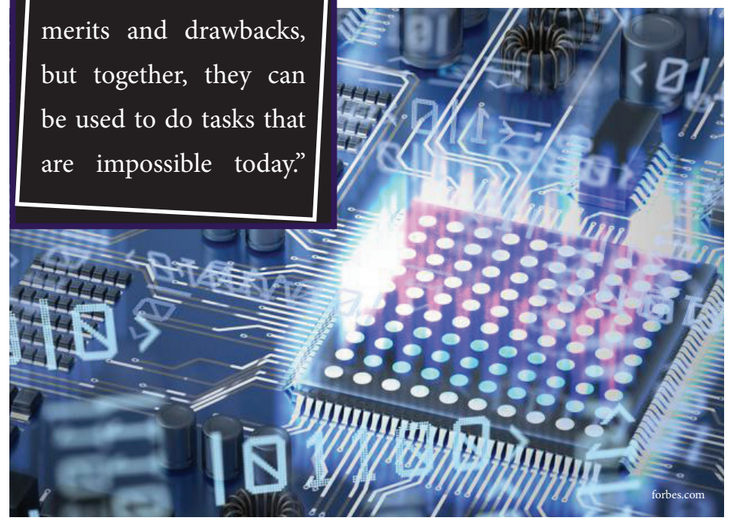
Qubits can be both 0 and 1 at the same time, with a certain probability of being either value. This is known as a state of superposition and allows the computer to operate both as if the qubit were a 0 and as if it were a 1. Since the order of 0s and 1s in the code determines what a computer is doing at a given moment, classical computers must perform tasks one at a time, which is especially laborious with larger sets of data. Replacing just one bit with a qubit, however, can double the processing power, and as more qubits are added, computers can process more data simultaneously, leading to an exponentially increased speed. The final value is produced when the qubits are measured through complex quantum equations, which causes them to collapse into either 0 or 1.

This ability to be exponentially faster—or rather, to do exponentially more things at once—is especially helpful for computing that requires multiple iterations, so many that it would take classical computers far too long to finish. In particular, the speed is critical for optimization, which is when a computer goes through enormous data sets in an attempt to find the best possible point for the situation at hand. Optimization is especially useful in the fields of artificial intelligence (AI) and machine learning. For both, programmers must develop the best possible algorithms so that a certain goal can be accurately achieved in a timely manner.

In machine learning, an algorithm takes a set of data and learns from it, updating and improving itself to become more specific or to address new information. For instance, an algorithm could be made to detect the presence of a cat in an image. In order to "train" this algorithm, it would need to be fed many different images, each one a new data point that either does or does not include a cat. The computer can either be told which images contain cats, or it can be simply given the set of images and left alone to use clustering methods, grouping the data based on observed patterns common to different pictures. Regardless of the method, classical computers are unable to examine too many data points at once. Each iteration requires a different sequence of bits; as such, programmers are often forced to wait long periods of time for an algorithm to go through all the sequences and finish "learning" from the data set. Quantum computing, on the other hand, can process large chunks of data simultaneously. Qubits that are neither 0 nor 1 allow multiple sequences to be processed at the same time. When larger amounts of the data can be processed in a smaller amount of time, algorithms can be trained exponentially faster, and previously impossible tasks can be done relatively quickly. An increased number of data points increases precision and accuracy as well, improving deep learning algorithms in machine learning.

AI is also governed by algorithms that tell them what to do. Many of the algorithms upgrade themselves through some form of machine learning, drawing on past experiences and assignments to improve the algorithms, which allows the AI to adapt to the environment and data presented. As such, benefits to machine learning are also benefits for AI—just as quantum computers' ability to process exponentially more data points makes data processing faster, it also makes AI more precise, allowing them to do their assigned tasks more quickly and effectively.

> "Both the systems in place now, as well as those being developed for the future, have their own merits and drawbacks, but together, they can be used to do tasks that are impossible today."



In the real world, quantum computing has the potential to make the most difference in areas that require speed and precision, such as the banking and financial sector. There, quantum computing can be applied to fraud detection. Currently, machine learning techniques applied to credit card transactions use previous trends to detect any unusual or suspicious activity. If detected, the credit card would be frozen. Unfortunately, AI using classical computing often give many false positives, freezing the card when the owner withdraws a larger than usual sum or simply travels to a different location. These transactions are not actually fraudulent, but based on the analyzed variables, the AI responds as if they are. As the number of false positives increases, the trends being analyzed become less trustworthy, further reducing the accuracy of the algorithms. However, when quantum computing is applied to these machine learning techniques, programmers are able to evaluate over 200 additional variables in each transaction. This paints a much more accurate picture of each transaction, allowing the algorithm to differentiate between actual fraud and a transaction with a few features changed.

Despite the many benefits of quantum computing in improving speed and accuracy, "it will be the two [quantum and classical] working together harmoniously [that will] solve challenging and complex problems" in the future, Daniel Newman, principal analyst at Futurum Research, said. Both the systems in place now, as well as those being developed for the future, have their own merits and drawbacks, but together, they can be used to tackle tasks that are impossible to handle today.

Biology

The Link Between Stress and Depression

Athena Rem
Staff Writer

Stress and depression have always had a clear link, but new scientific research holds the potential for an effective treatment. Scientists know that the body's response to stress causes depression, but previously, not much was known about why depression is the body's response. In order to cure or eliminate a bodily process, the specific reason that it occurs must be completely clear. New studies and experiments, including research around the p11 protein, show great promise in this field.

When thinking about possible treatments and medical care to combat depression, it is necessary to understand why depression happens physiologically. There are many factors that could induce depression, including genetics and chemical imbalances, but one of the most notable causes is stress from daily events and surroundings. Some degree of stress is necessary in life and is not always bad. Stress can help with motivation or drive and help improve memory. It also allows for the fight-or-flight reflex, which can save people's lives in dangerous situations. Stress can be a motivator and have positive effects if it is manipulated in correct and healthy ways. However, if stress is poorly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managed or ignored, depression can ensue. This makes sense intuitively; stress and anxiety can be damaging and detrimental to mental health, so other disorders appear, such as depression. Even so, it prompts the question of what exactly is happening in the body that causes stress to lead to depression.

The Karolinska Institutet in Sweden tried to answer this question. In one of their studies, the researches there discovered that people with depression have lower levels of the protein p11. It is important to keep in mind that these studies were done on mice, not humans. However, humans share about 97.5% of their DNA with mice, so it is possible that the results of the study will be applicable to humans. In mice with p11 deficiency, more serotonin is produced and used. Serotonin is one of many neurotransmitters, which transfer messages from a nerve cell to any sort of target cell across a synapse (the small junction where transmission occurs). It is heavily involved in stabilizing a person's mood and making people feel better in general. This provides a clear link between p11 and stress, because when serotonin is needed, stress is higher and more dangerous. When p11 is deficient, serotonin is needed, implying that p11 is synonymous with more stress.

A later study at this Institute involving p11 made two additional discoveries. First, p11 can manipulate the release of cortisol, adrenaline and noradrenaline, hormones that are involved in stress and can aid body systems such as fight or flight. These substances are helpful for the body when administered properly. A stronger reaction to stress came when p11 levels were lower as opposed to average. A stronger reaction entails more symptoms and cases of depression. This supports the evidence that those suffering with depression


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and suicidal thoughts or tendencies had lower p11 levels. Therefore, these insights can be used to gain insight into treating people who are suffering from depression. But how exactly? The Karolinska Institutet supported the idea of strengthening the level of p11 protein through medication and developing drugs to block initiation of the stress hormone response in the brain. Per Svenningsson of the Karolinska Institutet provided two possible strategies: "One promising approach involves administration of agents that enhance localised p11 expression, and several experiments are already being conducted in animal models of depression. Another interesting approach which needs further investigation involves developing drugs that block the initiation of the stress hormone response in the brain."

These insights can lead to the development of new antidepressants to target depression more aggressively and strategically. More than 264 million people suffer from depression globally, and 7% of men and 1% of

"Understanding the link between stress and depression is crucial to improving the lives of many people today and in future generations."

women commit suicide after a lifetime history of depression. These statistics only account for those who have been diagnosed and have had depression for a long time, meaning that there are many undiagnosed cases of depression and the actual number of people with depression is far greater. Current antidepressants are not improving quality of life and providing happiness. Some antidepressants replace pain with numbness, and the ones that don't (and even some that do) have a myriad of side effects. Antidepressants carry accompanying side effects such as hypotension, hypertension, tachycardia and low blood pressure, which are detrimental to a person's health and well-being, so it would be optimal to find a drug that avoids these risks. While it is not guaranteed that the drugs scientists are hoping will be produced to raise p11 levels will alleviate these side effects, it provides hope and prospect when so many lives are at stake.

The exact bodily processes that dictate the relationship between stress and depression are not completely understood, but that is starting to change. Possibilities for new medicines are being innovated each day, and more experiments are already underway to discover more about p11 and the relationship between stress and depression. These innovations are not just for patients with depression, and may be applicable for people with anxiety and other mental disorders. There have even been experiments with Parkinson's patients, which p11 also played a big role in. Around 1 million Americans have Parkinson's and need treatment. Understanding the link between stress and depression by understanding the importance of p11 in regulating stress is a crucial step in developing treatments for depression.


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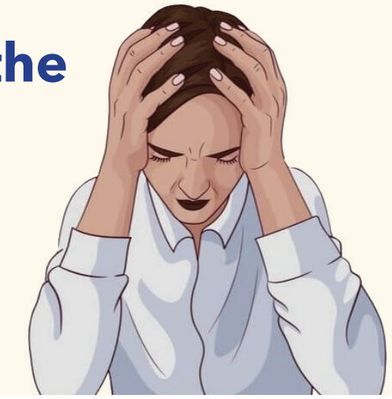
How PTSD Accelerates the Aging Process



Leah Sepiashvili
Staff Writer

Approximately 70% of adults have been affected by some trauma. For children, that number exceeds 30%. Trauma doesn't arise solely from war or sexual harassment, it can be from neglect, abuse, emotional turmoil, and mental health, among many other causes.

Trauma causes an abundant amount of problems to a person's health, both physical and mental. Mentally, there are not proven ways of completely escaping traumatic memories, and as a result, mental state declines. In addition, since one's mental state directly corresponds to their physical condition, a person's physical form will also deteriorate due to trauma.

However, Post Traumatic Stress Disorder (PTSD) and extreme trauma have shown to increase the rate at which the brain ages in children who have experienced it.

However, Post Traumatic Stress Disorder (PTSD) and extreme trauma have been shown to increase the rate at which the brain ages in children who have experienced it. PTSD has led to affect not only the brain's aging rate but also the body's as well.

PTSD is a mental disorder arising out of severe trauma. Usually, it is characterized by intrusive thoughts, hyperarousal—when the body acts as if someone is in danger, triggering the fight or flight response and heightening alertness—flashbacks, nightmares, sleep disturbances, changes in memory and concentration, and startle responses. It has been theorized that these symptoms are manifestations of stress-induced changes in the brain structure and its functions. Because stress causes chronic and acute changes in the neurochemical systems in specific brain regions, there are long-term and lasting changes in brain circuits and the way the brain works. Neuroscientists believe that PTSD affects the hippocampus, amygdala, and medial prefrontal cortex the most. In addition, PTSD affects cortisol and norepinephrine production, two brain chemicals responsible for dealing with stress. (Image 2)

The hippocampus is responsible for the formation of new memories, emotions, and learning, while the amygdala is primarily associated with the fight-or-flight response, and plays a key role in the formation and retention of memories. The medial prefrontal cortex is said to be responsible for maintaining emotional information within working memories. When exposed to high levels of stress, the hippocampus shrinks, severely inhibiting its ability to form new memories. In addition, high levels of stress can decrease the ability to recall long term memories, but increases the retention of short term memories, especially in regards to emotional memories. During times of stress, the amygdala will inhibit the functions of the prefrontal cortex. Cortisol and norepinephrine are primary brain chemicals responsible for stress regulation, PTSD and the effect it has on the brain, increases these chemicals, resulting in a faster heart rate, the fight-or-flight response, and increased blood pressure.

In addition, high levels of stress can decrease the ability to recall long term memories, but increases the retention of short term memories, especially with regards to emotional memories.

The brain matures through about 35 years of age when exposed to the conventional method of aging. Although most of the process is finished at about 21 years of age, some individuals may take up to 15 additional years to fully mature. As a result, the brain normally ages at a steady and healthy rate without harming a child or young adult.

Most brain development is completed in the uterus before a child is born. However, it continues to develop until about mid-life. The first five years of life consist of an expansion of the brain's volume because of the development of both gray matter–a significant component in the central nervous system that consists of neuronal cell bodies, glial cells, synapses, capillaries, and nerve cells–and white matter–matter

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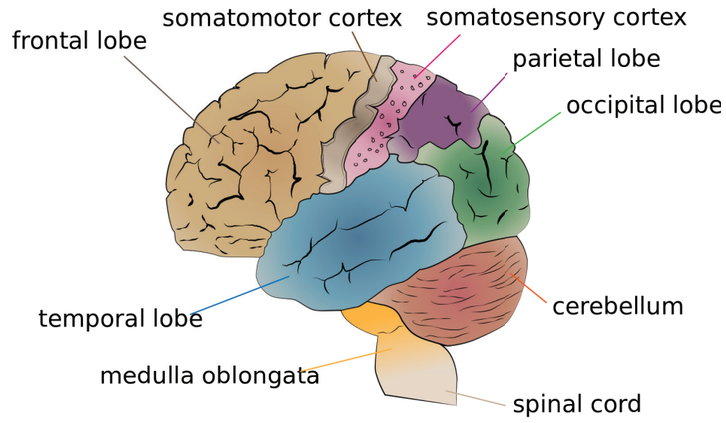

containing neurons parts called axons, found in the deeper tissues of the brain.

The amygdala, hippocampus, and medial prefrontal cortex all start the process towards full development in early childhood, especially after birth, and continue to develop through childhood. Each of these systems works with the increase in white matter in the brain and are most malleable in the stages of early childhood.

Then, from 7 to 17 years of age, there is a steady increase in white matter and a steady decrease in gray matter. Supposedly, white matter increases because the brain is going through increased myelination, the formation of myelin sheaths, which are fatty tissues that protect neurons and help transmit information across the neural pathways faster. Gray matter decreases because of neural pruning, thus keeping the brain about the same size. However, there are areas in which gray matter increases. The most prominent being the frontal cortex–the part of the brain covering the frontal lobe that is responsible for planning complex cognitive behavior, personality expression, decision making, and social behavior–and the parietal cortex–the part of the brain responsible for association between the senses and decisions. An increase in gray matter in these areas indicates a higher level of processing and better mobility. (Image 1)

During the middle part of life, right up until about 70 years of age, there is a gradual decrease in gray matter, caudate, and diencephalon. Caudate is part of the basal ganglia, and it is thought to take part in movement, as well as several non-motor functions. Diencephalon is the division of the forebrain, and it consists of structures that are on either side of the third ventricle, including the thalamus, hypothalamus, epithalamus, and subthalamus–an area of the brain that link the nervous system to the endocrine system. These changes are most pronounced in the frontal cortex and temporal cortex. In addition, there is an enlargement of the ventricles–hollow communicating pathways–in the brain, but no change in the white matter content. There is some evidence of people over the age of 70 who experience significant reductions in the hippocampal lobe as a result of the aging process as well.

In contrast, children who have experienced trauma show biological signs of aging faster than their peers. A research study performed by the American Psychological Association looked at three different areas of biological aging–puberty, cellular aging, and brain structure changes– and found that trauma, especially early exposure to trauma, significantly affected each of these stages.

Dr. Katie McLaughlin, an associate professor of psychology at Harvard University, and her team reviewed 25 studies with more than 3,253 participants and examined how early exposure to trauma affects brain development. Her team found that PTSD was associated with a reduction in the cortical thickness. In other words, they found a marker of aging in the brain. The cortex thins as people age. Different types of trauma thin different parts of the brain. In patients who were exposed to trauma and violence, their cortex thinned in the ventromedial prefrontal cortex, which is primarily responsible for social and emotional processing. In patients who experienced deprivation (neglect, starvation), their cortex thinned more in the frontoparietal, default mode–connected brain regions that are active when a person is not focused on external factors–, and visual networks, which are responsible for sensory and cognitive processing.

In another review done by her team, comprising of about 80 studies, with over 116,000 participants, Dr. McLaughlin found that children who had experienced threat-related trauma (such as violence or abuse) were more likely to enter puberty earlier and show cellular level aging. These patients had shortened telomeres–the protective caps at the ends of DNA strands that prevent them from wearing down–a sure sign of cellular aging.

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This research suggests that PTSD undoubtedly affects the brain and how it matures. Not only are the brain tissue and brain chemicals affected, but parts of the brain that regulate memory, sensory, emotional, and bodily aging are also affected. According to the proponents of the study, the findings suggest that there is a specificity in the implications of different types of trauma on early childhood development. This accelerated aging could, and often does, lead to later health disparities in one's life, and the earlier the trauma, the more at risk the patient is for illnesses that are often associated with age, including heart disease, cancer, and memory loss.

Pandemic Causes Increasing Mental Health Issues

Elise Kang
Staff Writer

To date, the coronavirus pandemic has taken the lives of 1.34 million people worldwide. 55.6 million people have fallen ill from the disease. Over 40.8 million people have been left jobless in the United States alone. Schools have shut down, businesses have closed, and masses of people have gone into quarantine to slow the spread of the novel virus. All of these factors contribute to worsening mental health issues amongst the population, a looming issue that if not addressed, will continue to haunt the public even after the pandemic is declared over.

Ever since the spread of COVID-19 began, indicators of underlying mental health issues have presented themselves in unusually high proportions. According to KFF, a non-profit organization dedicated to national health issues, 53% of American adults reported feeling worried and stressed since the pandemic started, compared to 32% of people before the pandemic. In addition, 36% of American adults said they struggle with sleep and 32% reported struggle with eating. 12% expressed increased alcohol usage and another 12% reported worsening chronic health conditions.

"53% of American adults reported feeling worried and stressed since the pandemic started, compared to 32% of people before the pandemic."

Children are even more susceptible to deteriorating mental states.. Juveniles who are too young to understand exactly what is going on around them may have a lot of questions, which commonly will end up going to their parents or caretakers, who are already frazzled. Kids who are apart from their classmates, school, and friends end up feeling isolated from the world around them, which can cause negative behavioral changes. According to the National Institute of Health, children will commonly demonstrate increased levels of crying, irritability, sadness, and struggles with concentration. It is also common for them to no longer enjoy activities they did before, have unexpected pain and headaches, and switch their food consumption patterns.

The elderly not only are at a higher risk for the effects of the coronavirus pandemic because of underlying health conditions, but are also more prone to impacted mental well-being. Even without underlying health conditions, people over sixty years old are still more likely to catch COVID-19 and develop serious conditions. This extra danger posed to senior citizens can cause increased stress levels, leading to more irascible behaviors, disrupted sleep and eating patterns, and emotional outbursts. Additionally, the elderly tend to have more social time built into their schedules. Social distancing and quarantines make the social time much more difficult to achieve, which can also negatively affect their mental state.

Another group at a higher risk of worsening mental health are healthcare professionals. Doctors, nurses, and paramedics, who come into contact with the infected every day, encounter fears of catching the disease for

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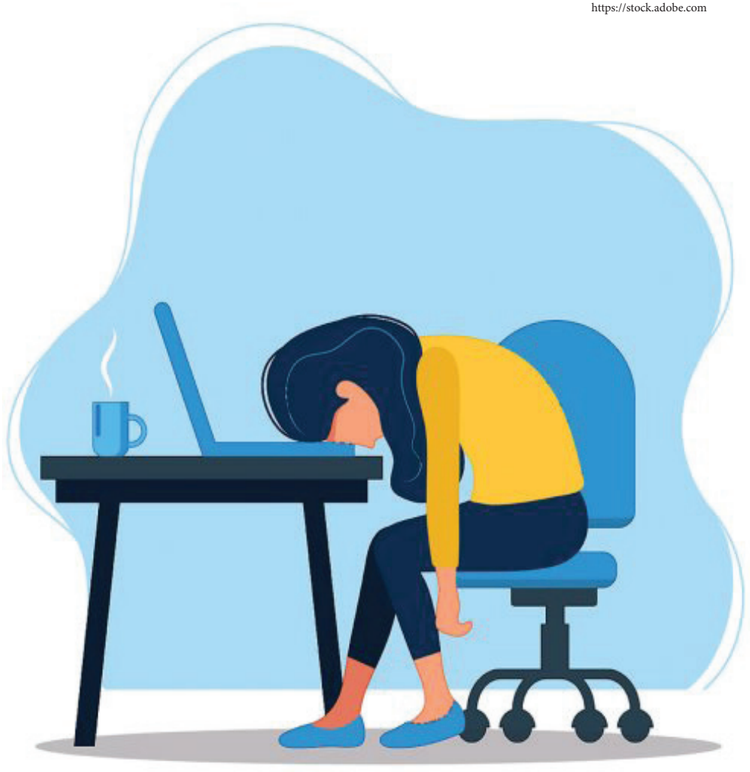

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themselves. The lack of protective equipment and medical gear needed to treat patients further boost these fears. Their long working hours combined with their consistent exposure to the virus will force many healthcare workers to see their peers pass away without ample time to recover emotionally. The extensive patient load, combined with the lack of effective treatments for COVID-19, and the critical state of their patients can make the pandemic seem as if it will never end and the situation impossible to resolve. On top of that, community members may be fearful of encountering healthcare workers in person. This fear is prevalent because they might have the notion healthcare workers have caught the disease, due to the number of infected people they meet regularly.

Social distancing requirements make obtaining help for these issues quite challenging. According to the World Health Organization, over 67% of nations reported disruptions to counseling and psychotherapy. Telemedicine and teletherapy can help people overcome the barrier posed by social distancing guidelines. In fact, 70% of nations have made the shift to telemedicine and teletherapy in response to the pandemic. However, low-income countries do not have the same widespread access to technology as high-income countries. Even though 89% percent of nations included support for mental health in their response plans for COVID-19, only 17 countries, including the US and Australia, allocated funds to support these endeavors. Many individuals without the resources to access telemedicine are left untreated for their mental health problems.

In precarious times like these, when treatments may not be available to all, community members can help one another stay positive. Maintaining a sense of calm around others can prevent people from getting excessively worried about something they cannot control. Parents can try to answer questions about the pandemic to their children and inform them of good news related to the pandemic. People can call elderly citizens to check in on them and talk to them to give them a sense of social interaction. When the pandemic is over, people can make sure to embrace healthcare workers back into the community, instead of keeping them distant because of the number of interactions they had with infected patients. Even though it may seem like the pandemic is an impossible situation to resolve at times, by working together, community members can help each other pull through.

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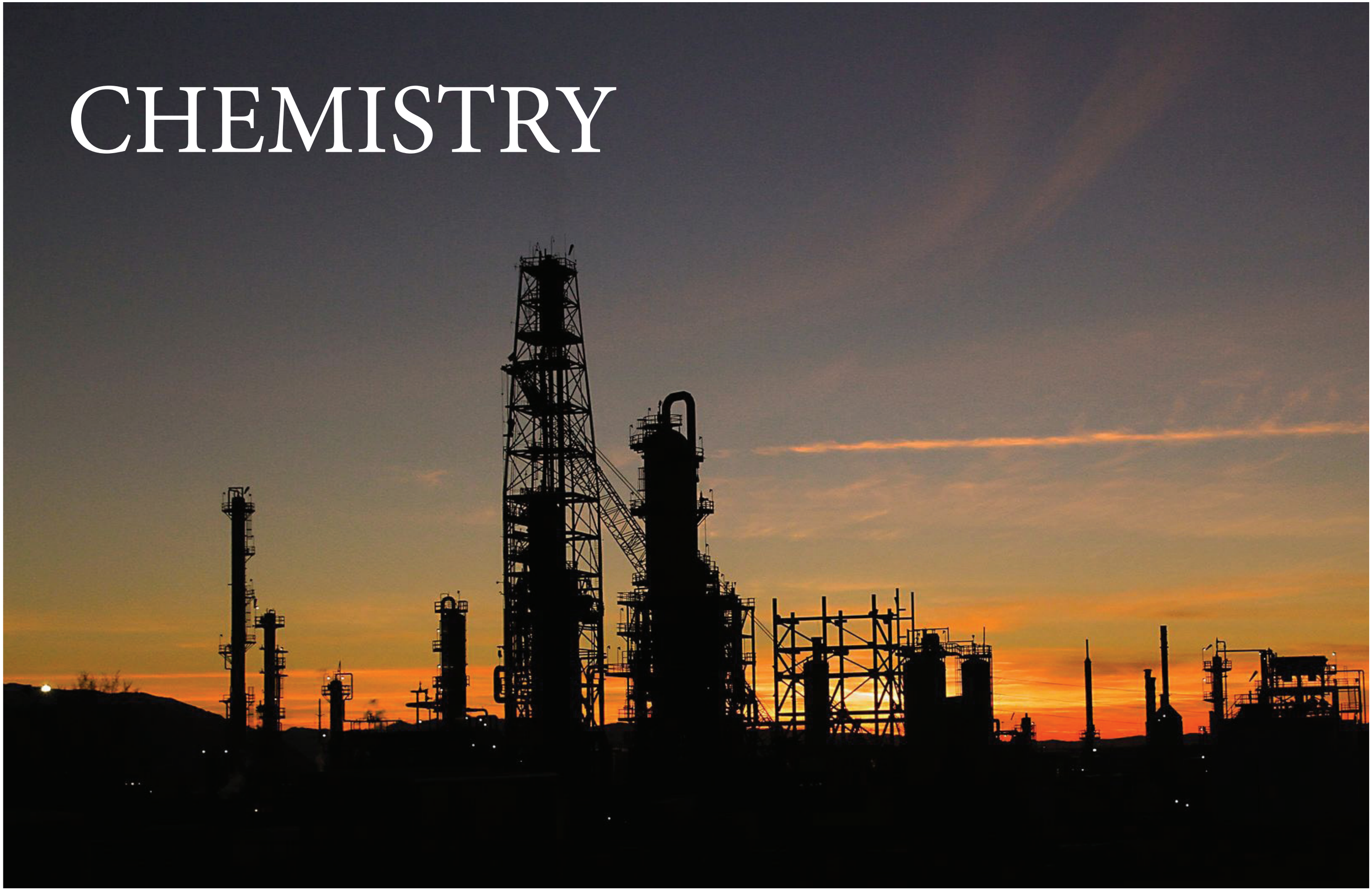
CHEMISTRY



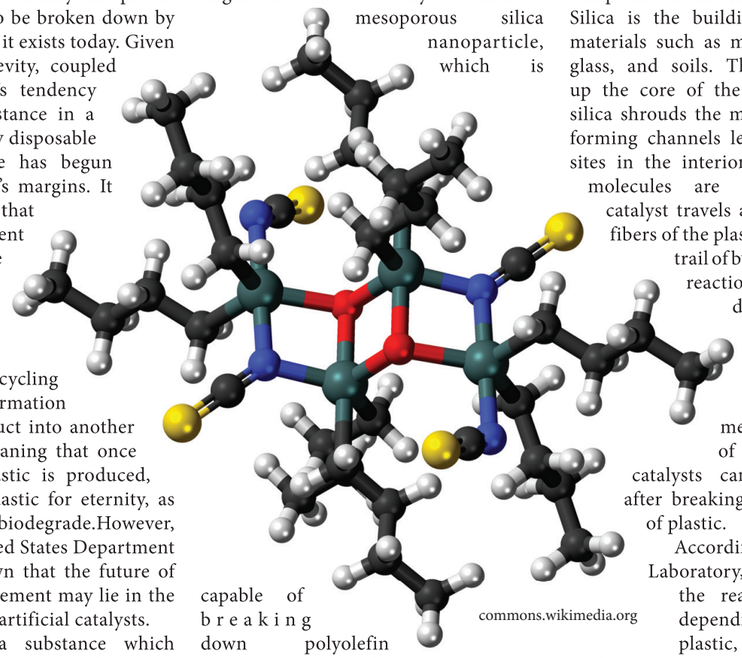
Laboratory-Developed Catalyst Can Break Down Plastics

Ryan Finlay
Staff Writer

There is no current scientific consensus on the amount of time required for plastics to naturally biodegrade. Potential answers to this mystery have varied from plastic taking several hundred years to decompose to the possibility that plastic is simply not able to be broken down by the natural world as it exists today. Given the material's longevity, coupled with the economy's tendency to market the substance in a single-use and easily disposable form, plastic waste has begun to pile up in Earth's margins. It has become clear that recycling, in its present form, is inadequate for handling the sheer scale of plastic waste being created. Currently, plastic recycling entails the transformation of one plastic product into another plastic product, meaning that once any amount of plastic is produced, it will remain as plastic for eternity, as long as it does not biodegrade.However, research at the United States Department of Energy has shown that the future of plastic waste management may lie in the mass production of artificial catalysts.

A catalyst is a substance which performs catalysis, the process of speeding up chemical processes by decreasing the amount of energy required for the reactants (the beginning components of a specific chemical process) to react with one another. In some cases, they facilitate reactions at temperatures or other varying conditions where they might not otherwise be possible, as in the case of plastics.

At the Department of Energy's Ames Laboratory, scientist Wenyu Huang was able to use nanoparticle technology to engineer a catalyst called a mesoporous silica nanoparticle, which is capable of breaking down polyolefin plastic. Polyolefin plastic, produced from petroleum products including crude oil and natural gas, is the most common type of plastic due to its recognized versatility. It is composed of two subgroups: polyethylene and polypropylene plastic. These two types can be found in a wide array of everyday products ranging from grocery bags to food containers.



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The catalyst itself is composed of platinum and silica. Silica, also known as quartz, is among the most common compounds found in Earth's outer crust. Silica is the building block for basic materials such as minerals, rock, sand, glass, and soils. The platinum makes up the core of the catalyst, while the silica shrouds the metal with structures forming channels leading to the active sites in the interior, where the plastic molecules are disassembled. The catalyst travels along the individual fibers of the plastic, leaving behind a trail of byproducts. While the reaction may temporarily deform the catalyst, it will revert to its original form by the completion of each reaction, meaning that each of the manufactured catalysts cannot be expended after breaking down any amount of plastic.

According to the Ames Laboratory, the byproducts of the reaction, which vary depending on the type of plastic, may have practical applications. They could potentially be refined into fuels, solvents, or lubricating oils. If the new catalyst could be utilized on a large scale to repurpose plastic waste as other materials, a major roadblock for adequate plastic waste management would be removed.

Since the invention of modern plastics in the 1950s, 9.2 billion metric tons have been manufactured, every pound of which is still pilling up. As of 2018, 1 million plastic bottles were being consumed around the world every minute, the vast majority of which were not recycled. Less than 10% of plastic consumed in the United States is recycled, and 10-15% of what is delivered to American recycling centers is not actually recyclable. In addition, there is no market for recycled materials large enough to absorb the amount of material being recycled, meaning that the recycling industry is highly unstable and largely unprofitable. All of these factors indicate that without continued research into methods for breaking down existing plastic, the recycling industry will be unable to prevent the environmental catastrophe that untamed plastic production threatens.

In addition, plastic waste poses a particular danger to marine habitats. According to National Geographic, 8 million tons of plastic waste leeches into the ocean from coastal nations each year. A significant portion of this plastic will be broken into smaller and smaller pieces over time, becoming microplastics, measuring less than one-fifth of an inch wide. Many marine species consume microplastics, mistaking them for food. While the plastic pieces are often cycled through the body without substantial effect, it has been found that microplastics can build up marine animals' digestive systems, sometimes piercing through the flesh, other times causing starvation and death.

> "At the Department of Energy's Ames Laboratory, scientist Wenyu Huang was able to use nanoparticle technology to engineer a catalyst called a mesoporous silica nanoparticle, capable of breaking down polyolefin plastic."

The United States Department of Energy's research on plastic degrading catalysts is a vital step in the search for sustainable solutions to the world's plastic problem. The research will be continued under the Institute for Cooperative Upcycling of Plastics (iCOUP), an institute associated with the Ames Laboratory which draws upon resources from a series of other laboratories at other national scientific institutions and university departments. Hopefully, with continued development, the development of artificial catalysts can be perfected in order to replicate natural processes for a range of different purposes.

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Towards a **Green** Future:

Efficient Laser Technique to Convert Cellulose into Biofuel

Elias Romero
Staff Writer

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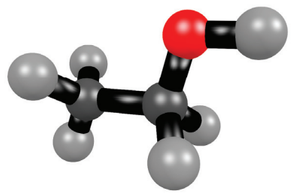
In June of 2020, ten researchers at the Tokyo University of Science in Japan developed a novel laser-based technique that can efficiently convert cellulose into biofuel. This new technique significantly aids global energy and fuel crises in light of the environmental problems caused by fossil fuels and climate change.

Cellulose is a molecule composed of carbon, hydrogen, and oxygen and is the main component found in plant cell walls to aid plants in remaining stiff and upright. This molecule is also very common in cotton and paper. As cellulose is constantly produced in plants, cellulose can be converted into simple sugars like glucose–a process called enzyme hydrolysis. From there, the simple sugars go through another fermentation process to be converted into bioethanol. Bioethanol is superior to other fuel sources in that it comes from renewable resources like crops and emits less greenhouse emissions.

This natural process, however, comes with many downsides as well. Converting cellulose into bioethanol is not time efficient, and it also emits some greenhouse gases, albeit in smaller amounts. The process requires very specific reaction conditions such as high temperature and high pressure, and it is difficult to perform in plants given that cellulose is not soluble in water due to its chemical composition



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> "To eliminate the emission of greenhouse gases as well as makemaking this process more efficient and easier, these ten researchers developed a new way to degrade cellulose molecules using laser technology."

and structure ($C_6H_{10}O_5$). Its strong crystalline structure makes it difficult for water to dissociate its atoms. To eliminate the emission of greenhouse gases as well as make this process more efficient, ten researchers developed a new way to degrade cellulose molecules using laser technology. This technique was based on a laser called the infrared-free electron laser–or IR-FEL–in which the laser's wavelength is in the range of three to twenty micrometers. The polymer of cellulose is composed of covalent bonds, which form between the molecule's carbon, hydrogen, and oxygen atoms. Cellulose has three infrared bands at wavelengths of 3.5, 7.2, and 9.1 micrometers.

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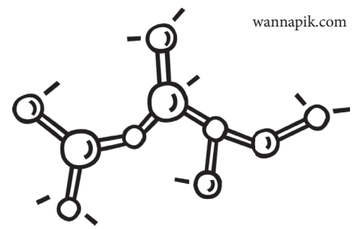

These correspond to different bonds in the polymer: C–H bonds, H–C–O bonds, and C–O bonds, respectively. What the laser does is expose the cellulose polymer to intense radiation by tuning the wavelength of the infrared-free electron laser to these three wavelengths.

Afterward, the products are analyzed using electrospray ionization spectrometry–a mass spectrometry technique commonly used to determine the molecular weights of macromolecules. This is a technique that produces ions, in which voltage is applied to a liquid to produce an aerosol-like substance. This method is applied to the cellulose molecules to confirm that they successfully decomposed into glucose and other simple sugars, which are precursors to making bioethanol. This new laser technique is the first in the world to efficiently decompose cellulose into glucose, and it is much better than the conventional natural process because it requires no specific reaction conditions.

So what does this mean for the world? The impactful thing that this new laser-based technology accomplishes is that it allows for more efficient transformations of cellulose into biofuels, so in the coming future, more biofuel-based projects and proposals can be expected. As was previously stated, bioethanol and other biofuels are significantly better for the environment than fossil fuels or fracking, as they come from crops and other plants, which can be planted frequently and renewed constantly, and are far less toxic since they emit little to no greenhouse gases. The transportation industry accounts for 22% of all greenhouse gas emissions; the use of biofuels instead of diesel in cars, trucks, boats, and buses, however,

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can create cleaner air environments in industrial cities. Some cars already run on a combination of 10% ethanol and 90% petrol; recent technological advancements are allowing some cars to run on 85% ethanol and 15% petrol. This method could also prove useful in processing certain types of wood and recycling forest biomass because as the fuel is used, the resulting waste is biodegradable, which means that

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as the fuel is expended, the waste can be disposed of anywhere and it will do no further harm to the environment. Cellulose itself is commonly used in paper, cotton, antibacterial sheets, and even as functional biomaterials such as cell membranes for different cells. This new efficiency of biofuel creation combined with the uses of cellulose provides opportunities in many industries–such as the healthcare, technology, and engineering industries to name a few–in operating biofuel refineries, distributing and marketing biofuels, and farming crops

> "This new efficiency of biofuel creation combined with the uses of cellulose provides opportunities in many industries in operating biofuel refineries, distributing and marketing biofuels, and farming crops solely for energy purposes."

solely for energy purposes. With this influx of biofuels also comes regulation of gas and fuel cost. Since biofuels are so common and available, consumers can expect minimal fluctuations in fuel prices.

In conclusion, while biofuels have not been utilized and taken advantage of as much in the past, thanks to new developing technologies, they will surely start to come to the forefront of many climate change and fuel conversations and concerns. So, the next time you're stuck at a gas station on a family trip or walking the streets of New York and smelling some crude gas, remember all of the advancements that are currently happening.

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PHYSICS

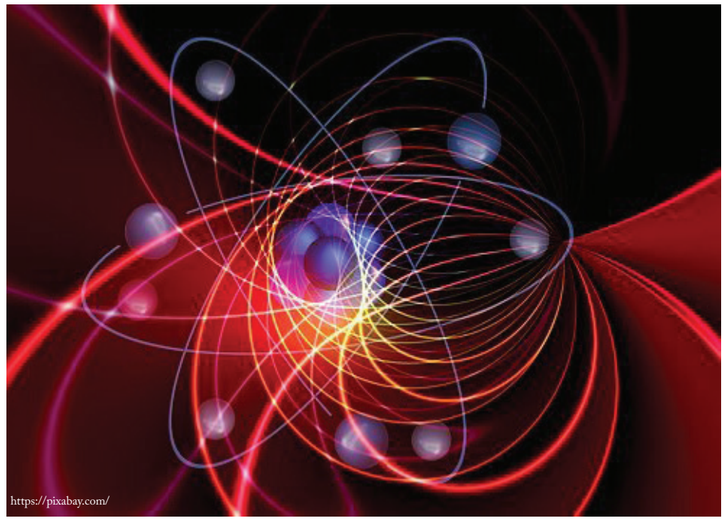
Axion Particle Solves Mysteries of the Universe

Purvi Jonnalagadda
Staff Writer

Did axions create the world? Created by physicists Roberto Peccei and Helen Quinn, an axion particle is a small hypothetical particle over a billion times lighter than a proton. Because axions are difficult to detect, researchers are yet to provide physical evidence of them. However, the existence of axions would answer three of the universe's mysteries: a property of quarks, the dark matter in the universe, and the reason why the universe contains much more matter than antimatter. Dark matter is a form of matter made up of particles that do not absorb or reflect light, making it undetectable. Additionally, antimatter is the essential opposite of matter. The idea of axions was first created to answer unknowns in the Standard Model, a theory that describes three of the four forces in the universe. The three forces that the model discusses are electromagnetism, which is a force between any charged particles, the weak force, which causes neutrons to break down, and the strong force, which causes the attraction between protons and neutrons.

The first problem that axions solved was the neutron problem. Neutrons, which have no charge, are made up of quarks, a type of smaller charged particles. Thus, neutrons are expected to interact with an electric field, but this is not the case. However, quarks do interact with electric fields, which creates a contradiction. So, physicists credited this anomaly to be caused by axions hindering the interaction between neutrons and electric fields, providing a solution to this conundrum.

Secondly, galaxies rotate at extremely high speeds and do not seem to have enough gravity or mass to hold themselves together; they should tear apart because there is not enough force to hold them together. However, the galaxies do stay intact, and this had confused physicists until the idea of axions emerged. With their observed mass, galaxies would not be able to rotate without breaking apart; essentially, they would need to have a greater mass. So, it seems that 85% of the galaxies' mass is not measured or detected. This undetectable mass was determined to be dark matter, a substance that can interact with matter through means of gravity and is thought to make up 80% of the universe, yet is not visible. Some people thought that axions were black matter, and researchers hypothesized that many axions in one place could assume the same behavior as dark matter and thus be called dark matter.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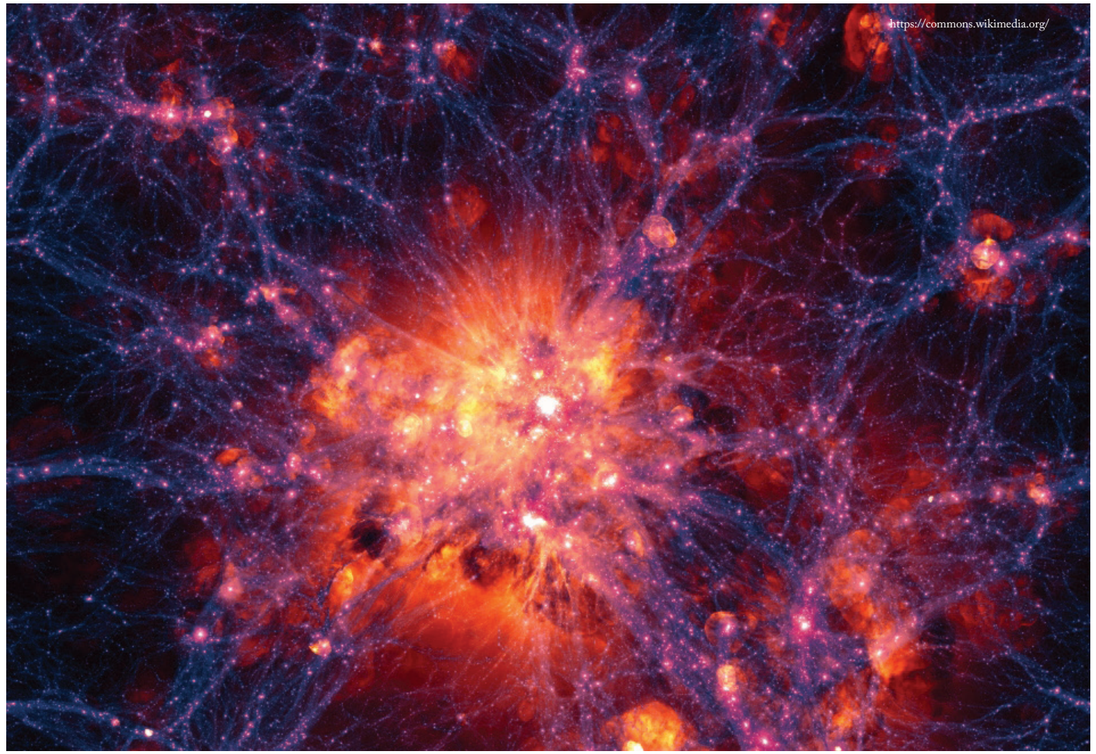
Regarding the third question, matter is anything that has mass and takes up space, and antimatter is essentially the opposite of matter, and its particles have opposite properties. For instance, antimatter particles have a reversed charge; antimatter contains anti-electrons, also called positrons, which act like electrons but have a positive charge. Likewise, anti-protons act like protons but have a negative charge. Antimatter was created after the Big Bang, along with matter, but is very rare. The Big Bang should have created an equal amount of matter and antimatter, and the Standard Model of particle physics said that the collision of matter and antimatter when the universe was created should have been destructive, and the earth, sun, galaxies, and humans should not have existed. The antimatter and matter were expected to annihilate each other. Physicists presented an idea called axiogenesis centered on the belief that the axions created more matter than antimatter so that when the two met, the world was created instead. More scientifically, it is suspected that the axion field essentially vibrated or moved, causing a slightly greater amount of matter than antimatter. As a result, instead of annihilating each other, the slightest amount of matter, enough to lead to the universe's creation, was left.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"The existence of axions would answer three of the universe's mysteries: a property of quarks, the dark matter in the universe, and the reason why the universe contains much more matter than antimatter."

All of these theories are just that, theories because axions are unconfirmed. However, physicists are using machines to interact with neutrons or electromagnetism. None of them have been detected, but researchers see this as positive since this reduces the range of masses that axions can be. If axions are found, they would instantaneously provide concrete evidence that supports all of the questions they are hypothesized to answer. They would also provide the grounds for further scientific discoveries and answer more fundamental physics questions. To answer these questions, it is important to know the origins of the universe, which would be further explained with axions. Without axions, humans, and the things that humans classify as life, may not exist. By proving the existence of axions, physicists could explore quarks, the existence of dark matter, and the creation of the universe more in-depth. This could then lead to additional abnormalities in scientific theories and thus more questions that need to be answered. Possibly, more particles like axions could be discovered to fill in these holes of questions physicists have pondered.

By starting with solving the mysteries of the universe, axions will possibly open up a gateway to more questions that need to be answered and more scientific opportunities. Although not proven to exist yet, axions have already had a significant impact on numerous physicists striving to prove their existence. These minute particles have drawn much interest to their subject and to physics just by physicists' hypotheses; with concrete evidence of axions, questions pondered over by many researchers for hundreds of years will finally have a definite answer.

Higgs Boson: The "God Particle"

Ayaan de Silva
Staff Writer

What are the building blocks of the universe? Is there something so small that it cannot be divided any further? For centuries, scientists have sought out the answers to these questions and possible explanations go as far back as 460 BC with Democritus' theory of the atom. Since then, human understanding of these questions has improved leaps and bounds and the current theory called the Standard Model suggests that the universe is made up of and governed by tiny particles, smaller than even the protons and neutrons that make up atoms. These particles are referred to as elementary particles and can be subdivided into two categories; firstly the Fermions. These are the particles that make up the protons and neutrons of the atoms that make up matter. The other type of elementary particles are called bosons or force-carrying particles. Bosons interact with matter to create either the strong nuclear force, the weak nuclear force, or electromagnetism depending on the particle. These forces, along with gravity, are referred to as the four fundamental forces that govern the universe.

For much of the 20th century, the Standard Model served as a solid and reasonable explanation for elementary particles. However, in the 1970s, physicists ran into a problem. According to their equations, certain bosons should be massless but they knew that some of these bosons did in fact have mass. This created a gaping hole in their theory that needed to be addressed. To solve this issue, three physicists, Peter Higgs and Robert Brout, and François Englert created a theory. They asserted that an invisible field, now called the Higgs field, pervades the whole universe. Elementary particles then interact with this field to different extents in order to gain mass. One can think of this field as a body of water in which a barracuda swims. Because of the barracuda's streamlined nature, it will glide easily through the water facing little resistance. As such the barracuda would be akin to a low mass particle that does not interact with the Higgs field. On the other hand, if one were to drag an open umbrella through the water, due to its large surface area the umbrella would face more resistance when gliding through the water. Because it interacts more with the water, the umbrella would be similar to a heavy particle. The Higgs boson, sometimes referred to as the God particle, is a physical excitation of this field. Using the water analogy, if two objects submerged in the water were to collide, it would create ripples in the water, and these ripples would be analogous to the Higgs boson. Higgs' theory would suggest that mass is not an inherent property of matter but rather something acquired through interaction with an external field. Using this definition of mass, the equations fall into place because the bosons can be thought of as inherently massless but physicists also have an explanation as to why the particles have mass.

Although it was initially scoffed at, Higgs' theory was revolutionary and over time, physicists grew to accept it and it became an integral part of the Standard Model even

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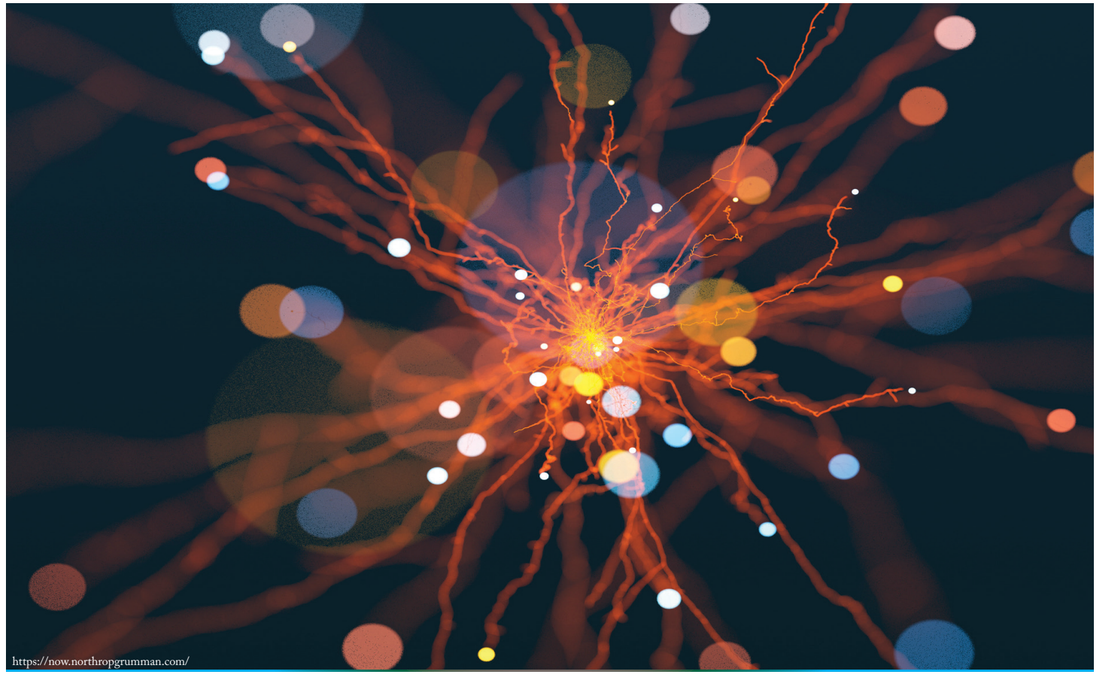

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though it had yet to be proven experimentally. The problem with this is that many things can make sense in theory but not exist in reality. Unless a theory can be supported by concrete data and evidence, it is hard to assert it as reality.

That's where the Large Hadron Collider (LHC) comes into play. Spanning 17 miles, the LHC acts as a racetrack of sorts where particles are fired at high speeds and then collide with one another. The theory was that if the Higgs field was real, then these high-speed collisions would create massive amounts of energy which would, in theory, create disturbances in the Higgs field, resulting in a Higgs boson. The Higgs boson is theorized to be highly unstable, meaning that it will decay almost instantaneously. As such the scientist would need to study the resulting particles and their properties to determine if they came from a Higgs boson. On July 4th, 2012 after analyzing the data found from the LHC, it was announced that the Higgs Boson had been found.

> "It is theorized that once scientists better understand the Higgs Boson, they may be able to influence how a particle interacts with the Higgs field and thus affect the mass of the particle and the material it comprises."

Since its initial discovery in 2012, physicists have been studying the Higgs boson trying to discern more of its properties to better understand it. The hope is that by understanding the Higgs boson these physicists can better understand other unknowns of physics that interact with the Higgs boson, such as dark matter. Physicists know that dark matter must exist, but they are currently unable to detect it. They believe, however, that dark matter should interact with the Higgs field and as such by observing the Higgs field they can detect dark matter. Additionally, it is theorized that once scientists better understand the Higgs boson, they may be able to influence how a particle interacts with the Higgs field and thus affect the mass of the particle and the material it comprises. This would have astounding implications in the world of engineering because if it is possible to manipulate the mass of something, it would then be possible to increase the density of something, making it more durable or making vehicles lighter and faster without having to use lighter materials. The Higgs boson is a relatively new discovery and scientists are constantly learning more about it, which will ultimately help them gain a new piece in the puzzle that is the universe.

> "Since its initial discovery in 2012, physicists have been studying the Higgs boson trying to discern more of its properties to better understand it."

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