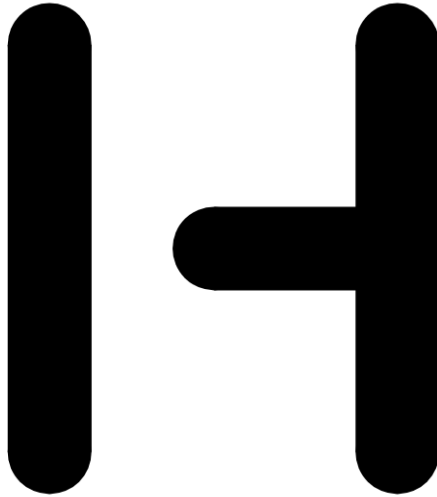


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AN IMSA EDITORIAL

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THE IMPACT OF A SIP OF COFFEE

By: Erin Yoo



Figure 1
The steps of coffee production.
Source: [[Coffee Bean Corral](#)]

Each morning, my dad would prepare a cup of coffee in his Thermos to take to work. It is a decades-old habit, as steady as the sun rising and setting, that he shares with billions of other people around the world (Okafor, 2021). Although people only drink a small cup of coffee each day, the portions add up to a lot over a long time. Consumer demand for coffee has increased over the last few decades, resulting in producers scrambling to find more efficient methods to grow and harvest coffee beans – methods that have come at the cost of the environment.

Figure 2
Top coffee producers of the world.
Source: [[Visual Capitalist](#)]



How Coffee is Made

Coffee travels a long way before making it into Starbucks cups and thermoses, as seen in Figure 1. Its journey starts with local farmers in coffee-producing countries like Brazil and Colombia (see Figure 2) who plant and harvest coffee crops. On the plants are coffee cherries, which house the actual coffee beans that turn into liquid coffee. The outer pulp of the cherries must be removed and fermented until only the beans are left to dry (Moore 2021). From there, the beans are roasted and ground to create the beloved drink.

Environmental Impact of Coffee Production

The coffee industry has a significant environmental impact due to its sheer size and the inherent environmentally invasive nature of agriculture. Perhaps the most obvious place of improvement of coffee consumption is switching away from disposable single-use plastic cups, filters, and coffee pods. However, plastic pollution is far from the main impact of coffee production. In fact, most carbon emissions from the industry come not from the consumption aspect but cultivation of crops (Okafor 2021).

Coffee plants grow in tropical and subtropical climate which are delicate ecosystems (Okafor 2021, Moore 2021). This means that over planting coffee plants can have dramatic effects on the

INFOGRAPHIC: SHADE-GROWN COFFEE



Figure 3

A comparison of sun cultivation and shade cultivation of coffee.

Source: [[Sustainable Business Toolkit](#)]

ecosystem and the other communities that live within it. Until the 1970s, coffee was usually grown in the shade of tree canopies which is considered to be relatively eco-friendly. In fact, the head of Rainforest Alliance, a conservation organization, considers shaded coffee farms to be “the next best thing to rainforests” (Okafor 2021).

However, a new technique was developed in the late twentieth century to meet growing market demand for coffee, known as sun-cultivation. This method involves clearing land to plant coffee crops directly under the sun which has a higher agricultural yield than the traditional method (Okafor 2021). In other words, it takes less land and labor to harvest more coffee beans using this

technique. Just a little over a decade ago, a study found that over 75% of coffee farms in Brazil and Vietnam, some of the largest coffee producers in the world, used sun-cultivation (Okafor 2021).

The effects of this more intensive agricultural process include deforestation, soil degradation, habitat loss, and pollution. For instance, 37 out of the top 50 countries (74%) with the highest deforestation rates are major coffee producers (Okafor 2021). In addition, the new method decreases biodiversity, since the only crops on sun-cultivation farms are coffee plants, and reduces soil quality. The lack of tree cover also facilitates soil erosion. As a result, some estimates suggest that although the

method is efficient now, *half* of all coffee-producing land will be unproductive by 2050 (Okafor 2021).

Sun-cultivation also makes it easier for pests to invade crops which forces farmers to increase

causes eutrophication which damages marine life by taking away oxygen. (Okafor 2021). except for the beans, like the pulp and residual matter, are thrown away (see Figure 4). This waste gets thrown into rivers, which

to communities (Okafor 2021). Of course, the consumer side of the multibillion coffee industry also results in waste and thus environmental harm through the use of single-use plastic and electric brewing machines (Okafor 2021). One study done by a natural resource institute in Finland found that coffee waste is the third largest category of household waste (Okafor 2021). Although one solution to the plastic problem is using recyclable cups, the technology needed to recycle plastic is not widely available so a significant portion of recycled cups still end up in landfills (Okafor 2021). The damage inflicted by the coffee industry onto the climate then makes it harder to grow coffee. Put simply, sun-cultivation and other unsustainable practices mean coffee producers and companies are harming themselves in the long run.

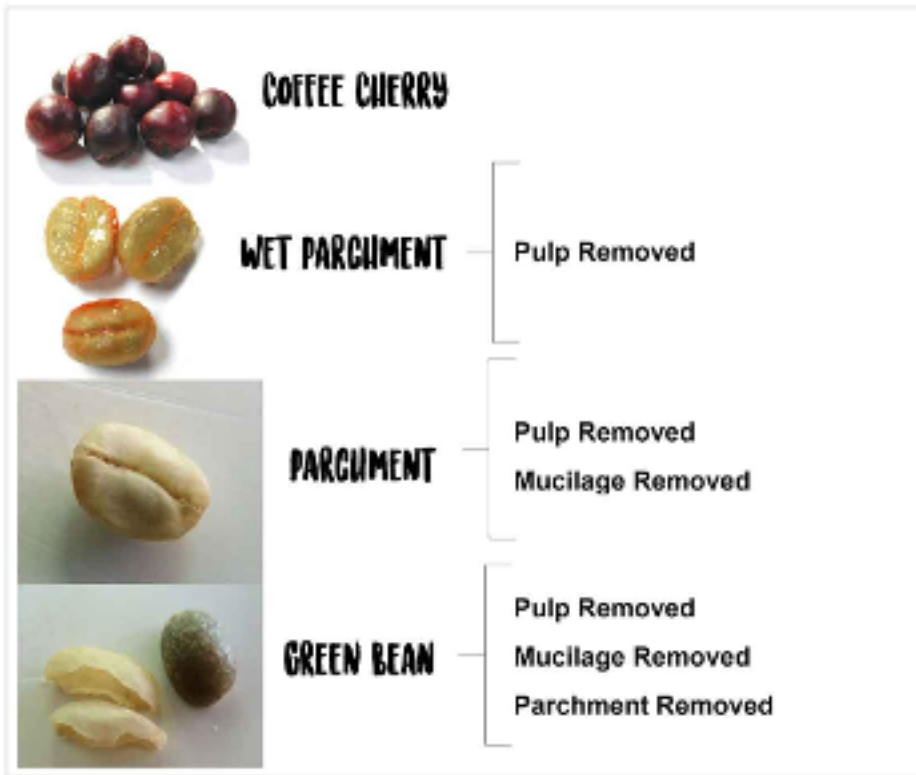


Figure 4

The stages from coffee cherry to coffee bean.

Source: [\[The Coffee Blog\]](#)

their use of pesticides and fertilizers. These chemicals then make their way to the air, soil, and groundwater and contaminate the environment (Okafor 2021). Further, enormous amounts of crops are wasted when coffee cherries are depulped to isolate the coffee beans because everything except for the beans, like the pulp and residual matter, are thrown away (see Figure 4). This waste gets thrown into rivers, which

causes eutrophication which damages marine life by taking away oxygen. (Okafor 2021).

Coffee can even pollute waterways after consumption. When coffee grounds are thrown away, caffeine can seep into the environment. Additionally, 2-3% of caffeine that a person consumes makes it into the sewage system. Afterward, water treatment facilities cannot completely filter out the pollutant before the water is returned back

Reimagining Coffee

One coffee startup based in Seattle, which is, interestingly enough, also where Starbucks was created, believes that there is no sustainable coffee-production method possible that can meet coffee's current demand (Giles 2021). Consequently, they reimagined the idea of coffee by replacing coffee beans with other ingredients. They aim to create coffee by using the pits, stems, and seeds of plants – parts which

are commonly discarded and ignored. They experimented with watermelon and sunflower seeds, for example, before finally landing on using date seeds (Atomo n.d., Giles 2021).

Their method uses 94% less water and results in 93% less carbon emissions compared to standard industry practices, as stated on their website (Atomo n.d.). With the innovation of companies like Atomo, the coffee industry can find more sustainable alternatives to meeting the high demand for coffee.

Conclusion

Although the coffee industry is responsible for soil erosion, deforestation, and lack of biodiversity, this doesn't mean that coffee production in its current form must be completely eliminated. It just means the current state of coffee production must be scaled back.

Oftentimes, calls for sustainable practices may seem like advocating for total reversal of existing systems, but that is not true. There are many benefits to the current coffee industry: mass employment, the preservation of an ancient Ethiopian drink, and the culture of cozy coffee shops and reliable morning routines. The same goes for other sectors like the fossil fuel industry. But, the point is that it is possible to both preserve current traditions and build a greener, more comfortable future. The world does not have to

entirely switch to Atomo coffee and forget other traditional breweries, but it's still important to encourage the creativity of such sustainability innovators. Without them, we'd eventually run out of coffee.



Figure 5

Atomo coffee products (not available for purchase yet).

Source: [[Atomo Coffee](#)]

ANY BRIGHT IDEAS ABOUT SONOLUMINESCENCE?

By Guatham Anne

The mantis shrimp is a crustacean that is well known for its unique hunting ability. They snap their claws 50 mph, with roughly the same acceleration of a 22-caliber bullet, causing water to travel at such high speeds that it “cavitates”. Cavitation occurs when liquids under negative pressure are pulled apart into bubbles of vapor. Over a very short time period, on the order of 100 picoseconds, the bubbles collapse and give off a loud snapping sound. Physicists are interested in studying other consequences of liquid cavitation – the production of small flashes of extremely bright light. They have yet to learn about why these flashes are generated.

What is liquid cavitation?

Liquid cavitation was first observed in 1934 by H. Frenzel and H. Schultes at the University of Cologne as an indirect result of wartime research on sonar radar. When water was subject to strong ultrasonic fields, it cavitates and produced clouds of flashing bubbles, now known as “multi-bubble sonoluminescence.” Scientists realized that this phenomenon can be reproduced in a laboratory with a fairly simple setup. The collapsing bubbles can



Figure 1

Source: *FactAnimal.com*

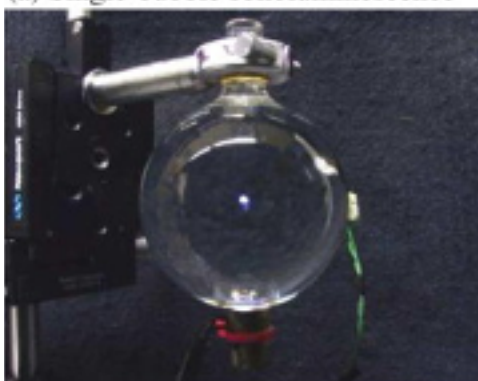
be created using sound waves, which are essentially molecules pushing and pulling apart from each other. If the intensity of these waves reach a certain threshold, the low pressure would be enough for the liquid to pull itself apart into vapor and cause cavitation bubbles. Under specific

conditions, the collapsing of the bubbles produces light even brighter than that produced by the mantis shrimps’ strikes.

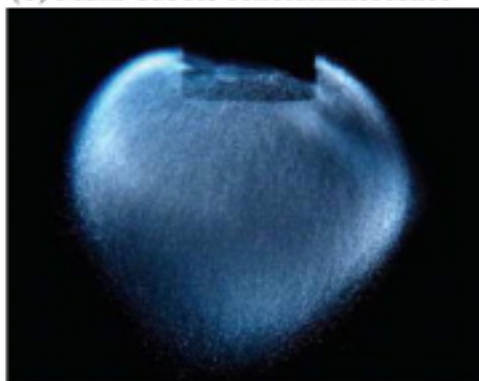
Figure 2

Source: *Science Direct*

(a) Single-bubble sonoluminescence



(b) Multi-bubble sonoluminescence



Surprisingly, these light flashes are extremely high-energy. The collapsing bubbles may heat up to 50,000 Kelvin - 10 times hotter than the surface temperature of the Sun! However, scientists have still yet to determine the cause behind these flashes of light.

Current Theories

There are numerous theories that attempt to explain the mechanism of sonoluminescence. Many of these can be categorized under either electrical or thermal processes.

The electrical processes describe the charge separation of the bubbles. That is, the bubbles are analogous to spherical capacitors, with charges at the center and along the bubble wall. Phenomena outside the scope of this article cause electric breakdown during the collapse phase. However, these theories assume that the bubbles collapse asymmetrically, since symmetric charge distributions do not radiate light.

Theories concerning themselves with the thermal energy of the bubble revolve around adiabatic bubble collapse. Adiabatic systems are those that do not gain or lose thermal energy during a process. This does not mean that the temperature of the bubbles remains constant, but rather that thermal energy is neither added nor subtracted from the bubble throughout its collapse. Specific details are beyond the scope of

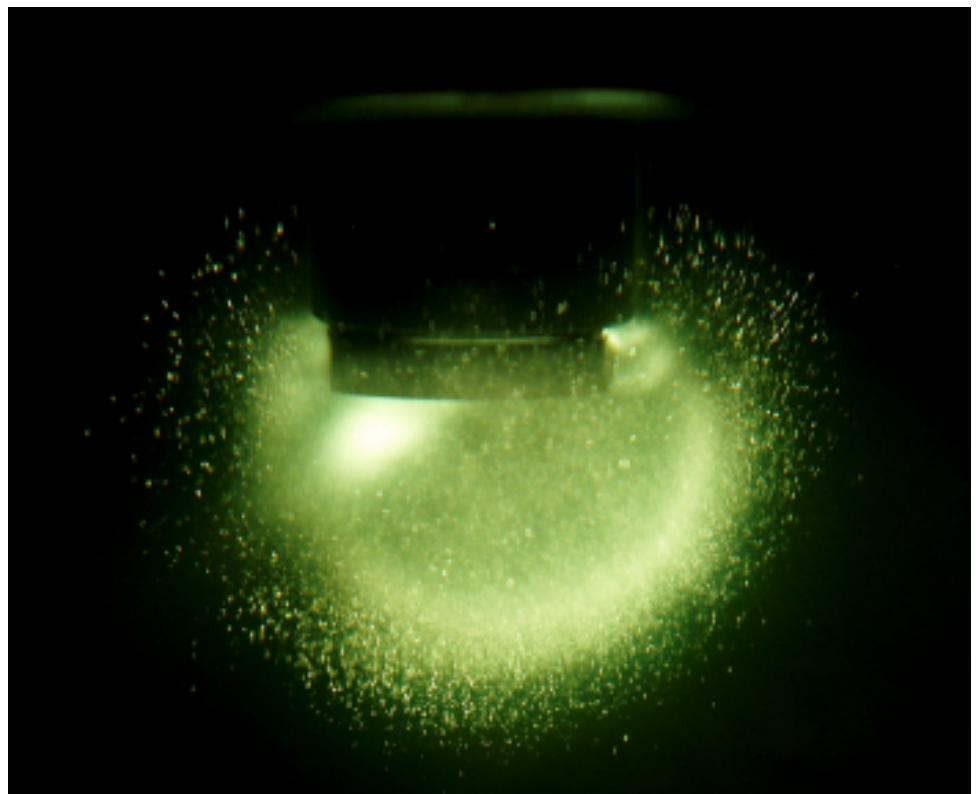
this article.

In opposition to the thermodynamics theory, a quantum mechanical theory proposed by Julian Schwinger received much popular attention. Similar to the production of Hawking Radiation from black holes, this theory suggests that the process in which the light is emitted is a result of the Casimir Effect. Essentially, the theory states that in a vacuum –similar to that of a negatively pressurized bubble – there exists virtual particles. The rapidly moving juncture between the water and the gas turns virtual photons to real ones. However, a shortcoming to this theory is that critics argue that sonoluminescence releases too

much energy in a short timeframe to be accurately described by the vacuum energy explanation.

The production of great amounts of heat and light in sonoluminescence tends to lead the discussion to a particular topic of interest to scientists: nuclear fusion. During the collapse of the bubble, the vapor inside heats up rapidly and produces a flash of light. Naturally, one would suspect that nuclear fusion might have been induced. However, this idea was quickly dispelled. Work by Yuri Didenko and Kenneth Suslick at the University of Illinois showed that endothermic reactions (absorption of heat) during the cavitation process would prevent the temperatures inside the bubble

Figure 3
Collapsing Bubble
Source: *Nature*



to reach the necessary amount for nuclear fusion.

An Obstacle with Models

A major obstacle preventing breakthroughs in research behind the sonoluminescence mechanism is the method of measuring the interior of bubbles. Currently, the most crucial measurements, like temperature and pressure, are indirectly measured through models of bubble dynamics mainly due to the short lifespan of the bubbles. Bubble dynamics models were made using 5 major assumptions: bubbles remained spherical, the contents of bubbles obey the ideal gas law, the internal pressure of bubbles remained uniform, and evaporation and condensation were not present within the bubble. The fifth assumption pertains to the thermodynamic properties of the bubbles.

Conclusion

Cavitation is a process that is still barely understood, even given the tools of the modern age. This is due to the lack of experimental evidence that can back up certain theories, since it is difficult to take measurements of the heat and intensity of light produced from the collapsing bubbles. Resorting to models is currently researchers' only methodology of observing how sonoluminescence occurs. However, we are in an era where one can buy a sonoluminescence kit online for low prices (www.sonoluminescence.com).

Or, we could also adopt a pet mantis shrimp. Either way, the simple setup of the phenomenon is quite unlike the complex concepts that understanding sonoluminescence requires.

MUSIC, MEMORY, AND THE BRAIN

By Dorrie Peters

Music is a defining factor of society, from its role as an expression of creativity to its connection to popular culture. Music has the ability to influence a person's mood and incite strong emotions. Beyond this, research is continually revealing music's role in human health and the brain. Specifically, music can have mysterious impacts on memory. Patients suffering from various forms of chronic dementia have shown miraculous improvements when exposed to carefully chosen pieces of music. This so-called 'music therapy' has been largely more successful than other forms of treatment such as traditional therapy or medication, begging the following question: why does music have such a prolific effect on the human brain?

Degenerative Neurological Conditions

Alzheimer's disease is one of the most common forms of senile dementia, a group of conditions characterized by the loss of memory with age. When affected by Alzheimer's disease, vital neural connections in the brain are destroyed, resulting in confusion, mood irregularities, and the overall decay of important brain functions. Additionally, the destruction of neural networks is irreversible, meaning that

Alzheimer's is an incurable disease.

one specific protein, Amyloid beta, in the brain that is partially

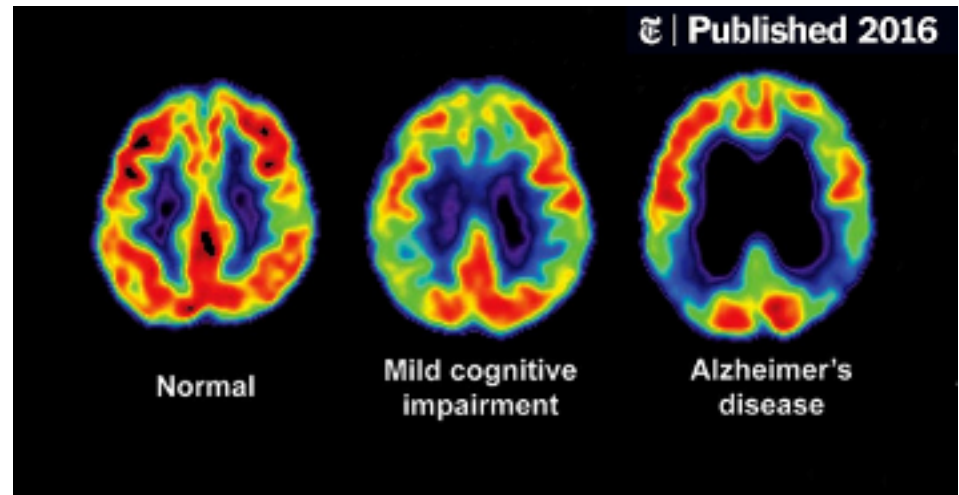


Figure 1

Less activity is visible in the Alzheimer's brain because of fewer neural connections

Source: *New York Times*

Alzheimer's disease is a direct result of protein-buildup in the brain that comes with age, but scientists have speculated that other underlying factors may relate to the development of this condition. Although it is still under investigation, some believe there to be other variables such as genetics and lifestyle choices.

Common Treatments

Alzheimer's is incurable, but that does not mean it is untreatable. Temporary aids to dementia disorders do exist, including the use of drugs and therapies. Aducanumab, a human antibody medication, is currently the only approved drug on the market for Alzheimer's disease. This antibody functions by targeting

responsible for plaque buildup and eventual memory loss.

Amyloid beta plaques breaking down vital neural connections

Source: Juan Gaertner

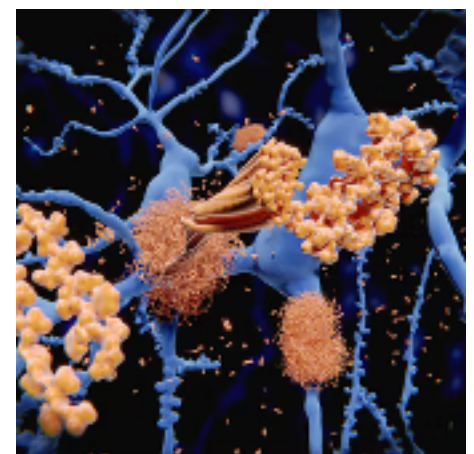




Figure 2

A dementia patient enjoying the benefits of music therapy

Source: The Center for Applied Neuroaesthetics

By removing this protein, the Aducanumab medication can slow the progression of an individual's Alzheimer's disease. However, this medication cannot completely halt or reverse the degradation of a person's neural pathways, meaning it is neither a cure nor permanent solution. It is also important to note that Aducanumab treatment can have dangerous side effects. Risks of using the drug include brain swelling and internal bleeding, both of which are serious medical issues. Furthermore, Aducanumab is mainly effective very early on in the development of dementia, meaning that patients with more developed cases will likely have little use for it.

Music Therapy

A safer and more effective form of Alzheimer's treatment is music therapy, a form of dementia aid that many scientists have yet to fully understand. When exposed to music that holds strong emotional weight, studies show that Alzheimer's patients have improved memory retention, mood, and behavior. This could include popular music from a person's childhood or music they associate with important memories. While an initial assumption may be that the music's calming qualities caused patients to become less distressed, a closer look at music's effects on the brain tells another story.

Music is known to connect distant components of the brain. Among other things, the brain uses the nucleus accumbens, the amygdala,

and the cerebellum to process and listen to music. While these regions are not adjacent in the brain, listening to music forms new neural connections between them.

The neural relation between Alzheimer's and music therapy lies in these brain connections. Whereas Alzheimer's disease breaks down neural pathways, listening to music creates and strengthens neural pathways. This form of treatment has no negative side effects and is accompanied by the joy and inspiring qualities that music holds. Additionally, it is much more effective in later stages of dementia when compared to pharmaceutical drugs. When examining all these benefits as a whole, it is clear that music therapy could be a formidable addition or even replacement to traditional Alzheimer's treatment.

Conclusion

Music therapy, while still mysterious in its scientific basis, can be far more safe and effective in treating dementia than traditional drugs. By strengthening pre-existing bonds in the brain and forging new pathways, listening to music can counteract the destructive qualities of brain plaque like Amyloid beta.

CLIMATE CHANGE SOON TO BE A THING OF THE PAST?

By Colin Ward

Climate change is undoubtedly among the most prominent issues facing humanity in the 21st century, as its effects appear to be potentially devastating and inevitable. Many different solutions have been attempted, such as reducing emissions and planting millions of trees, but none have yet seen results that could change the course of humanity. A company by the name of Carbfix may have just found a solution: they have begun injecting carbon dioxide saturated water into specific underground rock formations, which given just a couple of years, nearly completely converts the carbon dioxide into a stable form that will last for thousands of years. Given the proper scaling, their technology and methods could prevent a large-scale calamity from even occurring in the first place.

The Process

Carbon can be found in incredible quantities within everyday rocks, and the process of storing it in a rock form is a natural one. By using water saturated with carbon dioxide, the carbon can be absorbed into the rock, reacting to form solids like calcium carbonate. This process is naturally very slow, as it relies on the acidity of the water to dissolve

the rock around it, and allow materials to be freed up to react with the carbon. In nature, carbon dioxide is dissolved into water at a relatively slow rate, meaning that it is uncommon to find extremely acidic groundwater.

Scientists working with Carbfix attempted to accelerate this process. By increasing the amount of carbon dioxide stored within the water and using an ideal type of rock, they were able to greatly reduce the amount of time necessary for the mineralization of the carbon dioxide down to just two years. Increasing the quantity of carbon causes the water to become more acidic, meaning that the rock can be dissolved more quickly, therefore accelerating the rate of mineralization. This increase of carbon dioxide takes the form of carbonated water,

which is much richer in carbon dioxide than normal water, and is similar to sparkling water or soda. By injecting the carbonated water into rock formations like basalt, scientists were able to further increase the mineralization rate by providing an environment full of the elements needed for the reaction, while also providing more surface area upon which mineralization can take place, as basalt tends to be fractured and porous.

Scalability

There are three necessary ingredients for the Carbfix process: carbon dioxide, water, and basalt or another similar rock formation. There is certainly no shortage of carbon dioxide for the company to work with, but the

Figure 1

A diagram of the Carbfix process

Source: Carbfix



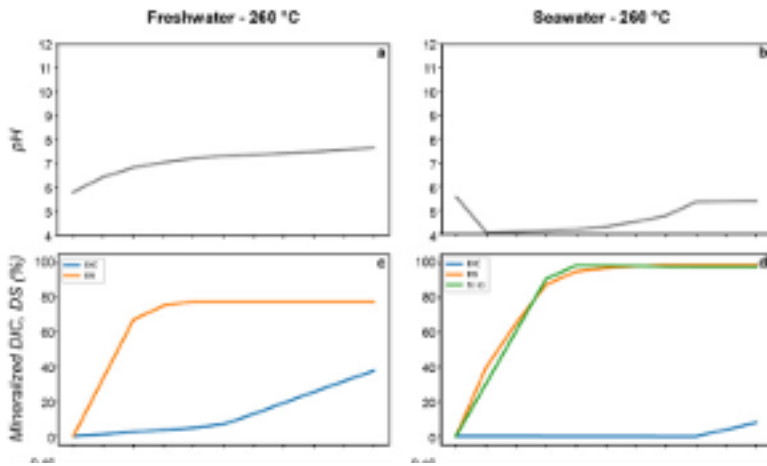


Figure 2

Graphs depicting the pH and corresponding mineralization percentage associated with salt water and fresh water

Source: *International Journal of Greenhouse Gas Control*

water and rock is a different story.

As of yet, Carbfix has used only fresh water for the conversion process, but are researching the viability of salt water utilization. Although they haven't conducted much research yet, the knowledge they have suggests that when salt water mixes with carbon dioxide, it becomes more acidic, releasing more reactants into the water and increasing the mineralization percentage over the same period of time. They will be attempting a demonstration of this process this year, and if it goes well, it would make the process much easier and accessible around the world.

Conclusion

While in its current state Carbfix's technology is impressive, given their research on the use of salt water in the carbon dioxide storage process, the effectiveness of the technology, and the extreme scalability that is

possible, this company could very well provide our planet with a solution to climate change. While it certainly isn't the only option, it has the potential to be the best, and is definitely something to keep an eye on.

Figure 3

A map displaying the areas that have basalt in quantities great enough for Carbfix's technology to function

Source: *Carbfix*



NON-FUNGIBLE TOKENS

By Avyay Duggirala

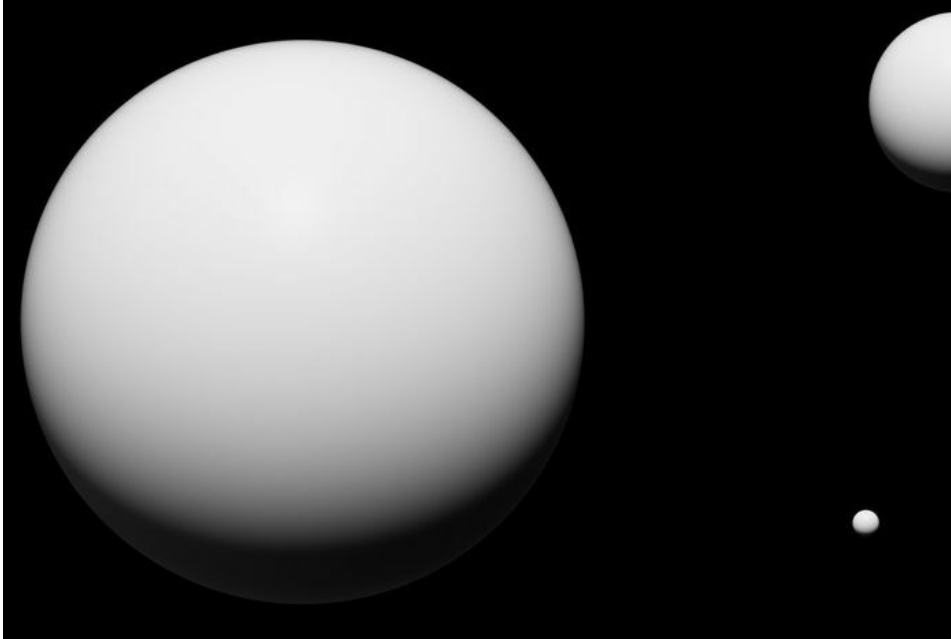


Figure 1

Image mentioned that sold for 91.8 million dollars

Source: *Barrons News*

A random computer generated picture of a white planet just sold for 91.8 million dollars. Now you may be thinking: how could that be possible? Well, this event is achievable due to the recent boom in the popularity of non-fungible tokens, better known as NFTs. These seemingly simple pieces of art are being sold for millions of dollars, and you can very easily create your own “collection.” The process to understand and start trading on the NFT market is extremely confusing, but it can be broken down into the artwork, blockchain and transaction.

Artwork

The first and most important

piece of any NFT is the artwork. NFTs are essentially just pieces of digital artwork that are often linked to physical things. An NFT often works like a picture, where the rights over the picture are sold, with the price varying based on the content and demand for that image. For example, a picture of something basic, like a tree, would sell for much cheaper compared to a rare picture of a sun exploding. The nature of how NFTs are valued is often based on the originality of the artwork. Some NFTs offer benefits along with the artwork, and these NFTs can be thought of as tickets. In fact it could be an actual ticket, like the Bored Ape Yacht Club, where

owning a bored ape invites you onto a private yacht. The more affordable NFTs often give you benefits like a special character in a video game or a discount at certain stores. Each NFT is valued on a variety of things, which is part of the reason why their prices are so volatile.

Due to the growing presence of NFTs, this has proved to be a great opportunity for hundreds of artists. NFT markets essentially serve as digital auction houses for the artwork of these artists, bolstering their career and giving them a solid start. This boom has incentivized hundreds of people to recruit artists and create huge NFT projects with the hope of them all being highly valued.

Blockchain

A blockchain is essentially a database that is shared among computer networks that is extremely safe and secure. Blockchain is so popular among crypto currencies because it creates a safe record without the need for a third party, meaning any transaction done through the blockchain is extremely secure. The reason why blockchain is so sought after is due to its difference in structure when compared to a traditional data table. Unlike the static, open, and non-linear structure of a datatable, a blockchain splits up the data given

into “blocks.” These blocks are filled with data, and once filled, the block will close and link itself to the previously closed blocks. This sequence is where the chain in the term “blockchain” comes from. Blockchain is very secure because as soon as a block is filled up, it is closed away from editing forever through cryptography, creating a chronological chain of secured blocks of data. This system of blocks allows for a system where no one person has control to hide or remove transactions from the blockchain. Blockchains are growing in popularity as well as applications, and as time progresses, blockchains will likely be used on a far larger scale.

Blockchains are important to NFTs because all NFT transactions are recorded through them, meaning if anyone buys or sells an NFT, you can tell who bought or sold it. This transparency is vital to NFTs to ensure that they aren’t stolen, and that they are legitimate and one-of-a-kind. This process is also why you can’t just screenshot an NFT and claim to own it, because the blockchain will prove you really don’t own the image or artwork. Thus, blockchain is vital to the validity of NFTs, much like a certificate of authenticity for any piece of art.

Transactions

The final step in understanding NFTs is comprehending the transactions involving them. NFTs

exist mostly on the Ethereum blockchain, which is the blockchain for a common cryptocurrency. On marketplaces using the blockchain, you can either list NFTs for sale or buy NFTs. These marketplaces could be websites or applications. If you decide to buy or sell an NFT, it creates a transaction which is then packaged onto a block. This block is then sent to all of the people involved in the transaction, typically two people. The purchase is then verified by both parties and added to the Ethereum blockchain. After the blockchain is updated, the new owner of an NFT is shown. This entire process is shown in Figure 3. NFTs are Non-Fungible, which means that

Conclusion

NFTs are becoming significantly more popular and widespread, making it increasingly important to understand the basis of NFTs. First is the artwork, which gives NFTs value and incentivizes artists to create NFTs. Second is the blockchain, the foundation that NFTs and all cryptos are built on. Finally, the transactions themselves are important to understand. Once all three are understood, the basics of NFTs are understood as well.

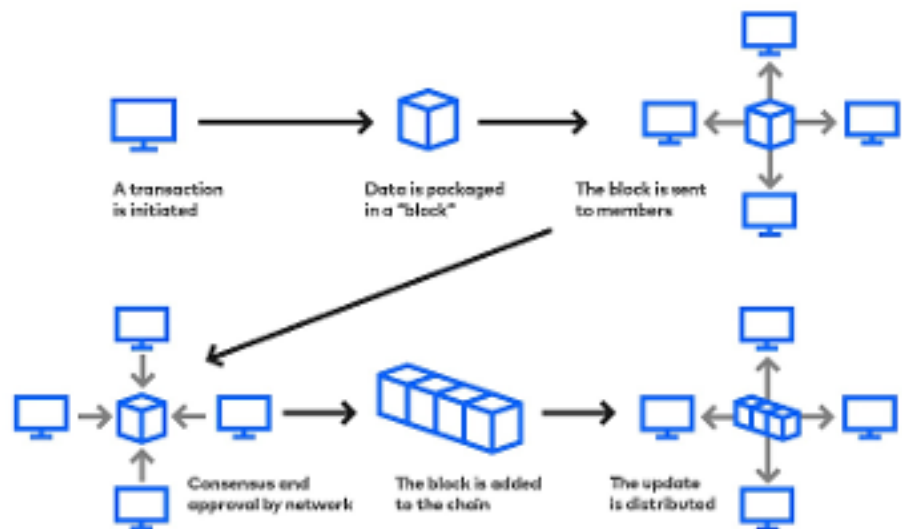


Figure 1

Steps taken during a transaction that lead to an addition in the blockchain

given NFT at a time. Because of this characteristic, once the transaction is complete, there will be one new owner of said NFT.

