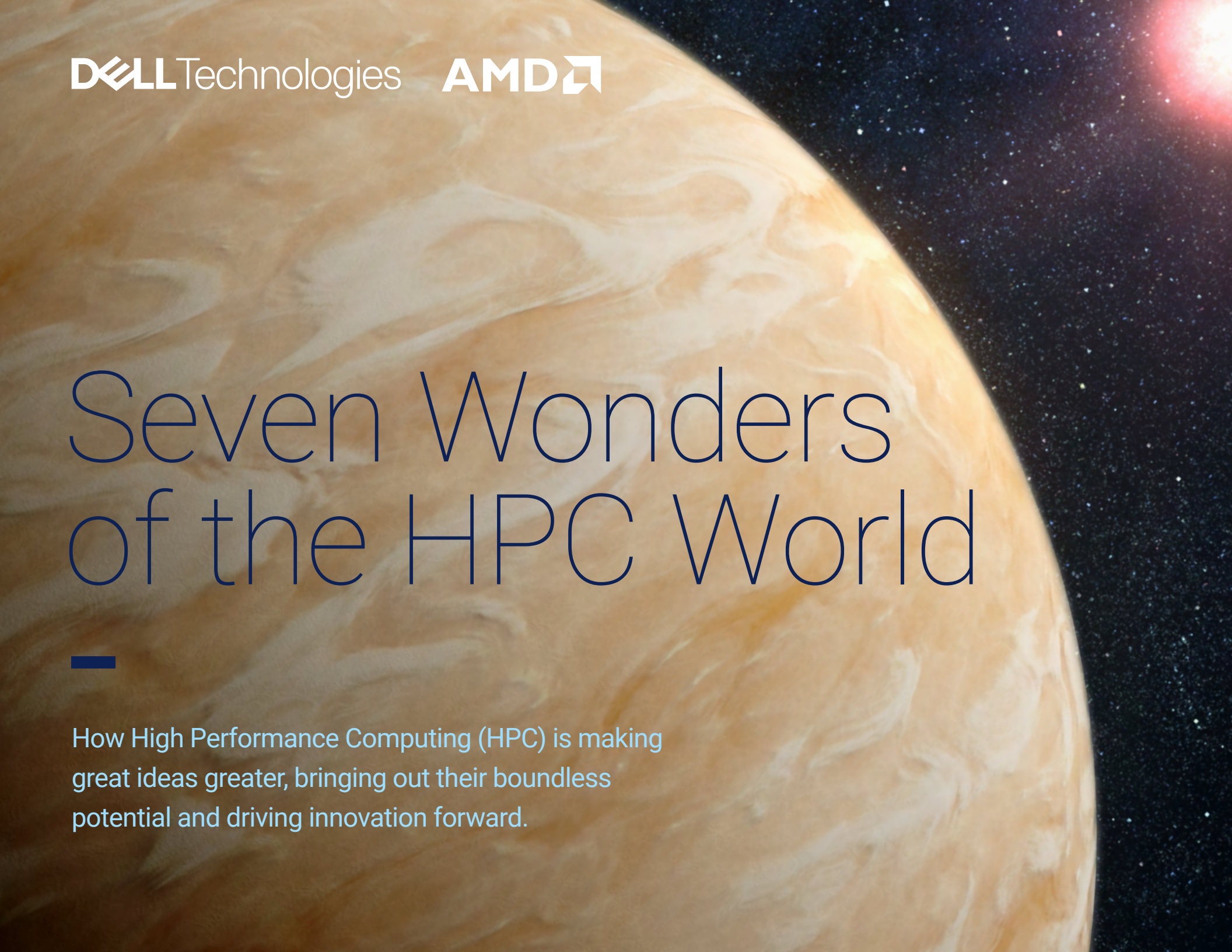


DELL Technologies AMD

Seven Wonders of the HPC World

How High Performance Computing (HPC) is making great ideas greater, bringing out their boundless potential and driving innovation forward.

HPC is Reshaping Tomorrow

by Powering Remarkable Discoveries Today

Many of today's advancements are being driven by HPC technology from Dell Technologies and AMD. The resulting research-based discoveries are profound and significantly accelerated by HPC to help reshape a better tomorrow.

Today's groundbreaking discoveries are key to our future. Better health, environmental sustainability, and the advancement of humankind all ride on the ability to continually innovate in engineering and science. These are areas that each of us–not just engineers and scientists–can get excited about improving.

That's where data and technology–specifically the supercomputing category of high performance computing (HPC)–come in. HPC is enabling possibilities that were previously only just imagined, unleashing novel innovations that can create a better future for us all.

Contents

Cover image source: Based on original artwork: NASA, ESA, CSA, Dani Player (STScI)

The Power of HPC Supercomputing.

What is HPC?

High performance computing (HPC) processes massive amounts of data, performing complex calculations at rapid speed across multiple servers in parallel. A supercomputer is a special class of HPC and is akin to having thousands of PCs working together to generate more compute power and complete complex tasks at lightning-fast speeds.

For example, a PC with a 4.2 GHz processor can perform 4.2 billion calculations per second. HPC, after reaching the exascale in 2022, can now perform at least 1,000,000,000,000,000,000 or a quintillion calculations per second.

HPC solutions

The three interdependent components of HPC solutions include compute, network and storage. HPC architecture crafts clusters comprised of hundreds or thousands of servers, called nodes, that are networked together. The nodes work in parallel to deliver incredible processing speeds that are the hallmark of high performance computing.

Dell HPC solutions can be deployed on-premises, at the edge or in the cloud. In short, HPC technologies utilize state-of-the-art componentry, like CPUs and GPUs that enable next-generation processing capabilities alongside storage and networking components.

HPC applications and industries

With record performance, HPC is being used to solve the world's most complex problems, transforming data into insights faster with AMD. It spans industries and applications such as research, energy, engineering, healthcare financial services, automotive and aerospace.

To put it in better perspective, let's look at seven awe-inspiring real-world examples of HPC in action and their profound impact on humankind.

Source: IMAGE: NASA, ESA, CSA, STScI

Solving mysteries of the universe

Helps us understand where we came from and where we are going.

The James Webb Space Telescope (JWST), together with HPC simulations, recently made an important and unexpected discovery about galaxy formation. Work is underway to verify the discovery as true. Peering back 13.5 billion years ago, close to the dawn of the universe, JWST found six new galaxies, all of which are way more mature and massive than anyone expected.

This surprising discovery would not be possible without HPC. That's because tackling colossal questions about the origins of the universe requires a massive amount of computing power.

Durham University, working with Dell Technologies and AMD, set up a Cosmology Machine (COSMA) to begin answering these questions. COSMA is part of the Distributed Research utilizing Advanced Computing (DiRAC) facility, with five deployments at the Universities of Cambridge, Durham, Edinburgh, Leicester and UCL[1]. COSMA allows scientists to process enormous amounts of data and continually conduct huge, in-depth simulations. Clues revealed by JWST can then be used to uncover big insights about the origins and makeup of the universe.

"HPC means we can run massively more detailed simulations, which we can compare much better with observations from telescopes," Dr. Alastair Basden, technical manager for the COSMA high performance computing system at Durham University. "This will help us to understand the meaning of the universe, dark matter, dark energy and how the universe was formed. It's really going to help us reach a fundamental understanding of the world that we live in."

1 https://www.itpro.co.uk/data-insights/big-data/369538/big-data-nasa-james-webb-space-telescope

Source: Original illustration: NASA, ESA, CSA, Joseph Olmsted (STScI)

"With HPC, we can find correlations—quickly and accurately—that would not be possible to find otherwise. For example, our DNA research is now able to look at the entire genomic sequence, boosting precision, expanding knowledge and ultimately impacting people's lives,"

Ian Fisk, Ph.D., Scientific Computing Core Co-Director at the Flatiron Institute.

Discovering cures for diseases

with incredible speed transforms patient care and impacts our health and well-being.

The quest to understand the human body never rests. Many aspects of our complex and dynamic molecular networks remain cloaked in mystery. But HPC is changing that by enabling genomic approaches and sophisticated analytics that help explain the human body's awe-inspiring sophistication. By doing so, scientists are discovering novel insights that help fight disease and improve lives.

At the core of genomic research is DNA sequencing. To be effective, it uses enormous volumes of de-identified DNA from thousands of families around the world. The goal is to analyze the data and find correlations between DNA and disease that can be used to help us better prevent and treat maladies. Data analysis at this scale and speed is only possible with a massive amount of compute power–or HPC. In one example, HPC-powered DNA sequencing that used to take 10 years can now be conducted within 4-6 weeks.

Using HPC together with DNA sequencing, research at the Flatiron Institute, an internal division of the Simons Foundation, recently uncovered a surprising correlation. Scientists studying the kidney cells of COVID-19 patients and diabetic kidney disease patients found that both types of patients experienced a similar set of molecular processes[2]. This finding suggests that diabetes patients may be especially vulnerable to COVID-19 and posits why the two diseases together can be so lethal. In addition, the study debunked the previously held belief that medications used for hypertension and diabetes do not likely increase COVID-19 infection risk.

And this is only the beginning. Decoding the human genome has only just scratched the surface of what is possible. But one thing is true, HPC, paired with genomic research, is making the previously impossible, possible. Our future selves will surely benefit from it.

2 https://www.simonsfoundation.org/2020/10/23/molecular-processes-in-kidney-cells-may-prime-diabetics-for-covid-19-infection/

Modeling wildfire behavior

Helps us understand how to mitigate their impact, boost people's safety and better sustain our environment.

Forest fires are getting worse. Today, they are burning nearly twice as much tree cover as 20 years ago, according to a study by the World Resources Institute.[3]

Forest fires, spurred by global warming and climate change, are forecasted to continue to grow in breadth and severity. Per the climate feedback loop, more forest fires exacerbate conditions for more and more forest fires.

With the goal of better-protecting lives, property and our forests, the University of California's San Diego Supercomputer Center is using HPC powered by Dell Technologies and AMD in their Expanse center to model wildfires. HPC modeling strives to understand how wildfires spread so that faster-than-real-time predictions can help to mitigate their impact.

Since wildfires are complex, highly dynamic and unplanned events, decoding their behavior is ideally suited to HPC modeling. Atmospheric data about wind speed, wind direction and humidity (including fuel moisture content) are coupled with other inputs such as topography, satellite data and landscape change data to model wildfire behavior via HPC's vast and sophisticated simulation and modeling capabilities[4].

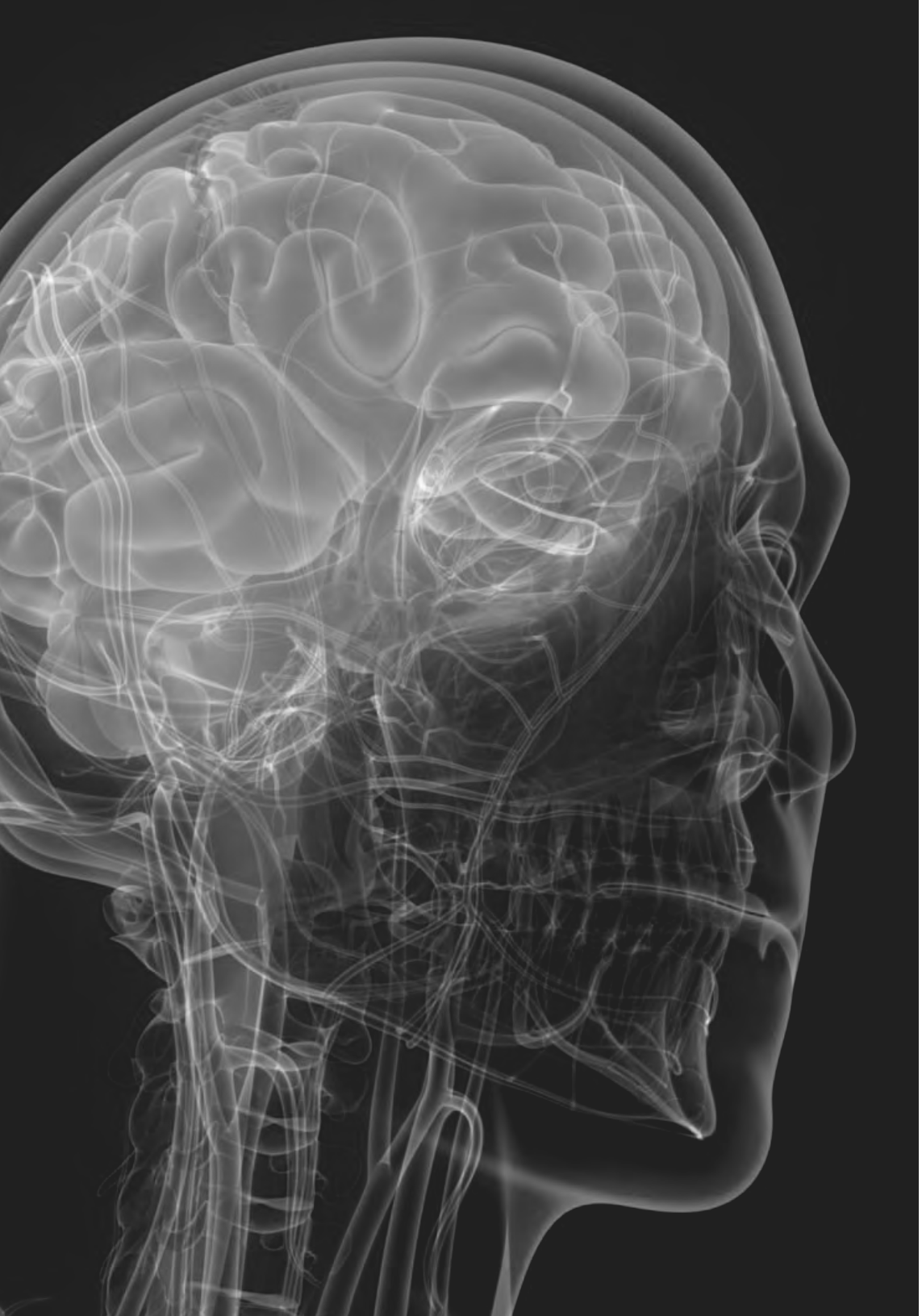
"This is important work because mitigating the impacts of wildfires is essential to securing a solid future for communities around the world. HPC is the vehicle enabling the prediction of wildfire spread—before it occurs and when it can be most effectively addressed. It's a powerful combination," shares Shawn Strande, deputy director of the San Diego Supercomputer Center at the University of California, San Diego.

Modeling wildfires is one way HPC is helping us create a healthier planet.

3 https://www.wri.org/insights/global-trends-forest-fires
4 https://ral.ucar.edu/sites/default/files/public/file_attach/features/KosovicHPCUserForum2022-compressed.pdf

View map of tree cover loss due to fires

Click here



Understanding how our brains store information

Helps us answer fundamental questions about learning and can also lead to better artificial intelligence.

Some memories are unforgettable. But scientists' understanding of how our brains keep them that way is undergoing a radical pivot. The longstanding belief was that memories were tied to specific neurons and their connective synapses. At the Flatiron Institute's Center for Computational Neuroscience, HPC and recent research have shown otherwise, pointing to a new concept termed "representational drift".[5]

When you drive your vehicle around your neighborhood, the specific recall neurons that fire your memory are not fixed, as previously thought, but rather in constant flux. One neuron group can help you navigate on Monday and another on Tuesday. That's representational drift, a concept tied to the ever-changing relationship between cells, not the specific cells themselves. Despite this dynamic phenomenon, our memories and learned behaviors can remain strong. For scientists, it's a puzzling paradox.

Dell Technologies and AMD are helping scientists at the Flatiron Institute uncover possible answers to how this can work by modeling representation drift. Early findings lend insight into how fluctuating representations operate. In short, when a synapse fails to transmit, our neural representations drift among different pathways but maintain similar patterns, enabling our memories to endure.

"Our brain memory work embodies Flatiron Institute's mission to advance scientific research through computational methods, including data analysis, theory, modeling and simulation. While our new model is essential, we are still a long way to understanding how the brain works," comments Ian Fisk, Ph.D., Scientific Computing Core Co-Director at the Flatiron Institute. "Thankfully, HPC is moving our research forward with incredible speed."

The brain is both a marvel and a mystery. HPC models are fast and powerful teachers that are helping to educate us about our brain, our memories and how we learn.

5 https://www.simonsfoundation.org/2023/03/09/computational-model-uncovers-new-insights-into-how-our-brains-store-information/

Researching material science

Helps us improve our energy posture—rapidly, responsibly, and reliably—as we collectively strive to improve tomorrow for humankind.

Room-temperature superconductors, when fully developed, will be a total game-changer for society. Currently, room-temperature superconductors are the holy grail of physics. Unraveling ways to create room-temperature superconductors have stumped scientists for decades, with many dedicating a lifetime to try and crack this challenge. When solved, superconductivity will change the world in profound ways, most notably in electrical grids and transportation—such as electric vehicles and magnetically levitating train systems–and, ironically, in supercomputing itself.

Today, conductors that transport electricity are inefficient, dissipating about 6-10% of the energy generated by the electrical grid as it passes through.[6,7] This costs consumers billions of dollars each year in wasted energy production and keeps us more dependent on fossil fuels. By contrast, superconductors enable frictionless electricity, operating without waste or excess heat. Historically, however, superconducting was only possible at ultra-cold temperatures, such as -450 deg F. Recent discoveries show the promise of breakthrough materials that can superconduct at 59 degrees F, also known as room temperature.

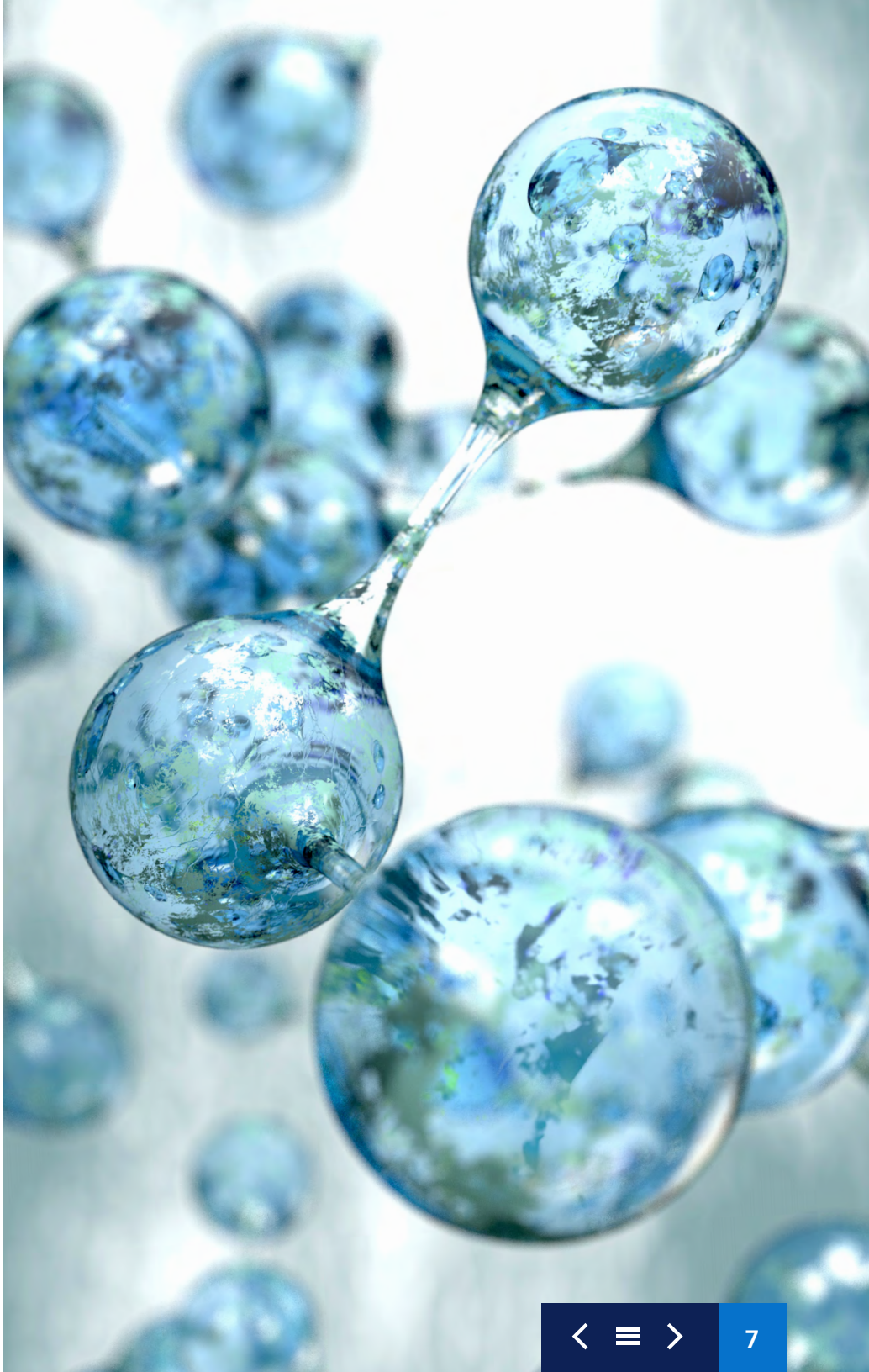
At the Flatiron Institute, Dell Technologies and AMD are accelerating material science research to unlock the incredible potential of superconducting. It shaves years off of research by enabling simulations that rapidly expand the number of potential materials to investigate, quickly eliminating non-starters and identifying high-probability options.

"Our work in material science is significant because previously 10,000 possible materials or compounds might have been investigated over the course of a career. Today, the depth and productivity of HPC-powered research allow 10,000 materials to be analyzed within months and with high levels of precision, such as a couple of percentage points," says Ian Fisk, Ph.D., Scientific Computing Core Co-Director at the Flatiron Institute.

That means we may be able to revolutionize energy and forge an accelerated pathway to quit fossil fuels, creating a better tomorrow much sooner than we imagined.

6 https://www.vice.com/en/article/y3gdgw/ok-what-is-room-temperature-superconducting-and-will-it-change-everything

7 https://theconversation.com/a-tenth-of-all-electricity-is-lost-in-the-grid-superconducting-cables-can-help-199001



Studying computational biology

Moves us closer to finding cures for diseases.

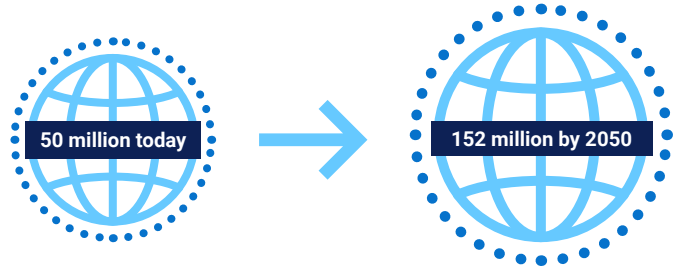
Alzheimer's disease is rampant, affecting an estimated 50 million people worldwide. A breakthrough to stem Alzheimer's is paramount. Without one, Alzheimer's disease could impact over 152 million people by 2050.

Research to find a cure is underway with San Diego Supercomputer Center's (SDSC) Expanse.* Using computational biology and SDSC's Expanse, researchers at the University of Kansas studying familial, or genetically inherited, Alzheimer's disease, made an important discovery. Cutting-edge HPC simulations provided first-ever mechanistic insights about y-secretase, an important protein enzyme in familial Alzheimer's disease. Understanding y-secretase interactions and mutations is key to uncovering pathways to better control thought, language and memory.

"Tackling Alzheimer's disease is a noble cause, uniquely enabled by our HPC supercomputer, Expanse. Early research findings show great promise in the ongoing pursuit of a treatment for the population at large and our scientists are passionately pursuing discoveries that will help," states Shawn Strande, deputy director of SDSC at the University of California, San Diego.

As the world's population ages, HPC-enabled research to find more effective treatments for Alzheimer's disease will be revolutionary for individuals, families and our communities.

* This research was made possible by HPC and the sponsoring organizations. This work was funded by the National Science Foundation and the National Institutes of Health. Supercomputing time on Expanse was funded by the NSF's Extreme Science and Engineering Discovery Environment.



50 million people curently affected by Alzheimer's disease

Could impact over 152 million people by 2050

Cracking cardiovascular disease

Can enable us to live healthier and longer with preventive care.

Each year, about 56 million people die.[8] By a large margin, the leading cause of death is cardiovascular disease, responsible for over 33% of deaths globally.

To peel back the layers, a major cause of human cardiovascular disease is atherosclerosis. The key culprit that acts early to kickstart the development of atherosclerosis is foam cell formation.[9] And, a major factor in foam cell formation is lipid droplets. Lipid droplets manage lipid storage, lipid balance and potential protein associations.[10] Interestingly, lipid imbalance is related to a variety of diseases beyond cardiovascular disease such as obesity, fatty liver disease, type 2 diabetes, Alzheimer's disease and cancer. That's why gaining insights about lipid droplets can be so transformational.

That led researchers at the University of Utah[11] to work on tackling atherosclerosis by exploring foam cell formation and lipid droplets. They are using AMD EPYC compute at Expanse at San Diego Supercomputer Center to model the effect of sterol esters and non-encoding RNAs on lipid droplet phase changes and foam cell formations. Breakthroughs in this area of science could help millions of people around the world mitigate the impact of diseases that are often fatal.

"Our researchers are fast-tracking what's possible with HPC at SDSC, a pioneering leader in high-performance and data-intensive computing. Helping tackle global epidemics like atherosclerosis is a great demonstration of what HPC can do for our world," says Shawn Strande, deputy director of SDSC at the University of California, San Diego.

8 https://ourworldindata.org/causes-of-death
9 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7961492/
10 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6770496/
11 https://www.biorxiv.org/content/10.1101/2022.06.05.494869v1

The seven wonders of the HPC world give us a glimpse into the extraordinary, emerging possibilities powered by supercomputing. While it's hard to grasp the magnitude of HPC-powered transformations, one thing is clear: Together with the capabilities of HPC technology, we can solve some of the world's most pressing and significant challenges, driving innovation and enabling breakthroughs that will help mankind in unprecedented ways.

At Dell Technologies and AMD, we are always innovating to help accelerate your ideas and drive innovation forward.

That's how we work together to build a better future for us all.

To learn more about HPC or discuss your specific needs, please visit Dell.com/HPC.

View an Interactive Version of this Ebook