JOLT MAGAZINE

Haverford's student-led STEM publication

ISSUE 2 – FALL 2022

FUSION: THE POWER OF A STAR BROUGHT TO EARTH

EXPLORING WIDESPREAD RACISM IN HEALTHCARE

EXCLUSIVE

RESEARCH FEATURES, INTERVIEWS & CROSSWORD

ON THE COVER:

I took this picture of plasma at the Large Plasma Device (LAPD) during my graduate dissertation at UCLA. This photo is from a more recent experiment where we studied rotation of the plasma as a means to improve confinement and reduce turbulence. It is important basic plasma work relevant to experimental fusion studies.

The photo is an axial view down the vacuum chamber during a plasma discharge through a window at the far end. The plasma is mostly a helium plasma — it is the purplish glow that you see. The bright spot in the center is the hot cathode. We pulse a voltage between the cathode and the anode, which causes a large beam of electrons to stream from the hot cathode and ionize the helium gas to make the plasma. The ovals around the edge are circular access ports. On the top, you can see two very faint sticks poking into the plasma. These are probes that are measuring the plasma density so we can get a 2D picture of the plasma.

It's quite hard to get a good picture, because the discharge lasts for less than a second. It took me about 40 attempts to finally get it right where it is bright enough to see the plasma, but not washed out by the bright hot cathode!

David Schaffner, PhD
Associate Professor and Chair of the Department of Physics at Bryn Mawr College

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EDITOR'S NOTE

Dear Reader,

At our first *Jolt* meeting of the year, we took time to reconnect with one another and share our summer experiences. From shadowing at hospitals to working at energy startups, our members explored different facets of the scientific community. These experiences became the jumping-off point for this semester's issue.

Jolt strives to be a space where students can pursue their interests, learn from their peers, and connect with researchers. Our second-ever print issue accomplishes these goals by delving into cutting edge developments in fusion energy technology and the many ways in which racism permeates healthcare. As you read, you'll learn how artificial intelligence, medical devices, and historical redlining practices contribute to widespread inequities in healthcare. You'll discover the past, present, and future of fusion energy, including exclusive interviews with plasma researchers at Bryn Mawr College and a leader of the Fusion Industry Association.

This issue embodies the collective knowledge and experiences of our members. I specifically want to thank advisors Celeste Cubbage, who spent the summer working at a fusion startup, and Sooyeon Jung, who is enthusiastic about improving equity in healthcare. Throughout the semester, they lent their expertise and passions to this magazine, encouraging their own teams of writers to inquire thoughtfully. This issue would not have been possible without them.

Our writers and editors have spent the semester learning about topics both new and familiar to them. Whether you are a seasoned professional, an aspiring scientist, or none of the above, I invite you to learn along with us.

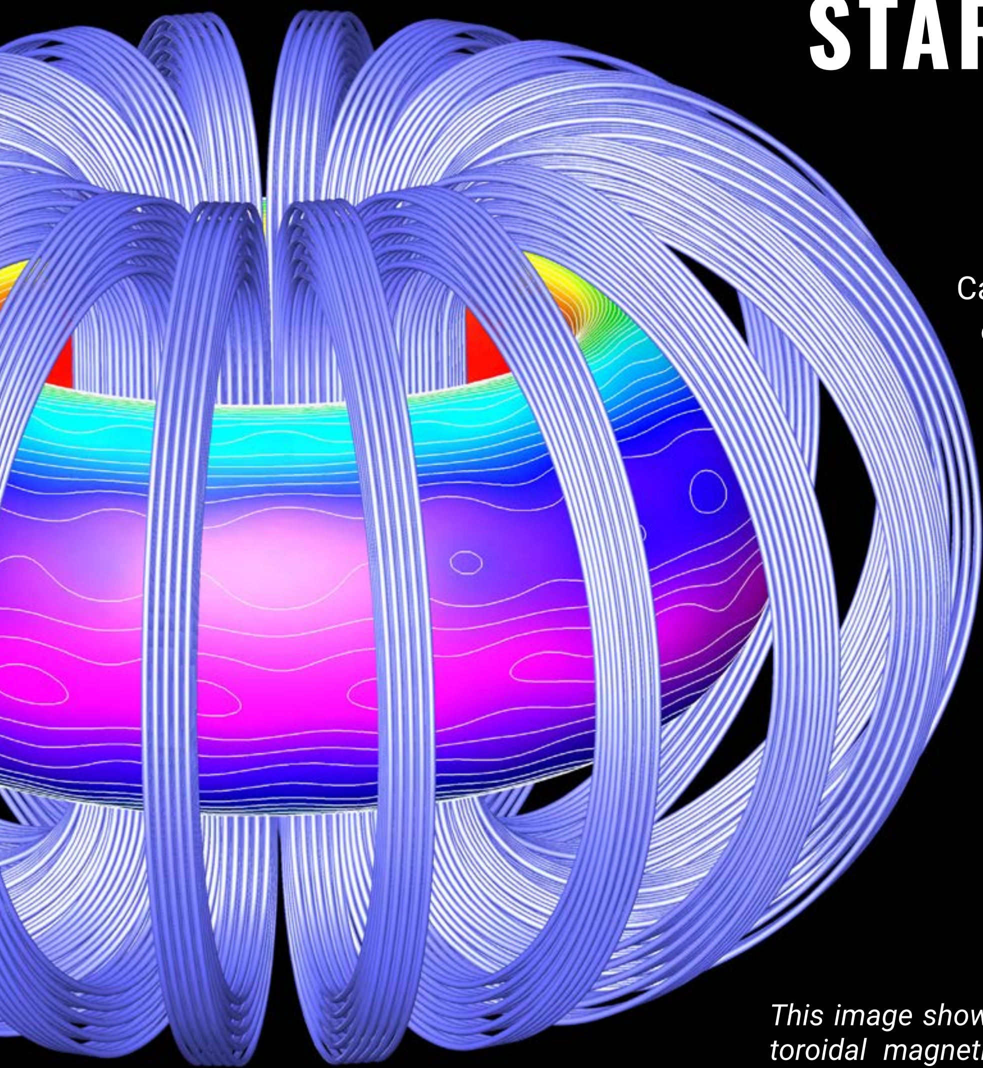
Emi Krish

EMI KRISHNAMURTHY

Print Editor and Co-Founder of *Jolt*

FUSION

THE POWER OF A STAR BROUGHT TO EARTH



Can we harness the power of the sun, and can it be a solution to our climate crisis? Scientists around the world are researching fusion as a new clean energy possibility. With recent advancements, fusion energy may become a reality in the next decade. Here's what you need to know.

This image shows the ITER plasma surface and its toroidal magnetic field coils. The color contours indicate local magnetic strength. Photo from the Oak Ridge National Laboratory in Tennessee (2009).

AN INTERVIEW WITH A FUSION PROFESSIONAL: ANDREW HOLLAND

Celeste Cubbage

With climate change looming, everyone is climbing aboard the clean energy train. Renewables like solar and wind are great options for the transition to net zero carbon emissions, but their current forms can't compete with the energy output of fossil fuels. That's why people are looking for alternative clean energy sources. One theoretically perfect solution is fusion energy.

To better understand fusion energy, I talked to Andrew Holland, CEO of Fusion Industry Association (FIA), the official trade organization for private fusion energy companies in the US and a touchpoint for the global industry.

WHAT IS FUSION ENERGY?

> **HOLLAND:** Fusion is the power of the sun brought to earth. It is taking light elements and combining them at very high temperatures and pressures to release energy. It's like Einstein's $E = mc^2$ brought to life.

Calling something "the power of the sun" may sound hyperbolic but it's actually true. Fusion constantly occurs in the sun as hydrogen atoms fuse into helium to keep it burning. The basics of fusion rely on Einstein's famous equation, $E = mc^2$, that says when mass is lost, energy is released. In the case of fusion, elements like hydrogen will have less mass after they fuse because helium has less binding energy than hydrogen. So, the energy from a fusion reaction is actually the binding energy from atoms being released as heat.

While fusion is a continual process in stars, it's harder to sustain on Earth. There are three main components, also known as The Lawson Criteria, required for fusion to occur: heat, pressure, and confinement time. For the past five decades, scientists have tried to meet these requirements by creating devices that contain plasmas, the fourth and hottest state of matter. While many have been able to spark fusion (with some scientists even creating fusion devices in their homes; Moynihan 2022), the race is on to be the first to achieve a net energy gain as early as 2030.

> "THE PROMISE IS UNBELIEVABLE, BUT THE SCIENTIFIC CHALLENGE IS REAL."
>
> *Andrew Holland*

WHAT, TO YOU, ARE THE MOST COMPELLING ASPECTS OF FUSION ENERGY?

HOLLAND: It's limitless, always-available energy. It changes the entire paradigm of energy from something that has to either be mined, drilled for, or dependent on local weather conditions to something you manufacture. The fuel sources are so abundant that there is no geographical limitation on where you could put fusion or how to deploy it; it simply is about how much fusion you can deploy and how fast. So, the promise is unbelievable, but the scientific challenge is real.

HOW WOULD YOU REASSURE A FUSION SKEPTIC?

HOLLAND: There is nothing to be wary about with fusion. As with any energy source, there are challenges that have to be dealt with. We have to make sure it's safe. We have to make sure it's non-polluting. With fusion, I am convinced this is the one we are looking for. It does produce, depending on the fuel source, various amounts of lightly radioactive waste — defined as low-level waste — which is easily disposed of in commercial facilities around the country. [The waste] can be buried under inches of dirt and safely put away that way.

The question of radioactive waste disposal is often discussed with fusion, even though it is predicted to produce amounts similar to hospitals. However, this misconception is in part due to fears around nuclear fission, which people often conflate with fusion. Fusion is a fundamentally different process from nuclear fission, with no risks of meltdown or long-lived nuclear waste.

HOLLAND: We make a mistake if we put fusion in the same box as nuclear fission. We have to compare fusion with not only nuclear, but all energy sources. When you see the whole life cycle impacts of every energy source, fusion ranks the lowest in terms of safety [concerns], pollution, and geopolitical impacts.

WHAT IS GENERATING THE BUZZ AROUND FUSION?

Fusion has been a topic of conversation for decades, but more articles are now appearing in mainstream news platforms like *The New York Times* and *The Washington Post* (Stanley, 2021; Verma, 2022).

HOLLAND: There are a few things that have brought us to this moment. A big driver is private investment. The fact that investors now see fusion as something you can make money off of in the timespan of an investment portfolio means that a significant amount of money is going into it. But, it is also scientific advances and advances in the materials — and the broader technology spectrum — that we see in every other field. The exponential advances that have led to the increased computing power of the phones in your pocket are being applied now to high science facilities like fusion. Through artificial intelligence, advanced manufacturing techniques, and simple things like HTS, new materials and processes will allow for exponential change within the plasma facility and the science of fusion.

Holland mentions one material in particular that has made a big difference for fusion research: high-temperature superconductors (HTS). HTS was first discovered in the 1980's by J. Georg Bednorz and K. Alexander Müller, awarded with the 1987 Nobel Prize in Physics for their discovery. HTS has unique superconducting abilities, or zero electrical resistance, at temperatures above zero kelvin. In recent years, scientists have realized that HTS can be used to make high performance electromagnets for fusion devices — a huge step forward for fusion design.

> **HOLLAND:** So, combine gains in science, gains in surrounding materials, private investment, and then finally the need. We are at the point now where the world needs this. The world needs always-on, always available, zero-carbon energy sources.

Holland is not the only person who sees the world's need for fusion. Governments around the world are starting to invest more time and money into fusion as a solution for climate change. In March of 2022, the US government hosted a historic event at the White House decaring a "Bold Decadal Vision for Fusion."

WHAT ARE SOME CRUCIAL STEPS BEFORE FUSION CAN REACH NET ZERO BY 2050?

> **HOLLAND:** It's moving fast. The next step — we're well past the first step — is called "proof of concept." These are machines that companies are building right now that will show that fusion works and is a potential energy source. They're our "Kitty Hawk moment": it's when you fly the airplane but you're not necessarily ready to sell the airplane yet. So, our companies are building those right now, and we'll be rapidly moving towards that moment in the next couple years. You should expect to see that headline "Kitty Hawk Moment" in the middle of the decade and then from there, we'll rapidly move into "pilot plants." This is something that produces power over enough of a length of time at a competitive cost. That's going to be a multi-year effort to show that fusion will be a viable market. Once those pilot plants are done then it's just selling as many as you can and just build, build, build. To meet the climate challenge we need to put out gigawatts of power every day; we need rapid full scale manufacturing capacity as fast as possible.

While it may be a few more years before we fully achieve the promise of fusion energy, it would be a game-changing source of energy for humanity and our climate. So, like Holland and many others, I will be keeping my eyes on fusion and waiting eagerly for this energy dream to come true.

A visit with the HyperJet Fusion Corporation and NearStar Fusion in Virginia. Pictured: Andrew Holland (second from the left), House Fusion Caucus Chairman Don Beyer (middle), and Celeste Cubbage '24 (second from the right)

PLASMA

FROM OUTER SPACE TO FUSION REACTORS

A Bryn Mawr Research Feature

Ashley Schefler

Despite its critical applications to nuclear fusion, electronics, and astrophysics, plasma remains on the periphery of both the popular consciousness and the scientific community. I interviewed Professor David Schaffner, a plasma physicist at Bryn Mawr, to learn more about plasma and how scientists might confine it to create fusion.

Plasma is considered the fourth state of matter, but Professor Schaffner explains that "the first state of matter" would be a more apt description. Originally, all of the universe was plasma before it cooled down enough to condense into solids, liquids, and gases. Even now, plasma makes up the majority of the universe! In plasma, protons and electrons are detached and move freely through the system, instead of being confined within atoms. The presence of these freely flowing charged particles enables the system to respond to an electric or magnetic field, allowing scientists to infuse plasmas with large amounts of energy using electromagnetic waves.

Professor Schaffner was initially interested in particle physics but was drawn to plasma physics by the opportunities he saw in this relatively understudied field. Although physicists have been studying plasma since the 1800s, many unanswered questions remain. Plasmas are very complex systems, making them harder to study than single particles. On top of that, they are difficult to produce in the lab, and every plasma is different, so understanding the properties of one plasma doesn't guarantee that you can predict how another will behave.

Professor Schaffner's research group does plasma laboratory astrophysics, meaning that they study how the universe works by recreating plasma systems in the lab. One example relatively close to home is the solar wind, a plasma ejected by the surface of the Sun that spreads throughout the solar system. The solar wind can interfere with and sometimes destroy satellites and other spacecrafts, making it important to understand. It also creates the beautiful displays of light we call auroras.

PLASMA IS THE ONLY MATERIAL ON EARTH THAT WE HAVE BEEN ABLE TO PRODUCE FUSION WITH.

Professor Schaffner's lab is particularly interested in studying the turbulence properties of plasma. Turbulence is when a fluid moves in ways that are extremely chaotic, bordering on randomness. This happens when energy that is put into a system on a large scale mani-

Photo of Professor Schaffner (center) and some of his lab students with a plasma globe.

fests as motion at much smaller scales. This concept is important to astronomical plasmas, and has applications in fusion.

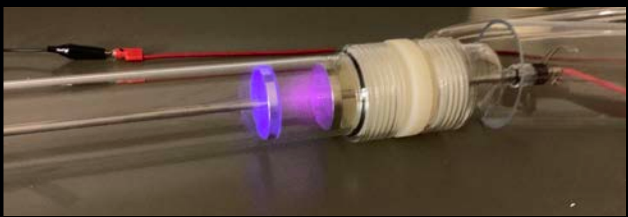
Plasma is the only material on Earth with which we have been able to produce fusion, because conditions must meet the three Lawson criteria: the system needs to be hot enough, dense enough, and stay in place for enough time. In nature, this happens in stars, which are incredibly hot, dense, and held together by the strong gravitational force generated by their immense mass. In the lab, we don't have access to such powerful gravitational force, so we have two alternative methods for keeping the plasma together. One is to confine it using strong magnetic fields. The other is to slam plasmas into each other fast enough (e.g. using lasers) that momentum will force the particles close enough together for long enough for fusion to occur.

How does turbulence play into this? The turbulence of plasma makes it harder to confine, and as we know from Lawson's criteria, confining plasma for a sufficient period of time is necessary to produce fusion. Additionally, magnetic fields can behave in a turbulent way, so when they are used to confine the plasma, it can result in two turbulences. Plasma then becomes much harder to control. Professor Schaffner's lab and other research on plasma turbulence can bring us one step closer to developing fusion.

I asked Professor Schaffner what he saw as some of the main challenges to developing successful fusion. He explained that two main issues from the physics perspective are how to confine the plasma with the challenge of turbulence, and how to heat the system to extreme temperatures. However, in the past decade, scientists have made a lot of headway on these problems. Labs like his have given us a much better understanding of plasma turbulence, and we have developed ways of heating the plasma with large amounts of energy from particle beams and electromagnetic radiation (e.g. microwaves).

According to Professor Schaffner, the biggest challenge at the moment is actually that the physics has gotten ahead of the engineering. Scientists know how to theoretically build a fusion reactor, but they are still working on developing materials that can withstand incredibly high heat and density without destroying the walls of the reactor. One creative strategy is a liquid wall, such as a cycling fountain of lithium, so that high-energy particles colliding with the wall will not cause permanent damage. ITER's strategy is to make the whole system bigger so that less energy is encountering the walls — but this is not very cost-efficient. Another method being investigated is superconducting magnets, which can provide a greater confining force to the plasma and limit the amount that escapes the magnetic fields.

I also corresponded with Amelia Stevens '25, one of the students in Professor Schaffner's lab. She is "working on recording data from the Bryn Mawr Experiment (BMX). The BMX takes measurements of the Taylor Scale. BMX consists of a cylindrical flux-conserving vacuum chamber with a magnetized plasma gun source (MPGS) at one end." When asked about the best part of doing plasma physics research, Stevens said, "it's pretty exciting seeing plasma being ignited!"



Glow discharge system built by Amelia Stevens '25.

LIGHT AT THE END OF A TUNNEL:

A BRIEF HISTORY OF FUSION

Masha Kilibarda

Nuclear fusion, the inner mechanism of stars, has allowed the universe to shine since the beginning of time. For most of human history, scientists were in the dark, attempting to discover the source of starlight. Here are some of the biggest breakthroughs from the twentieth century to today.

1920s

The idea of fusion was born in the 1920s, when Arthur Eddington, a British astrophysicist, attempted to explain the source of stars' energy. Only a decade later, New Zealander physicist Ernest Rutherford and German-American physicist Hans Bethe explained the fusion process. Scientists began to research fusion by experimenting with hydrogen atoms. As time passed, the world became increasingly captivated by the massive energy fusion could theoretically produce.

1940s

The quest to utilize fusion started during one of humanity's darkest moments — the mid-twentieth century. At the time, scientists across the globe were working on nuclear fission research, aiming to produce high quantities of energy by manipulating atomic particles. Influenced by the surrounding horrors of the war, fusion research had a terrifying purpose — to create a hydrogen bomb, a weapon more powerful and frightening than a nuclear bomb. However, as countries started to recover from the devastating effects of the war, fusion exploration took a positive turn. Through international scientific collaboration, the focus shifted from creating weapons to finding a sustainable and powerful energy source.

The first real breakthrough in fusion research occurred in the late 1940s in the UK, when George P. Thomson and Moses Blackman patented a toroidal reactor, a donut-shaped machine fueled by deuterium, a hydrogen atom with a proton and a neutron in its nucleus. However, this initial machine was limited and further research was needed to achieve a stable fusion reaction that produced net power. At the time, all fusion research was strictly classified, as countries feared their work would be stolen. The lack of global coordination proved to be a detriment — scientists in multiple countries had achieved the same results independently at different paces.

1950s

In the 1950s, the possibility of more rapid and collaborative research inspired President Eisenhower to call for international nuclear collaboration, coordinated by the newly formed International Atomic Energy Agency (IAEA). Subsequently, the narrative around fusion started shifting toward sustainable energy. The veil was finally removed after the 1958 Second United Nations Conference on the Peaceful Uses of Atomic Energy held in Geneva, Switzerland. The journal *Nuclear Fusion* and the Fusion Energy Conference (FEC) were created, and information about the fascinating devices made so far was made public.

First, there was the American stellarator, a helical (spiral) system designed by Lyman Spitzer at the Princeton Plasma Physics Laboratory. Then, British scientists presented an initial version of a reversed field pinch, later perfected in the 1960s. Open magnetic structures, dubbed magnetic mirrors, were constructed by both US and Soviet scientists independently. Finally, the most attention was attracted by the tokamak, a donut shaped nuclear reactor that uses magnetic fields to change paths of electric particles. Made by Soviet physicists Andrei D. Sakharov, and Igor Y. Tamm, the tokamak is the best fusion reactor to date. Its symmetrical shape allows particles to move smoothly and produce high quantities of heat.

1960s

The 1960s were shaped by a challenge and a breakthrough in tokamak research. First, in 1965, German scientists discovered plasma disruption, a partially ionized gas needed for the fusion reaction formed when electrons within a heated gas start leaving their atoms. Plasma disruption causes an energy loss as the plasma cools rapidly and unstabilizes the fusion reaction. Subsequently, the majority of fusion research was aimed at resolving this issue. Meanwhile, in Soviet Russia's Kurchatov Institute, the T-3 tokamak had achieved a performance so groundbreaking, it prompted other countries to start using tokamaks in their laboratories. One such device was the IAEA-founded International Tokamak Reactor (INTOR), a cooperative international initiative that paved the way for late-20th and early-21st century's International Thermonuclear Experimental Reactor (ITER), the biggest international scientific collaboration so far.

1980s TO NOW

At the end of the 20th century, fusion research began its golden era. In the 1980s, the scientists working on the Axially Symmetric Divertor Experiment (ASDEX) tokamak in Germany discovered a phenomenon called high confinement. As a result, researchers were able to keep the plasma in a state suitable for a fusion reaction for a longer period of time by heating it intensely.

Another important breakthrough happened on the international political scene, as the USSR president Gorbachev and US president Reagan agreed to further cooperate on fusion research. This deal intensified the speed of fusion exploration, additionally signifying the birth of the ITER program. ITER now includes countries such as Russia, the US, the EU, Japan, China, and Korea, working together to produce sustainable energy for the world to use. The ITER Organization was officially established in the 21st century.

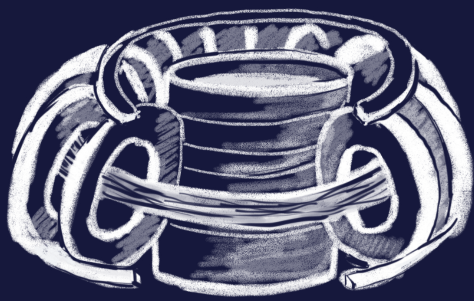
Before ITER, scientists across the globe were working on projects such as the Joint European Torus (JET), US Tokamak Fusion Test Reactor (TFTR), and Japan Torus-60 Upgrade (JT-60U). Now, researchers aimed to pave the way for ITER and set the foundation for its construction (Barbarino, 892). At the beginning of the new century, more tokamaks were built in Asian countries such as China and Korea, as they joined the international fusion research union. Other important modern initiatives include the work to develop diverse fusion machines such as the Wendelstein 7-X stellarator, the reversed field pinches in Italy and the US, and magnetic mirrors in Japan and Russia. Additionally, the journal *Nuclear Fusion* plans to become open access in January 2023 and private startups are joining in this field.

The history of fusion research is filled with great challenges and groundbreaking scientific discoveries. Like the plasma glowing in the darkness of a tokamak, fusion research ignited quickly and continued growing, supported by the efforts of physicists around the world. As ITER prepares for its very first run, the hope remains that it will glow indefinitely.

Abby Ryan

FROM FUSION TO USABLE ENERGY:

MAJOR EMERGING TECHNOLOGIES



The fusion dream: Finally a zero-carbon, low-waste solution to our growing climate change crisis. But we still have yet to turn this dream into a reality.

Scientists are trying to harness this energy on earth by creating self-sustaining fusion reactors of their own. Generally this process involves heating atoms to temperatures hotter than the sun within a confined space. One of the problems with high-energy plasma is its instability: particles constantly resist confinement, travel to less dense edges, quickly lose energy, and dissipate. Scientists can create plasma but are trying to determine how to heat, contain, and control it long enough to convert its energy into a net gain in power.

Fusion energy has gained popularity recently, summoning a wave of enthusiasm to harness the theoretically massive amounts of energy that can be produced. Lack of development has been an ongoing issue due to the complex science behind this energy source. However, along with mounting interest, many competing fusion devices are emerging.

Of the growing variation in devices designed to utilize fusion energy, there are five techniques that stand out from the rest.

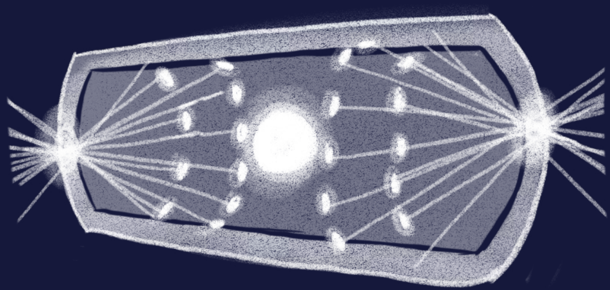
MAGNETIC CONFINEMENT FUSION

Magnetic Confinement Fusion (MCF) uses strong electromagnetic fields and steel structure to control and stabilize plasma. The most prevalent type of MCF device is a tokamak. Nearly 150 of these doughnut-shaped devices have been built so far. Tokamaks collect energy from the plasma by pumping it into neutrons, which then are collected in a layer of molten lithium and lead around the plasma. The excess heat from this mixture can be used to make steam to power turbines and generate electricity. However, scientists are having trouble preventing damage to reactor walls due to the immense energy that the neutrons carry. Additionally, magnets powerful enough to sustain the required magnetic field are costly, but engineers are beginning to develop stronger magnets at half the size.

The prominence of MCF is undisputed — the biggest fusion project in the world, the International Thermonuclear Experimental Reactor (ITER), is a tokamak device. ITER is a multi-country collaboration in fusion energy. If completed, it would only need 50 megawatts of input power to produce 500 megawatts of power for 400 seconds! The possibilities are huge for MCF power, but corporations' lack of funding and patience is proving a major hindrance.

INERTIAL CONFINEMENT FUSION

Much like the previous technique, Inertial Confinement Fusion (ICF) uses powerful laser beams to compress and transform a small fuel pellet into plasma. The fuel pellet then enters a momentary state of laser-plasma instability, when fusion burn must be performed to capture the desired energy. The largest and most powerful ICF is the National Ignition Facility, located in Liverpool, California. In 2021 the device managed to produce a record-high 70% of the energy of the laser. However, the process of ICF is extremely precise and costly due to the immense power required by the lasers, making it is a less suitable solution to harnessing fusion energy compared to other devices.



MAGNETIZED TARGET FUSION

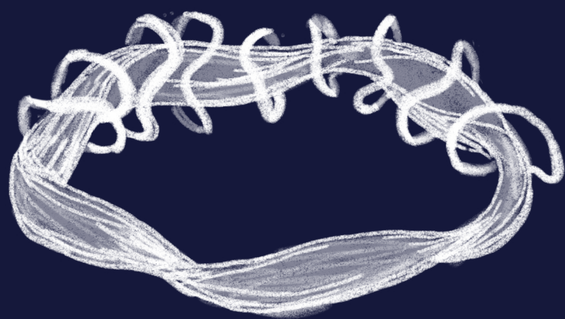
Magnetized Target Fusion (MTF) is a hybrid device that uses magnetic fields and shock waves to confine plasma into an extremely high-density. Lasers or pistons compress and heat the plasma within a spherical structure, while a layer of molten lithium and lead circulate within the sphere to collect resulting heat. By bringing together both MCF and ICF, this technique has been successful in harnessing lower-density plasma, but its instabilities have made it difficult to consistently initiate a normal-density plasma fusion in which the majority of fuel combines into energy. However, MTF has great potential and should be followed closely.

FIELD-REVERSED CONFIGURATION

Field-Reversed Configuration (FRC) utilizes magnetic fields to control the plasma in a torus shape within a cylindrical container. Its magnetic field works differently than a tokamak — in FRC, the axial magnets create an eddy effect with the plasma and cause the direction of the flow to be reversed. The heat produced can then be captured and turned into energy. FRC tend to be more effective than tokamaks because of their smaller size yet higher magnetic field, which creates denser plasma. However, there has yet to be any significant advancements with this technique.

STELLARATOR

The stellarator is shaped like a spiraling ribbon. The innermost layer is plasma, surrounded by a twisted magnetic field, a similarly twisted vacuum vessel, and then magnetic coils. This shape allows plasma to be contained at a high density and flow steadily and symmetrically. This provides multiple benefits over a tokamak: it requires less energy to sustain the plasma, has greater design flexibility, and simplifies plasma control. Yet, due to the specific and complicated geometry of a stellarator, it is difficult to produce as it is more susceptible to imperfections.



These are just a few examples of the types of emerging fusion reactor designs, but many more are in the works. Scientists have successfully harnessed fusion energy, but they face a continual obstacle: how to create self-sustaining fusion reactions. This is the current issue at the forefront of all fusion research, but the question is: Who will solve it first?

ITER

THE WORLD'S LARGEST FUSION EXPERIMENT

Anquon Neely

Fusion is a process that all stars experience, including our sun. Seeking the immense power fusion can produce, scientists have tried to replicate the process here on Earth for decades. ITER, a project conceived in 1985, represents the ongoing international collaboration toward fusion energy.

HISTORY OF ITER

ITER, the International Thermonuclear Experimental Reactor, started as an idea proposed by General Secretary Gorbachev of the Soviet Union to the former president of the United States, Ronald Reagan, during the Geneva Superpower Summit of 1985. A year after this proposal, the European Union, Japan, the Soviet Union, and the United States agreed to work together to build a large fusion facility. In 2001, the final design for the facility was approved. Within the next four years, the People's Republic of China, the Republic of Korea, and India joined the project.

Through a lengthy process, board members unanimously agreed to begin construction of ITER near the Aix-en-Provence of southern France in 2005. In 2007, the ITER organization became the legal international entity responsible for the project. Between the time the first team arrived at the site in 2005, and the time construction began in 2010, about 500 people joined the project. Now there are thousands of people working on the fusion facility.

PROJECT GOALS

ITER lists five goals that they wish to achieve with the project. The first is to produce 500MW of fusion power. The highest recorded fusion power production is 59 megajoules for 5 seconds by JET (December 2021), which was preceded by an earlier record from the same facility of 21.7 megajoules for 4 seconds (1997). Although the earlier record still holds the title of "peak power" according to Nature, it only lasted a fraction of a second. The newest record had a gain factor (Q) of 0.33. Q is the ratio of power output to input . A Q of 1 means there is equal power out and in – "net zero." A Q greater than 1 means that the energy output is greater than the energy input — "net energy." Achieving this is very important because currently it takes a lot more energy to cause the reaction. Though this is an important goal, it only takes into account the *thermal* energy in and out. In order to produce enough power to run the whole facility, there would need to be a Q of at least 10. To meet this goal, the ITER project aims to input 50MW with an output of 500MW.

ITER MILESTONES

2010	Work begins on the ITER site.
2011	The concrete for the foundation of the Tokamak Complex is poured.
2014	The basement slab for the Tokamak Complex is finished and construction of the walls of the building at the heart of the facility begins.
2015	Five years have passed since construction first began. Civil construction has now begun on the first of seven levels for the Tokamak Complex.
2018	The first machine component for the complex, a magnet feeder for one of the poloidal field coils, is installed.
2021	The first of many superconducting magnets, manufactured by the Chinese Academy of Sciences, is installed in the tokamak pit.
2022	The JET fusion facility achieved its record-breaking feat using the same materials and fuel that ITER will use. Its success suggests that ITER will not only be possible, but perhaps even better than JET.

The second goal is to demonstrate the potential of fusion power plants. Since ITER won't be transforming the heat it produces into electricity, it will be used to prove the efficacy of future fusion plants and test technologies like heating, plasma manipulation, and cryogenics.

The third goal is to better sustain fusion reactions by more efficiently trapping heat inside the plasma. This is important because plasma is the only medium in which fusion can occur. If the heat from the plasma escapes then the tokamak won't be able to continue heating the hydrogen isotopes inside, resulting in a decaying fusion process. ITER scientists are confident that their tokamak will be able to sustain the reaction for longer than current reactors can.

The fourth objective is to produce tritium, an isotope of hydrogen and the fuel used in fusion reactions, in the vacuum vessel. There is not enough tritium for future fusion reactors, so it's important to find ways to produce more.

The fifth and final goal is to demonstrate the viability of similar facilities. ITER wishes to exhibit its control of plasma and show that fusion reactions do not harm the surrounding environment.

ITER will also house the largest tokamak in the world once it's completed. It'll be twice the size of the current largest fusion chamber (JET) and hold ten times the volume. ITER's first plasma, or the first time the machine will be turned on, is scheduled for December 2025. Full fusion is predicted to be achieved in 2035, just 13 years away!

A look inside JET as it breaks its previous record. Image via UKAEA.

HOW DID AI CREATE THESE IMAGES?

Ashley Schefler '23

These images were submitted for the *Jolt* cover contest, but they aren't photographs, and they weren't created by an artist. They were generated by artifician intelligence (AI). In the past few months, there have been incredible advances in AI's ability to generate realistic or artistic images and videos. One of the most advanced examples is DALL•E (or the newer version, DALL•E 2), which I used to generate the submitted images. It's hard to get a sense of just how advanced and game-changing this technology is until you look through examples (I recommend the @openaidalle Instagram account).

There are many artistic, philosophical, political, and economic concerns about AI. If you're interested in delving deeper into these elements, I recommend the *New York Times* article "We Need to Talk About How Good A.I. Is Getting," an episode of the podcast *Cortex* entitled "AI Art Will Make Marionettes Of Us All Before It Destroys The World," and the *Atlantic* article "We're Witnessing the Birth of a New Artistic Medium."

The prompt entered into DALL•E's image generator:

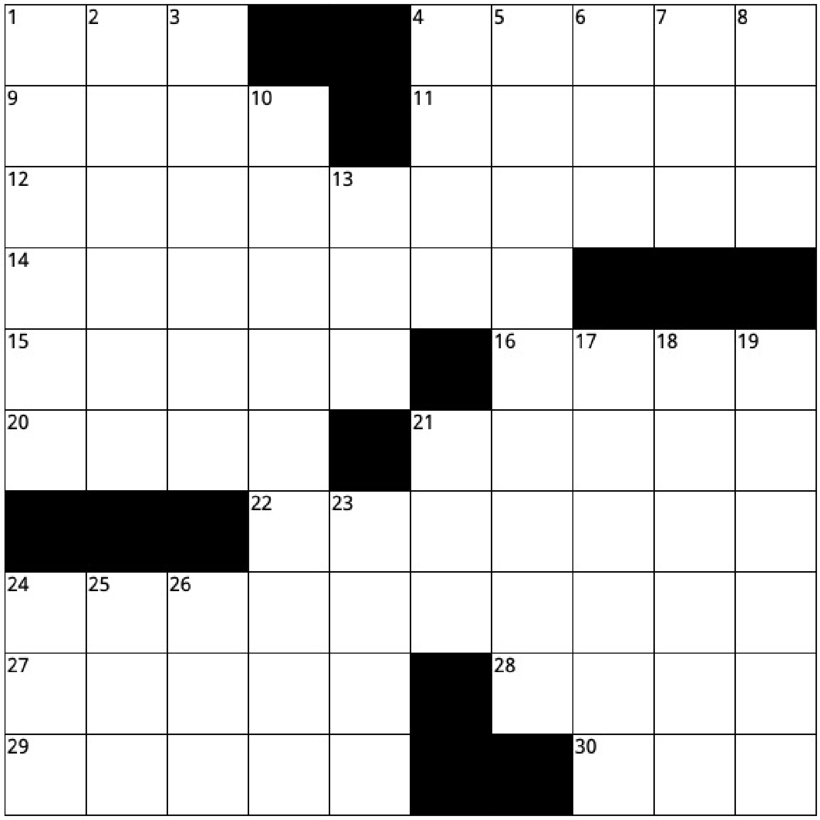
"A SPHERICAL STAR BURNING BRIGHTLY AND SPEWING FLARES OF PLASMA FROM ITS SURFACE, AGAINST THE BACKDROP OF OUTER SPACE."

I want to briefly explain some of the computer science behind this technology. In order to use text to generate images, the AI must have some understanding of the relationship between words and images, like a dictionary that can be used to translate between the two. DALL•E uses a neural network called CLIP (Contrastive Language-Image Pre-training) to accomplish this. Older attempts at solving this problem relied on predetermined categories into which images were sorted. CLIP, on the other hand, is trained using pairs of images and phrases, learning to determine which phrase would be an appropriate caption for a given image. CLIP can then produce a vector space which includes aspects of both phrases and images, and it maps the relationships between them: this comprises DALL•E's dictionary.

DALL•E's next step is to generate an image from the text. This is done using a process called diffusion, which is actually inspired by thermodynamics! You may have heard of entropy in physics or chemistry class. Put simply, entropy the amount of disorder in a system. In the universe as a whole, entropy can only increase, but in a diffusion model, the goal is to reduce entropy — to bring order from disorder. Diffusion models can take an image with scrambled pixels and slowly change the pixels, building order out of the noise, until it has restored the original image. Once it has trained on these actual images, the diffusion model can generate a new, never-before-seen image from a random set of pixels. CLIP guides the diffusion model at each step of the process, helping it make choices that will result in an image that matches the text prompt.

CROSSWORD PUZZLE

By Jay Wild



ACROSS

1 Cooling units, briefly
4 Adding, as to an email
9 Product of saponification
11 Infamous figure skater Harding
12 NASA's moon buggy
14 Crispy appetizer often served with duck sauce
15 Patronize, as a restaurant
16 Word after SIM or playing
20 High school dance
21 Prefix with economics and path
22 Thin, slippery, and Jolt-y, perhaps?
24 Jolt's originators?
27 Nintendo's plumber
28 Fenty Beauty's founder, to fans
29 Groundbreaking astronomer Carl
30 Illinois hrs.

To check your answers, scan the QR code below or visit our website: jolt.sites.haverford.edu/puzzles

DOWN

1 Experiencing REM, maybe
2 Big Cat native to the Americas
3 Serenaded
4 ___-V ("paste" on a PC)
5 Blue or purple, e.g.
6 Edison or Tesla's profession, for short
7 "Science guy" Bill
8 Letters missing from "mar___ita"
10 Commonly studied aquatic ciliate
13 Decompose
17 Not basic
18 ___ Island: NYC prison site
19 Skeptical response to "It works!"
21 Camera type, briefly
23 Notable boarding school near Windsor Castle
24 Acute care grp.
25 When repeated, the yellow teletubby
26 Unit of work in physics, or workout for a crew team

UNDERSTANDING RACIAL DISPARITIES IN HEALTHCARE

Image by upklyak via Freepik

A NOTE FROM THE EDITOR

Ethnic and racial minorities face inequity in every facet of society. The US healthcare system is no exception. In the past few years, the COVID-19 pandemic disproportionately impacted ethnic minorities, drawing attention to existing racial disparities. In order to create a healthier and more equitable society, we need to identify these gaps, acknowledge their causes, and support those who are working for justice.

Factors as intangible as doctor-patient trust — and as tangible as racial bias in diagnosis — contribute to the vastly different health outcomes for patients of different races. Looking to history, we explain how redlining in cities is at the root of geography-dependent health disparities. Looking towards the future, we consider how artificial intelligence can either perpetuate or ameliorate existing health disparities. This series explores the racist, multiscale infrastructure that seeps into healthcare at every level, as well as conscious innovators who are working to mend these inequities.

– Sooyeon Jung

Jaclyn Holtby

BIAS IN MEDICINE

HOW RACISM PERMEATES CLINICAL DIAGNOSES

In the US healthcare system, racial and ethnic minorities face poorer treatment quality, fewer treatment options, and less accurate medical diagnoses than the general population. Internalized racial biases, both implicit and explicit, often permeate the diagnostic process, perpetuating and worsening these health disparities.

There are two types of bias: implicit and explicit. Implicit bias is an automatic, unintentional bias that affects decisions, behavior, and opinions. In contrast, explicit bias occurs when individuals are aware of their prejudices towards certain groups of people, both positive and negative. Implicit bias causes misdiagnosis and maltreatment, impacting pentients' physical health. It can also weaken the doctor-patient relationship, through non-verbal cues and stereotyping. This leads to patients refusing care, even if it would be to their own benefit. Clinicians' biases can be extremely damaging to the patient-doctor trust, leaving patients with appalling care standards and without a medical advocate for their treatment options.

Many of these biases stem from racist roots. In the 19th century, Dr. Samuel Cartwright, a pro-slavery physician in the antebellum South, claimed that Black people were unable to feel pain when punished (Guillory, 1968). Originally published to "prove" the inferiority of Black people, Cartwright's writings became widely accepted, emboldening bigotry in medicine and allowing these falsities to be taught and re-taught to physicians, to the detriment of Black patients. Today, many people, including medical professionals, believe that Black bodies in particular have different, stronger biological tolerances than White bodies (Staton et al., 2009). In a study of about 100 medical students and residents, about half believed that Black patients had higher pain tolerances (Hoffman et al., 2016). In physicians, this generational bias often manifests as an inability to recognize Black patients' pain, leading them to prescribe lower doses of pain medication: Black patients were 22% less likely than their White counterparts to receive any pain treatment (Hoffman et al., 2016). A 1972 study found that physicians were more likely to recommend White patients for coronary bypass surgery than Black patients, regardless of symptom similarity (Dovidio et al). The majority of physicians had independently concluded that Black patients would be less likely to follow their physical recovery plans after surgery due to a presumed lack of education, making them substandard patients for the surgery. In a similar study, medical students were less likely to recommend PrEP, a live-saving pre-exposure HIV drug, to Black patients compared to White patients (Calabrese et al, 2014). The medical students made the assumption that Black patients were more likely to engage in risky sexual behaviours if they had access to PrEP, reducing their willingness to prescribe the drug. Because of physician bias, Black patients have been denied life-saving medications.

Dermatology, a field that investigates the skin, is especially susceptible to racial biases. The lack of dermatology specialists from minority backgrounds is stark. In the US, out of 739 dermatology applicants in the 2018 – 2019 academic year, 53 were Black and 43 were Latinx (Downie, 2019). In general, Black and Latinx students account for 5.7% and 4.6% of medical school graduates, respectively (Downie, 2019). This lack of representation causes a the lack of understanding of minority groups' healthcare needs, which can have fatal consequences.

> ***"We don't only need more representation like this — we need more people willing to create representation like this."***
> *– Chidiebere Ibe*

In general, the medical field lacks knowledge about the diagnostic differences between dark and light skin. Only 4.5% of general medical textbooks show dark skin, according to a 2020 study from the University of Pennsylvania (Lipoff et al., 2020). Chidiebere Ibe, a Nigerian medical student, recently became viral on Twitter for his medical illustration of a Black fetus in the womb. Ibe's illustration calls to attention not only the lack of diversity in illustrations, but also the disproportionate maternal mortality rate of Black women. In an interview with *HuffPost UK,* Ibe said he wanted to "show the beauty of Black people," encouraging other illustrators to create

Chidiebere Ibe's viral illustration depicts a Black fetus in the womb. Explore Ibe's many medical illustrations on Instagram or Twitter (@ebereillustrate).

representation alongside him (Kaur, 2021).

Because of this knowledge gap, healthcare providers rely on stereotypes or generalizations, lacking the ability to diagnose conditions that present differently across racial groups. For instance, Hispanic and Black patients are more likely to be diagnosed at advanced stages of cutaneous melanoma, a serious skin cancer, leading to mortality rates two to three times higher than for White patients (Harvey et al., 2014).

Social determinants like education, income, neighborhoods, nutrition access, and pollution already contribute to health disparities and increased rates of disease among ethnic minority groups. These biases degrade accessibility of care and exacerbate these inequalities, especially for ethnic and racial minorities. Increasing diversity in healthcare is necessary in order to improve care for minority populations. Medical, cultural competency, and community training should involve education in how implicit biases manifest, how to recognize them, and how we can avoid them. Providers should be equipped to recognize the needs of these populations and identify resources available to fill these needs. Becoming comfortable with identifying and discussing implicit bias is a crucial step towards health equity.

MEDICAL TECH

"SMART" TECHNOLOGY PERPETUATES RACIAL HEALTH DISPARITIES

Jamie Joslyn Melville and Emi Krisnamurthy

Medical technology is a booming industry, boasting innovations like wearable fitness trackers and cutting-edge diagnostic tools. However, there is ample evidence that many devices are less accurate on dark skin, a significant danger that perpetuates health inequalities.

Racial minorities access health information through smartphones at higher rates than their white counterparts (Brewer et al., 2020). The development of technologies like smart watches, heart rate monitors, and sleep trackers are further expanding the reach of digital health devices. Most optical sensors on these devices use a type of light that is absorbed by melanin, a pigment that is more abundant in dark skin. This causes these devices to be less accurate in dark skin: for example, most smart watches have lower heart rate accuracy in dark-skinned users (Brewer).

In the hospital setting, these disparities have even more urgent consequences. An inexpensive, easy-to-use, non-invasive device that detects symptoms of many illnesses would be ideal for busy hospitals. However, studies have found that both pulse oximeters and thermometers are less accurate on Black patients, overestimating blood oxygen levels and underestimating body temperature. Both machines rely on measurements that are likely affected by skin pigmentation. The failure to adjust machines for Black patients is color bias, a serious issue that adversely affects treatment and health outcomes.

Pulse oximeters are widely used in household and clinical settings to measure oxygen levels in the blood (Liao and Carbonell, 2022). Since one symptom of COVID-19 is low blood oxygen levels, pulse oximeter usage has increased in recent years. The oximeter shines red and infrared light through skin; the device then calculates how much of the light is absorbed by hemoglobin in the blood. If more infrared and less red liight passes through, there is not enough oxygen in the blood, and vice versa. However, melanin also absorbs light.

Several studies have found that pulse oximeters are less accurate on dark skin tones than light ones (Gottlieb et al., 2022). The studies compared pulse oximeters to alternative measures of blood oxygen like breath and blood tests, factors unlikely to be affected by skin color. This corroborates scientific findings from 1976, when engineers at Hewlett-Packard found that oximeters overestimated blood oxygen levels for Black subjects compared to non-Black subjects. They calibrated the device to limit this effect but concluded honestly that their "method is not capable of making absolute measurements" due to color and other

PULSE OXIMETERS

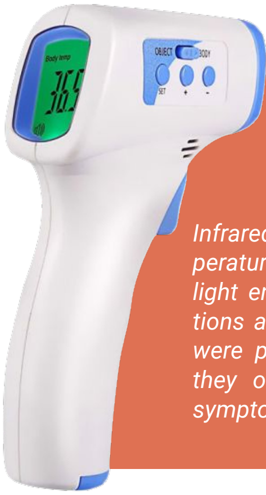
Pulse oximeters are a fast and non-invasive way to measure blood oxygen levels. The device clips onto the fingertip and shines a red light through the skin. It cormpares how much light is absorbed by the finger's red blood cells to how much light is reflected back at the detector.

characteristics of the skin (Merrick and Hayes, 1976). Still, when the pulse oximeter became available in the 1980s, they exploded in popularity among hospitals and households.

Reliance on oximeters reduces the likelihood that Black and other dark-skinned patients will receive proper medical attention and treatment. In an interview with NPR, Dr. Leo Anthony Celi of MIT said, “We were given the false impression that patients were okay. And what we showed in this study is that we were giving them less oxygen than they needed” (LeMoult, 2022).

A few researchers, aware of the pulse oximeter problem, are working on alternative devices that rely on different technologies. At Tufts University, Valencia Koomson’s device adds more light if a higher level of melanin is detected in the skin. At Brown University, Kimani Toussant is working on a device that uses polarized light, which is not absorbed by melanin (LeMoult).

Forehead thermometers, similarly, may miss fever symptoms in Black patients. A 2022 study by Emory University compared forehead and oral thermometers’ results with Black and White patients, finding that forehead thermometers were less likely to show high temperatures in Black patients than White patients (Bhavani et al.). Less research has been done on thermometers than oximeters, and a link to skin color has not yet been established. The authors of the study note that since they were studying data collected by hospitals, inaccurate data collection and technician error could also have contributed to the unequal results. Since forehead thermometers also use optical scanning, more research is needed to determine if skin color directly affects results.



INFRARED THERMOMETERS

Infrared thermometers estimate surface temperature by detecting the amount of infrared light emitted by the forehead. Despite frustrations about the efficacy of these devices, they were prevalent during the pandemic because they offered a contact-free way to monitor symptoms.

Oxygen levels and temperature are important vital signs for medical professionals, informing diagnoses of COVID-19, lung disease, hypoxia, and sepsis, among others. Even small improvements in effectiveness translate to increases in quality of care and lives saved.

Effectiveness across skin tones should have been assessed before these technologies reached the market. One broader issue preventing inclusive development is that clinical trials primarily involve white subjects. Another is that there is a lack of motivation to solve these issues, as scientists are generally hesitant to explore medical differences across races (LeMoult).

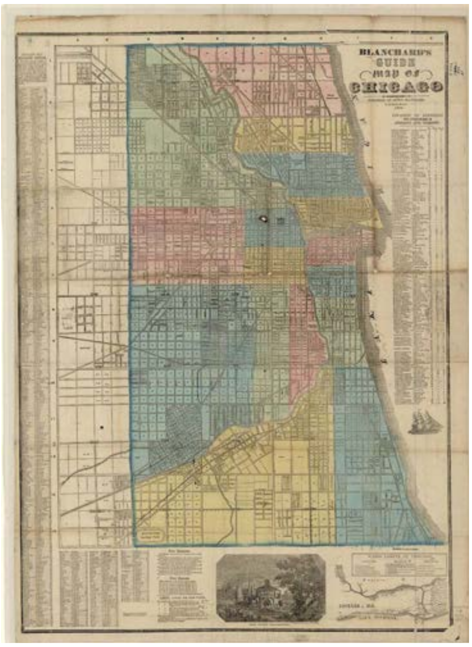
This past September, the FDA announced a panel to investigate racial biases in medical technologies, specifically pulse oximeters but also many other devices (Center for Devices and Radiological Health). While this is certainly a step forward, pulse oximeters and forehead thermometers are only two devices that perpetuate racism in healthcare. In order to prevent more devices from reaching a widespread market, engineers and researchers need to prioritize inclusive design and development.

Anagha Aneesh

URBAN GEOGRAPHIES

CHICAGO'S REDLINING PRACTICES AND HEALTH EQUITY

Studying the history behind the makeup of urban areas is essential to understanding the development of racialized environmental health inequalities. Chicago, with its practice of redlining, is a prime example of the negative influence that geography can have on health outcomes of urban communities.



An 1864 guide map of Chicago (Blanchard).

Chicago is one of the most segregated cities in the US. There is a stark racial divide between the predominantly White north side and predominantly Black south side. This segregation runs deeper and spills into each enclave of the city. From Humboldt Park on the west side with its strong Puerto Rican community to Armour Square on the south side, which houses Chinatown, each of the 77 designated community areas of Chicago has its own ethnic and racial identity.

The New Deal, a series of public works projects enacted by President Franklin D. Roosevelt, created the Home Owners' Loan Corporation in 1933. During the Great Depression, this government-sanctioned corporation categorized certain neighborhoods as "high risk" and declared that its residents should not receive mortgages (Hunt, 2004). Using this method of categorization, the Home Owners' Loan Corporation developed color-coded 'residential security' maps that assigned green lines to racially homogenous and affluent areas and placed red lines around low-income Black neighborhoods. This practice, now known as redlining, has greatly contributed to the patterns of segregation observed throughout Chicago. In addition to color-coding, letter grades were given to each neighborhood. Predominantly Black and immigrant filled communities were given a 'D' while White neighborhoods received an 'A'. These residential security maps led to discrimination in mortgage approvals and denials because banks used race as a litmus test for real estate desirability (Nardone et al., 2020).

Although the Fair Housing Act of 1968 effectively banned redlining, community areas once deemed "dangerous" are now among the lowest income areas of the city. The practice of redlining is a form of structural racism that erodes the possibility of wealth accumulation for Black Chicago residents.

Discriminatory housing and transportation policies implemented in the same era compounded the effects of redlining. Under the Housing Act of 1949, the federal government subsidized slum clearance and urban renewal projects. As a result, Black neighborhoods were declared a "safety threat" and consequently demolished. In the 1950s and 60s the federal government also subsidized the construction of interstate highways. These highways were often built through Black neighborhoods, destroying them in the process (Ware, 2021).

Historical redlining practices and federal housing and transportation initiatives of the 20th century have not only divided Chicago neighborhoods by race and ethnicity but also created racialized health disparities.

Several health indicators including life expectancy, high blood pressure, and obesity are correlated with geography. The disparity becomes evident when comparing the 2019 health statistics of Englewood, a 95% Black neighborhood on the south side, and the Gold Coast, a 85% White neighborhood on the north side (City Health). In the Gold Coast, the life expectancy in 2019 was 80.7 years, whereas in Englewood it was only 64.7 years. Similarly, in 2015, high blood pressure rates in the Gold Coast were only 26.5% but were an astounding 45.6% in Englewood. Obesity percentage in the Gold coast in 2019 was only 20.4% but was much higher in Englewood at 45% (City Health).

Englewood is considered a food desert, an urban area where access to affordable, fresh food is limited or nonexistent. This lack of commercial real estate development is a direct consequence of the policies of the 20th century. In an attempt to combat this disparity, then-Mayor Rahm Emmanuel supported the construction of a Whole Foods Market. The store was closed this November because it could not cater to the needs of the community (NBC5 Chicago, 2022). In contrast, the Gold Coast neighborhood has several grocery stores including Trader Joe's, Whole Foods Market, Jewel Osco, and Mariano's.

Although preventative measures can improve these health trends in the long term, having a robust healthcare system that is personalized to each community is necessary for the short term. It is vital to understand Chicago's racially charged history to create an effective health infrastructure.

Mohan Chennakesavalu is a third year medical student at the University of Chicago, which sits at the heart of Hyde Park, a neighborhood on Chicago's south side. His curriculum requires a health disparities course in the first semester of medical school. "[The course] sets a tone for the rest of medical school," says Mohan, adding that "In medical school, you see the effects of what you read in textbooks, like white flight and redlining."

Physicians who do not have a thorough understanding of how history impacts the lives of urban residents are often the ones serving the community. Education is an important factor in ameliorating inequalities in healthcare. Physicians, medical students, and other healthcare professionals should be acutely aware of these racialized environmental disparities as they develop strategic solutions to reverse the decades of damage in these urban communities.

"It shall be unlawful to discriminate against any person in the terms, conditions, or privileges of sale or rental of a dwelling, or in the provision of services or facilities in connection therewith, because of race, color, religion, sex, familial status, or national origin."
- Section 804 of The Fair Housing Act, Title 42 US Code § 3604

ENCODED BIASES IN ARTIFICIAL INTELLIGENCE

Aamina Dhar

Racism penetrates medical algorithms in many ways. Here's how.

DATA COLLECTION

Data collection is a big problem. But it's not the data itself that poses a barrier to equitable healthcare; it's what isn't in the data. The goal of AI is to look through past information and make predictions about future decisions. But what if there aren't sufficient amounts of data? When this is the case, AI isn't able to make accurate decisions. AI is trained on large health records, predominantly composed of populations that are wealthy enough to see a doctor and have access to healthcare systems. In these datasets, historically underrepresented populations are just that — underrepresented. At best, algorithms trained on these data are ineffective; at worst, they perpetuate biases in healthcare.

ARTIFICIAL INTELLIGENCE

Artificial intelligence is used when a problem involves too many variables for humans to accurately account for. But certain types of variables pose problems when examining bias in healthcare: sensitive variables and confounding variables.

Sensitive variables contain sensitive information, like race, gender, and sexual orientation. Problems arise when providers blindly use these variables in healthcare. When providers equate procedural success rates and race, they fail to address the root of why such statistics are lower for people of color. They can even perpetuate bias in healthcare with no rationale — like the American Heart Association's (AHA) guidelines for heart failure. When trying to determine who is at a high risk of heart failure, it adds three extra points for any patient identifying as 'nonblack.' The AHA does not specify why, though this action directs care away from Black patients (Vyas et al., 2020).

A 2019 study found that race Black and Latinx patients with a principal heart failure diagnosis were less likely than White patients to be admitted to the cardiology service (Eberly et al.). While they were still directed to the general medicine department, access to cariology care greatly improves outcomes. Why is race a deciding factor in who gets access to healthcare? It appears that "despite mounting evidence that race is not a reliable proxy for genetic difference, the belief that it is has become embedded, sometimes insidiously, within medical practice" (Eberly).

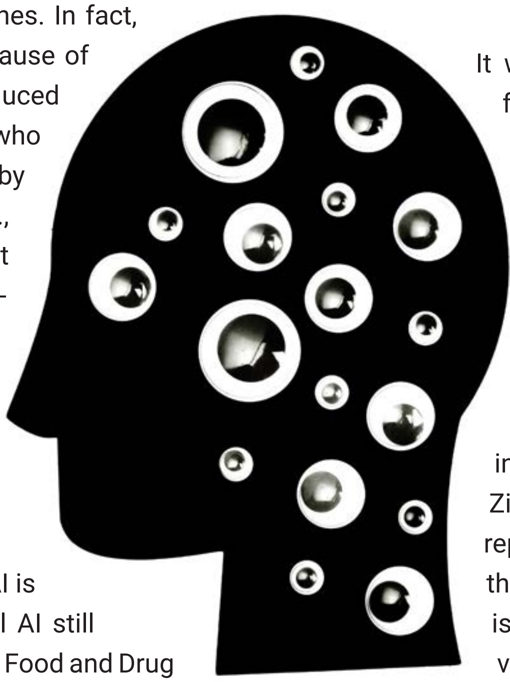
Another notorious example of the shortcomings of sensitive variables is the VBAC algorithm. The VBAC algorithm attempts to predict the success of having a vaginal birth after previously having undergone a cesarean section (VBAC). Since Black and latina women have a lower labor success rate than White women, they have lower VBAC scores, making them more likely to have C-sections (Grobman et al., 2007). Yet C-sections pose a greater risk to the mother than a vaginal birth — not a trivial fact given that Black women have the highest rate of pregnancy related death in the US (Vyas). The reasons for this correlation are unclear: Does it have to do with a physiological difference between Black women, a lack of appropriate maternal care for Black women as a whole, or a confounding variable?

Confounding variables influence both independent and dependent variables. Think of a child trying to distinguish between cats and dogs in a picture. If all the cats are presented as Black, and all dogs are presented as white, the child may assume that color is equivalent to species. AI frequently makes this mistake, which can be devastating in healthcare. Optum, a health services company, developed an algorithm to predict which patients would need extensive care, impacting both admittance to the hospital and prescription to medication. This algorithm used cost of care as a proxy for severity of illness, making cost of care a confounding variable. Sicker patients usually need more expensive treatment, but Black patients are disproportionately affected by poverty and thus spend less on healthcare. Cost of care affects both the independent variable (patients), and the dependent variables (type of care). Because of this, the Optum algorithm falsely concluded that White patients were sicker than Black ones. In fact, researchers estimated that because of racial bias, this algorithm reduced the number of Black patients who were offered additional care by more than half (Obermeyer et al., 2019).oreover, it's estimated that 200 million people are affected by similar systems used in healthcare systems and government agencies (Obermeyer).

DEPLOYMENT

Challenges arise even after an AI is developed. Regulating unethical AI still remains an issue. In the USA, the Food and Drug Administration is responsible for regulating machine learning models used in healthcare. Despite the risks AI poses to minority groups, the FDA does not explicitly consider health equity in machine learning. Conducting a premarket review of the data used to develop the algorithm could ensure the quality of data in minority groups is robust, or could signal that an algorithm may or may not perform well when applied to people of color.

It's clear that to end medical inequity, we first have to examine our own biases. Luckily, AI can help with that. A novel 2021 study aimed to re-examine why underserved populations report higher levels of knee pain, despite getting less severe diagnostics from physicians (Pierson et al.). Previously, this discrepancy was attributed to factors external to the knee, like stress. However, using a deep learning approach on a racially and socio-economically diverse dataset, researchers were able to identify that the cause of underserved populations' pain is internal to the knee. This not only confirmed patients' reports of pain, but also indicates that the severity metrics used by doctors lack a complete understanding of osteoarthritis in Black patients. So what did this AI do right?



It wasn't the AI that did something different: it was the researchers behind it. Rather than aiming for optimization at the expense of minorities, they prioritized the efficiency of the algorithm for underrepresented groups. "The dirty secrets of a lot of artificial intelligence tools is that a lot of the things that seem like biological variables that we're predicting are in fact just someone's opinion," Ziad Obermeyer, one of the researchers, reported to *Discover Magazine* in July. So they sought to do better. Their algorithm is proof that when minority opinions are valued, healthcare as a whole improves.

Cover contest honorable mentions

STUDENT PHOTOGRAPHY

BIOLOGY SUPERLAB

*Rebecca Osbaldeston ’24
and Annabel Flint ’24*

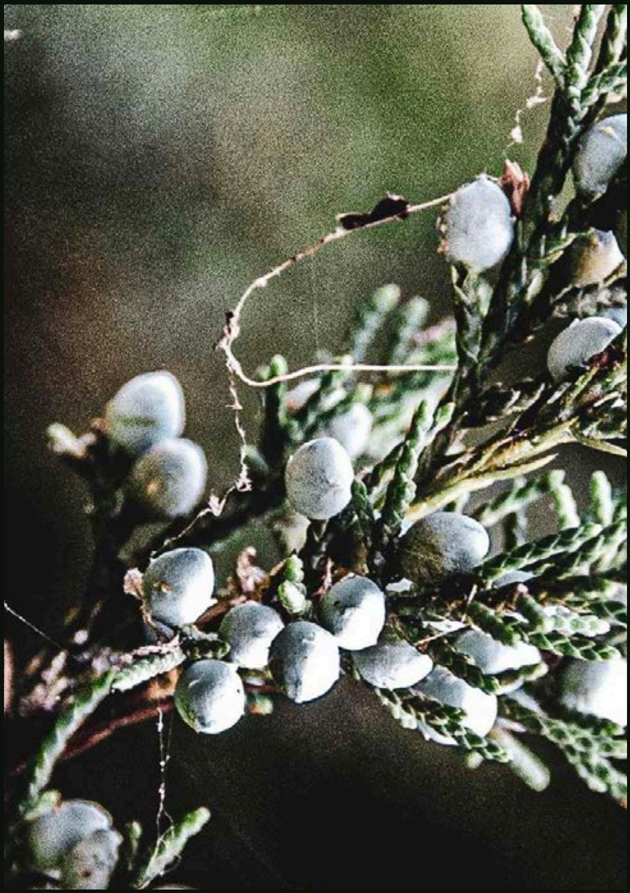
This image shows mature neurons grown from a line of undifferentiated mouse neuroblast cells. This image was taken by students Rebecca Osbaldeston and Annabel Flint as a part of Haverford’s Biology Superlab, where students are conducting research on Alzheimer’s Disease with Professors Courtney Marshall and Karl Johnson.

Osbaldeston and Flint differentiated mouse neuroblast cells into the mature neurons imaged above. Tubulin, the main protein that makes up the microtubules of the cytoskeleton, was stained with fluorescent green dye, and DNA was stained with fluorescent blue dye. Images were taken using fluorescence microscopy, then overlayed to create this composite image.

ON A PHOTO WALK

Julie Edelstein ’26

Julie Edelstein’s macroscopic photos show a raspberry plant (top) and a juniper tree (bottom) in her backyard in central New Jersey.



“I wanted to explore a familiar space from a closer angle by zooming into the miniscule, unseen details of the landscapes I typically take for granted. After capturing the photos, I further zoomed in and altered the values of light and color using Photoshop. Photography, specifically nature photography, has been a hobby of mine since elementary school. I would go on ‘photo walks’ with my father to explore our local neighborhoods with a camera and a critical eye. I find that the more I pay attention, the more layers and details I see standing out. There is so much beauty in the world, and visual art has always been my tool for expressing my appreciation for it all.”

– Julie Edelstein

REFERENCES

Fusion: The Power of the Sun Brought to Earth

About Plasma and Fusion. (n.d.). Princeton Plasma Physics Laboratory. Retrieved October 19, 2022, from https://www.pppl.gov/about/about-plasmas-and-fusion

Adarlo, S. (2016, June 30). 10 facts about fusion energy via magnetic confinement. Andlinger Center for Energy and the Environment. Retrieved October 19, 2022, from https://acee.princeton.edu/acee-news/10-facts-about-fusion-energy-via-magnetic-confinement/#:~:text=1%20It%E2%80%99s%20Star%20Power.%20Fusion%20energy%20is%20what,Costs%20Depend%20on%20Component%20Durability.%20...%20More%20items

Barbarino, M. (2020). A brief history of nuclear fusion. Nature Physics, 16(9), 890–893. https://doi.org/10.1038/s41567-020-0940-7

Bryn Mawr Plasma Laboratory (BMPL). Bryn Mawr College. Retrieved October 24, 2022, from https://www.brynmawr.edu/inside/academic-information/departments-programs/physics/research-opportunities/plasma-physics

Clynes, T. (2020, January 28). 5 Big Ideas for Making Fusion Power a Reality. IEEE Spectrum. Retrieved October 19, 2022, from https://spectrum.ieee.org/5-big-ideas-for-making-fusion-power-a-reality

IAEA. (2016, June 8). History. IAEA. Retrieved October 18, 2022, from https://www.iaea.org/about/overview/history

Lanctot, M. (n.d.). DOE Explains ... Stellarators. U.S. Department of Energy. Retrieved October 19, 2022, from https://www.energy.gov/science/doe-explains-stellarators

Moynihan, Jessica Dawid, Qayyah. “This 12-Year-Old Built a Nuclear Reactor at Home Using Equipment He Found on EBay.” Business Insider. Accessed October 18, 2022. https://www.businessinsider.com/12-year-old-builds-nuclear-reactor-at-home-with-equipment-from-ebay-2019-4.

National Ignition Facility. (2021, December 5). Wikipedia. Retrieved October 19, 2022, from https://en.wikipedia.org/wiki/National_Ignition_Facility

R.A. (2014, May 1). Who ‘invented’ fusion? ITER. Retrieved October 18, 2022, from https://www.iter.org/mag/3/29

Reed, Stanley. “Nuclear Fusion Edges Toward the Mainstream.” The New York Times, October 18, 2021, sec. Business. https://www.nytimes.com/2021/10/18/business/fusion-energy.html.

Shafranov, V. D. (2001). The initial period in the history of nuclear fusion research at the Kurchatov Institute. Physics-Uspekhi, 44(8), 835–843. https://doi.org/10.1070/pu2001v044n08abeh001068

Verma, Pranshu. “Nuclear Fusion Energy Inches Closer toward Reality.” The Washington Post, August 26, 2022. Accessed October 18, 2022. https://www.washingtonpost.com/technology/2022/08/26/nuclear-fusion-technology-climate-change/.

What is Iter? ITER. (n.d.). Retrieved October 18, 2022, from https://www.iter.org/proj/inafewlines

Understanding Racial Disparities in Healthcare

Adelekun, A., Onyekaba, G., & Lipoff, J. B. (2021). Skin color in dermatology textbooks: An updated evaluation and analysis. Journal of the American Academy of Dermatology, 84(1), 194–196. https://doi.org/10.1016/j.jaad.2020.04.084

Bhavani, S. V., Wiley, Z., Verhoef, P. A., Coopersmith, C. M., Ofotokun, I. (2022). Racial Differences in Detection of Fever Using Temporal vs Oral Temperature Measurements in Hospitalized Patients. Jama Internal Medicine, 328(9), 885-886. doi:10.1001/jama.2022.12290

Brewer, L. P. C., Fortuna, K. L., Jones, C., Walker, R., Hayes, S. N., Patten, C. A., & Cooper, L. A. (2020). Back to the future: Achieving Health Equity Through Health Informatics and Digital Health. JMIR MHealth and UHealth, 8(1). https://doi.org/10.2196/14512

Calabrese, S. K., Earnshaw, V. A., Underhill, K., Hansen, N. B., & Dovidio, J. F. (2014). The Impact of Patient Race on Clinical Decisions Related to Prescribing HIV Pre-Exposure Prophylaxis (PrEP): Assumptions About Sexual Risk Compensation and Implications for Access. AIDS and Behavior, 18(2), 226–240. https://doi.org/10.1007/s10461-013-0675-x

Center for Devices and Radiological Health. (n.d.). Pulse oximeter accuracy and limitations. U.S. Food and Drug Administration. Retrieved October 23, 2022, from https://www.fda.gov/medical-devices/safety-communications/pulse-oximeter-accuracy-and-limitations-fda-safety-communication

Chen, I. Y., Pierson, E., Rose, S., Joshi, S., Ferryman, K., & Ghassemi, M. (2021). Ethical machine learning in Healthcare. Annual Review of Biomedical Data

Science, 4(1), 123–144. https://doi.org/10.1146/annurev-biodatasci-092820-114757
City Health dashboard. City Health Dashboard. (4687, October 15). Retrieved October 23, 2022, from https://www.cityhealthdashboard.com/il/chicago/metric-detail?metric=36&metricYear-Range=2019%2C%2B1%2BYear%2BModeled%2BEs-timate&dataRange=city
Dovidio, J. F. (2016). Racial biases in medicine and healthcare disparities. TPM - Testing, Psychometrics, Methodology in Applied Psychology, 1, 489–510. https://doi.org/10.4473/TPM23.4.5
Gawronski, Q. (2019, November 7). Racial bias found in widely used health care algorithm. NBCNews.com. Retrieved October 22, 2022, from https://www.nbcnews.com/news/nbcblk/racial-bias-found-widely-used-health-care-algorithm-n1076436
Gottlieb, E. R., Ziegler, J., Morley, K., Rush, B., Celi, L.A. (2022). Assessment of Racial and Ethnic Differences in Oxygen Supplementation Among Patients in the Intensive Care Unit. Jama Internal Medicine, 182(8), 849-858. doi:10.1001/jamainternmed.2022.2587
Guillory J. D. (1968). The pro-slavery arguments of Dr. Samuel A. Cartwright. Louisiana history, 9, 209–227.
Harrison, S. (2022, July 13). How bias can creep into health care algorithms and data. Discover Magazine. Retrieved October 22, 2022, from https://www.discovermagazine.com/health/how-bias-can-creep-into-health-care-algorithms-and-data
Harvey, V. M., Patel, H., Sandhu, S., Wallington, S. F., & Hinds, G. (2014). Social Determinants of Racial and Ethnic Disparities in Cutaneous Melanoma Outcomes. Cancer Control, 21(4), 343–349. https://doi.org/10.1177/107327481402100411
Hoffman, K. M., Trawalter, S., Axt, J. R., & Oliver, M. N. (2016). Racial bias in pain assessment and treatment recommendations, and false beliefs about biological differences between Blacks and whites. Proceedings of the National Academy of Sciences, 113(16), 4296–4301. https://doi.org/10.1073/pnas.1516047113
Hunt, Bradford D. (2004). Redlining. Encyclopedia of Chicago. Retrieved October 23, 2022, from http://www.encyclopedia.chicagohistory.org/pages/1050.html
Jeanine Downie. (2019, July). Diversity in the Dermatology Workforce: What Can We Do? Practical Dermatology. https://practicaldermatology.com/articles/2019-july/diversity-in-the-dermatology-workforce-what-can-we-do
Kaur, H. (2021, December 9). A viral image of a black fetus is highlighting the need for diversity in medical illustrations. CNN. Retrieved October 24, 2022, from https://www.cnn.com/2021/12/09/health/black-fetus-medical-illustration-diversity-wellness-cec/index.html
LeMoult, C. (2022, July 11). When it comes to darker skin, pulse oximeters fall short. NPR. Retrieved October 23, 2022, from https://www.npr.org/sections/health-shots/2022/07/11/1110370384/when-it-comes-to-darker-skin-pulse-oximeters-fall-short
Liao, S., & Carbonell, V. (2022). Materialized Oppression in Medical Tools and Technologies. The American Journal of Bioethics. doi.org/10.1080/15265161.2022.2044543.
Merrick, E. B., and Hayes, T. J. (1976). Continuous, Non-Invasive Measurements of Arterial Blood Oxygen Levels. Hewlett-Packard Journal, 2-9. www.hpl.hp.com/hpjournal/pdfs /IssuePDFs/1976-10.pdf
Nardone, A., Chiang, J., & Corburn, J. (2020). Historic Redlining and urban health today in U.S. cities. Environmental Justice, 13(4), 109–119. https://doi.org/10.1089/env.2020.0011
NBC Chicago. (2022, May 4). As Whole Foods prepares to leave Englewood, company plans to open New River North Store. NBC Chicago. Retrieved October 23, 2022, from https://www.nbcchicago.com/news/local/as-whole-foods-prepares-to-leave-englewood-it-prepares-to-open-new-river-north-store/2824033/
Pierson, E., Cutler, D. M., Leskovec, J., Mullainathan, S., & Obermeyer, Z. (2021). An algorithmic approach to reducing unexplained pain disparities in underserved populations. Nature Medicine, 27(1), 136–140. https://doi.org/10.1038/s41591-020-01192-7
Staton LJ, et al. When race matters: Disagreement in pain perception between patients and their physicians in primary care. J Natl Med Assoc. 2007;99(5):532–538
Vyas, D. A., Eisenstein, L. G., & Jones, D. S. (2020). Hidden in plain sight — reconsidering the use of race correction in clinical algorithms. New England Journal of Medicine, 383(9), 874–882. https://doi.org/10.1056/nejmms2004740
Ware, L. (2021). The government's role in the development and perpetuation of segregated neighborhoods. RSF: The Russell Sage Foundation Journal of the Social Sciences, 7(1), 92. https://doi.org/10.7758/rsf.2021.7.1.06

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