THE POWER OF COMPUTATIONAL SCIENCE

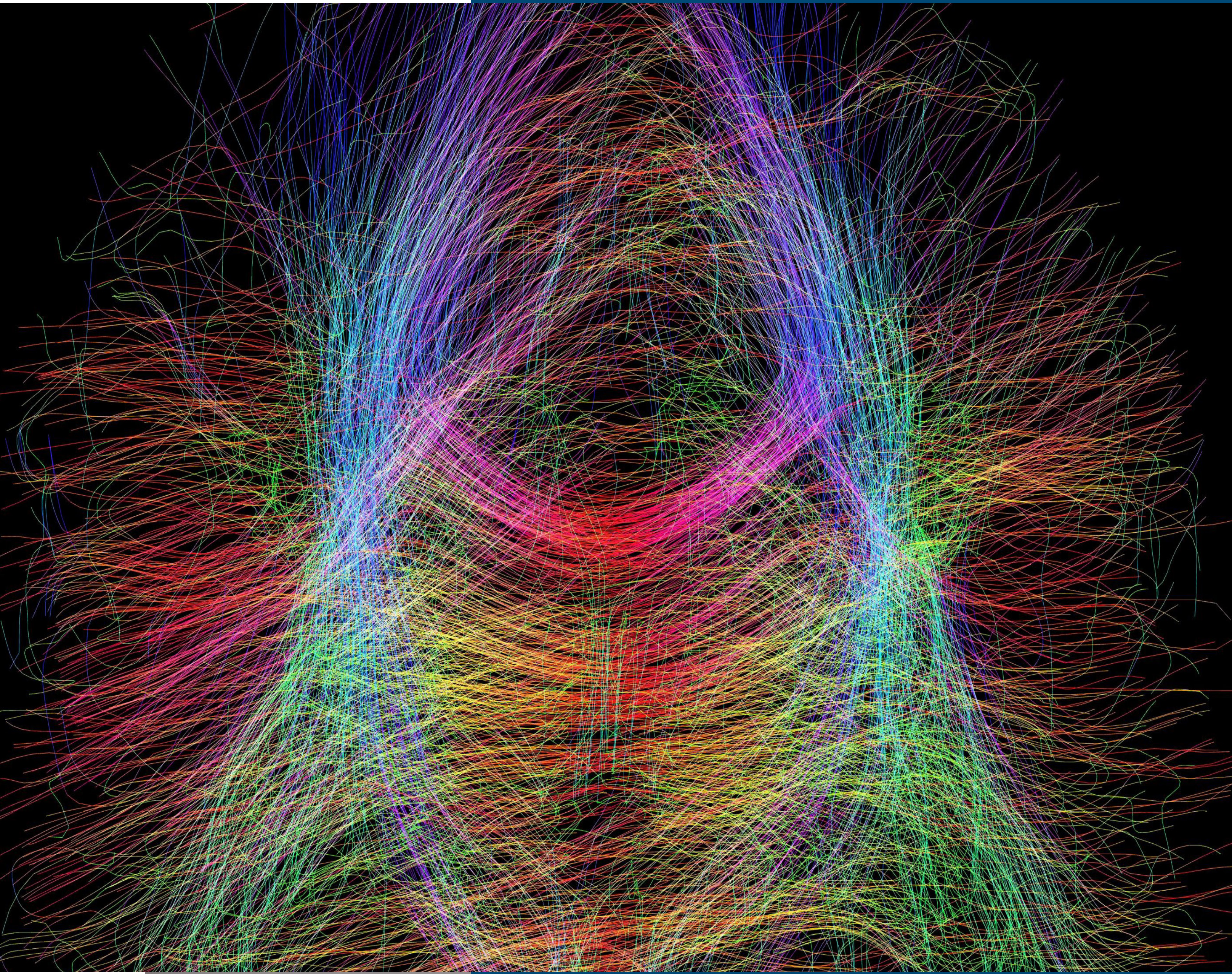
30 YEARS OF DISCOVERIES BEYOND IMAGINATION

2020

CASC

COALITION FOR ACADEMIC SCIENTIFIC COMPUTATION

ABOUT THE COVER



ADAM GOODMAN
UNIVERSITY OF ALABAMA, BIRMINGHAM

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A 3D map of the remarkable network of neurons within the human brain. University of Alabama, Birmingham researcher Adam Goodman and colleagues generated this image from magnetic resonance imaging (MRI) scans, adding colors to indicate the orientation and direction of each nerve fiber. While traditional, sequential data processing methods could take years to analyze these maps, supercomputers operating in a parallel framework make it possible in hours. Analysis of these maps helps researchers better understand the complex neural networks that enable emotional experience and underlie changes in mental health states. Copyright Adam Goodman, University of Alabama at Birmingham, Epilepsy Research Center.

(below) Scott Birch from Indiana University's Advanced Visualization Lab worked with Scott Echols from Scarlet Imaging and colleagues at Pixelbeaker to develop this visualization of the complex arrangement of blood vessels inside a parrot's head. Researchers imaged the animal with a form of computed tomography (microCT) and then rendered its vasculature in 3D. Visualizations like these provide a platform for veterinary students and researchers to study the complex anatomy of a variety of animals in precise detail.

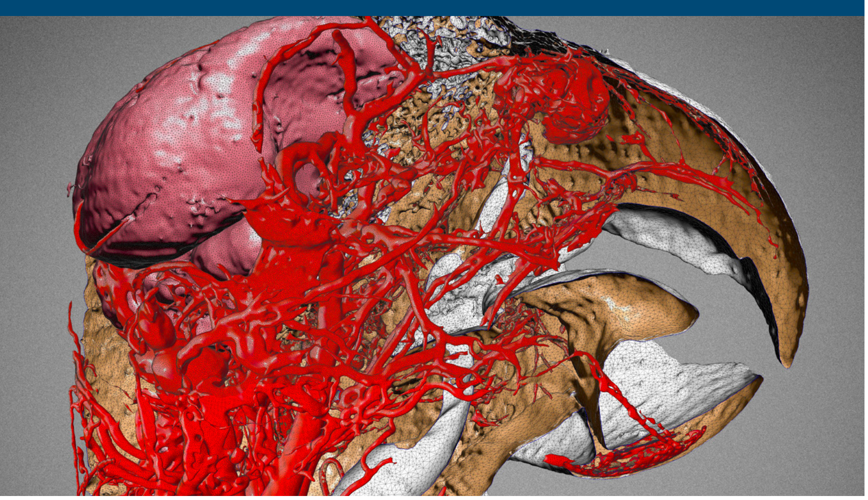

IMAGE COPYRIGHT SCOTT BIRCH, INDIANA UNIVERSITY

ABOUT CASC

Founded in 1989, the Coalition for Academic Scientific Computation (CASC) is an educational nonprofit 501(c)(3) organization with 90+ member institutions. CASC envisions a robust, sustainable ecosystem supporting academic research computing and data services, enabled by a vibrant, diverse community of professionals.

CASC Mission

• To advocate for the importance of and need for public and private investment in research computing and data services to support academic research.
• To serve as a trusted advisor to federal agencies on the direction of relevant funding programs.
• To actively engage in discussions of policies related to research computing and data services.
• To foster advancement of a robust and diverse community of current and emerging leaders in this field.
• To provide a forum for the community to share strategic ideas and best practices.

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CASC MEMBERS POSED WITH A CUT-OUT OF "INTERNET SUPERHERO" VINT CERF AT THE NATIONAL INVENTORS HALL OF FAME IN 2018.

CASC AT 30

Since its founding in 1989, CASC has grown from a scrappy band of universities excited about their first supercomputers to a thriving network of 90+ research computing centers representing a wide range of educational institutions, national laboratories and other research organizations.

While the data, technology and scientific tools—and certainly the hairstyles—have changed over three decades, the need to cultivate research computing expertise has not.

In the early days, academic investments in high-performance computing (HPC) were largely rooted in the needs of researchers focused on fundamental physics and astronomy. While HPC remains vital to these fields, demand for computing resources exploded as computational science began revolutionizing research methods in almost every field of science, from medicine to chemistry to climate to political science.

Today, computational science is perhaps more vital to our national priorities than ever before. Researchers across America are using big data and computational muscle to build knowledge and create solutions that will be central to strengthening the nation's infrastructure, ensuring safe food and clean drinking water, improving access to health care, reducing the impacts of disasters, protecting natural resources and promoting space exploration, among many other goals.

While developments in computational science have opened countless opportunities for discovery and innovation over the years, new challenges have emerged as well. Data collections are larger, more dynamic and more complex than ever. Computing is not just about supporting individual scientists and facilities but connecting vast networks of observatories, data repositories, and analytical tools across disparate locations and in the cloud. At the same time, complex ethical, privacy and security concerns continue to develop and evolve at staggering speed.

As a hub for building expertise and guiding investments in research computing infrastructure, CASC expands understanding of the roles, opportunities and challenges of computational science among researchers, businesses, governments, elected leaders and the American public. To plan for our next 30 years, we're taking a renewed look at our organization's goals and how we operate, having appointed special committees to update CASC's mission, vision, and by-laws. Drawing upon the rich history and diverse aspirations of our membership, these efforts will help position the organization and its members to continue to advance computational science for many fruitful decades to come. We welcome your ideas at info@casc.org.

CASC Then and Now

Former CASC leaders reflect on the organization's role at its founding and today

"I became involved with CASC when I was directing HPC at the University of Arkansas. For a smaller university then and now, CASC made the difference between being able to provision nationally competitive computing resources, and not. The CASC community is a great source of information and professional support, and the need for the expertise provided by the CASC community is as high as ever."

– Amy Apon, Clemson University

"We have new tools, new members, new challenges and new foundational precepts, but they all seem not so different at their cores than the way they were for me 30 years ago. We may now be talking about quantum computing, but the lessons learned from the inception of the parallel processing evolution still bear studying [...] Like Officer Clubs in the military, there needs to be [...] an organization to speak for many, and a locus for future vision creation. As the HPC community evolves, these needs will become increasingly important, albeit continually shifting."

– Dan Davis, University of Southern California (retired)

"I remember the beginnings of CASC 30 years ago [...] We had no idea of the tremendous success that it would become. The idea of CASC was partly inspired by the NSF's Supercomputer Center program and the NSFnet, which brought high level computing within reach of all major universities. CASC immediately became a major communication channel for computational scientists."

– John Connolly, College of the Desert (Connolly directed NSF's Division on Advanced Scientific Computing in the mid-1980s and was director of the Kentucky Center of Computational Sciences when it became one of CASC's founding members.)

"Academic supercomputing has always been about specialized hardware and software and exciting research enabled by supercomputers. This is still true, but over the decades, what has changed is the expanded research impact across a broader spectrum of domains and the support system that is necessary for this impact. The support system is made up of institutional and national aspects, such as policy, funding, and strategy, as well as training, consulting, workforce development, and specialized operations and development expertise. CASC is critical in advocating for all of these needs, both to government and to local and regional academic stakeholders."

– Sharon Broude Geva, University of Michigan (current CASC Chair)

REMEMBERING 9 11

Sue Fratkin, CASC Washington Liaison 1989-2015, recalls gathering with CASC members on a fateful date

The CASC member organization regularly meets twice per year (spring and fall) in Washington, D.C. The dates were never important, until we happened to be meeting on September 11, 2001.

That year, the CASC members wanted to convene on Capitol Hill. We scheduled a luncheon in the Rayburn House Office Building, and invited the Members and staff of the House Science Committee. We also set up a meeting at the White House with the President's Science Advisor, Dr. John Marburger. I knew Dr. Marburger when he served as the Chancellor of SUNY Stony Brook, before his White House post; we enjoyed working with him on the issues that were important to CASC.

We started with breakfast at La Colline, a restaurant conveniently located near the U.S. Capitol building. Beverly Clayton, Executive Director of the Pittsburgh Supercomputing Center, was the CASC Chair. We created a folder with a map of the United States, indicating the location of all the CASC members at that time (22), and included notes on the research activities underway at member sites. As the CASC representatives visited their respective members of Congress, this folder was to be left behind, and then more copies were to be distributed at the luncheon.

As the breakfast meeting was adjourning, I went into the restaurant bar to pay the bill. The televisions in the bar were showing the scene unfolding in New York. One building had already been hit, and I watched horrified as the second plane hit the second tower.

The La Colline bar was a local breakfast spot for press and media working the Hill, and pandemonium ensued. Cell phones and pagers started beeping, and chairs scraped across the floor and fell as the diners threw their money on the tables and ran out of the restaurant to track the story.

Returning to the "back room" where we had just met, I quickly told the assembled CASC members that it was unlikely that we would be convening later in the day, as we could hear the televisions blaring that now Washington, D.C. was a target, and (erroneously, it turned out) that the State Department was already hit and burning. Realizing that the airports were going to be closed, the CASC members started looking into alternative ways to get home. The San Diego folks connected with others in town to rent a bus and drivers to go across the country. Those closest to D.C. rented cars and drove home; others hunkered down for the duration. The Alaskans stayed for a week before they could fly home.

Unfortunately, after all the efforts to obtain White House clearance for the CASC members to attend the briefing with Dr. Marburger, there was no question that the meeting would be cancelled.

On a positive note, we were able to donate the food that was being delivered to the House Science Committee Room for our luncheon, so it wouldn't go to waste. It went to So Others May Eat (SOME.org), a long-standing D.C. charity for the homeless.

Living in Washington, D.C. has always offered a touch of excitement and intrigue. On that fateful day, a few blocks from the U.S. Capitol, CASC as an organization grew closer, and we learned not to take our freedom for granted ■

Supercomputers Over the Years

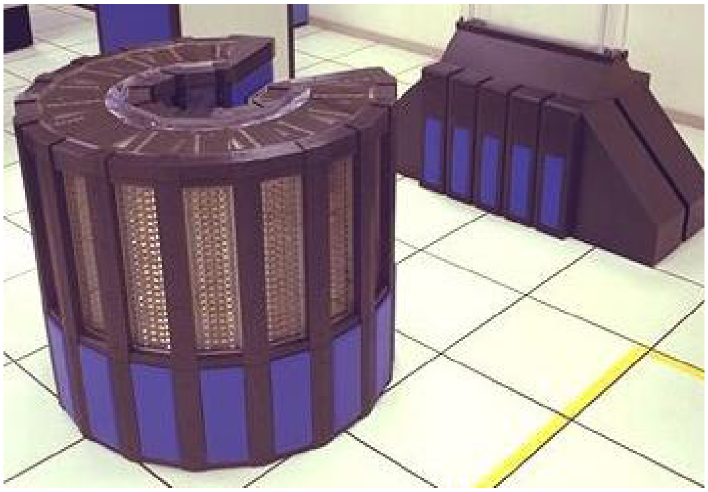


IMAGE BY NASA

The Cray 2 supercomputer was the state-of-the-art machine in the mid-1980s, when the National Science Foundation established the first university-based supercomputer centers in the U.S.

IMAGE BY DAVE PAPE, NASA/GSFC

The Cray Y-MP supercomputer was a popular model during the Coalition for Academic Scientific Computation's early days. Today's smartphones and gaming consoles have more computational power!

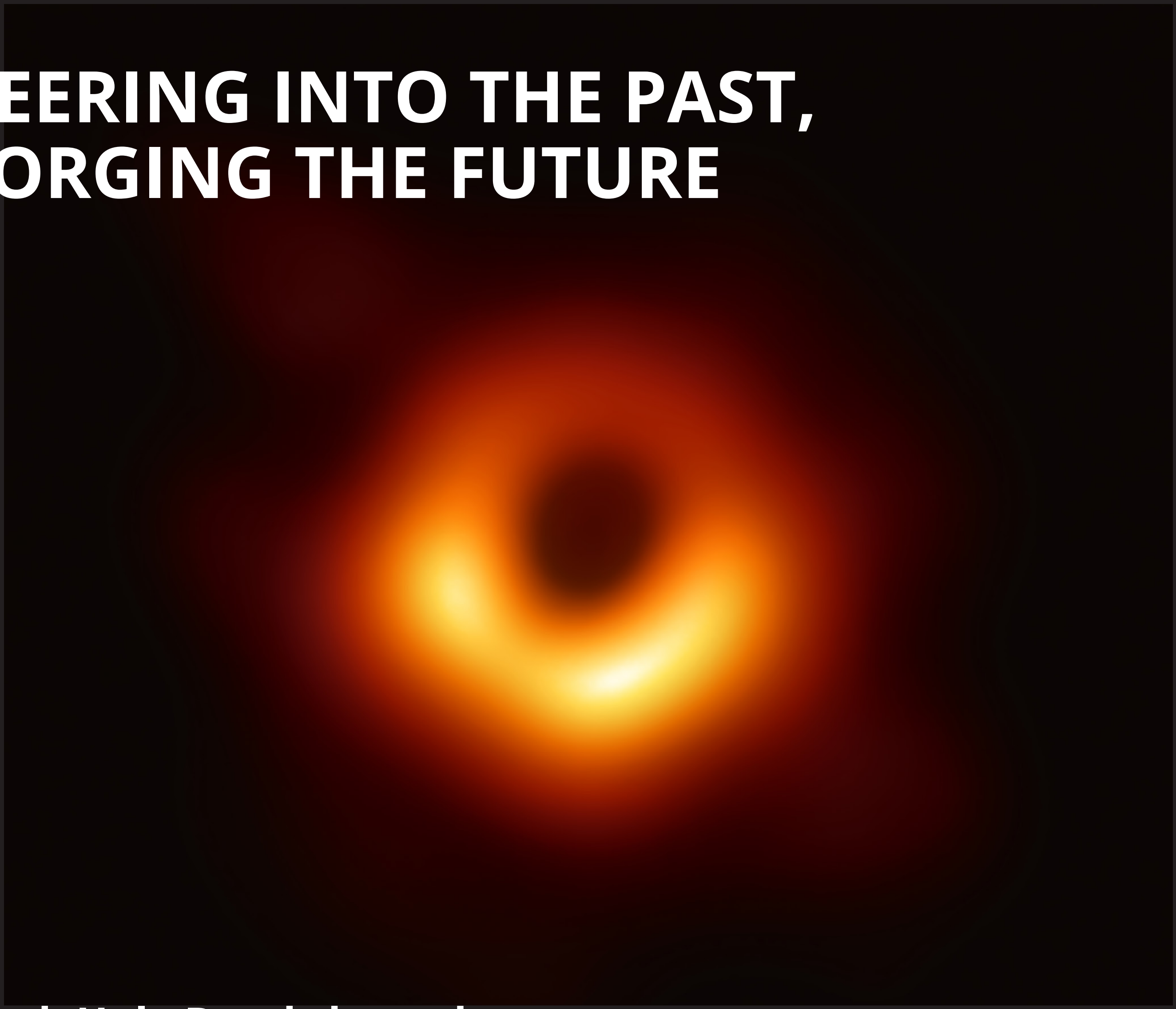
IMAGE COPYRIGHT ARGONNE NATIONAL LABORATORY [CC BY-NC-SA 2.0]

The IBM Blue Gene/P supercomputer at Argonne National Laboratory in 2007. By the 2000s, supercomputers were processing on the petascale (performing more than one quadrillion floating point operations per second).

IMAGE COPYRIGHT TEXAS ADVANCED COMPUTING CENTER

Frontera came online in 2019 as the world's 5th fastest supercomputer and the #1 fastest computer on a university campus. The system, funded by the National Science Foundation, is located at the Texas Advanced Computing Center at The University of Texas at Austin.

PEERING INTO THE PAST, FORGING THE FUTURE

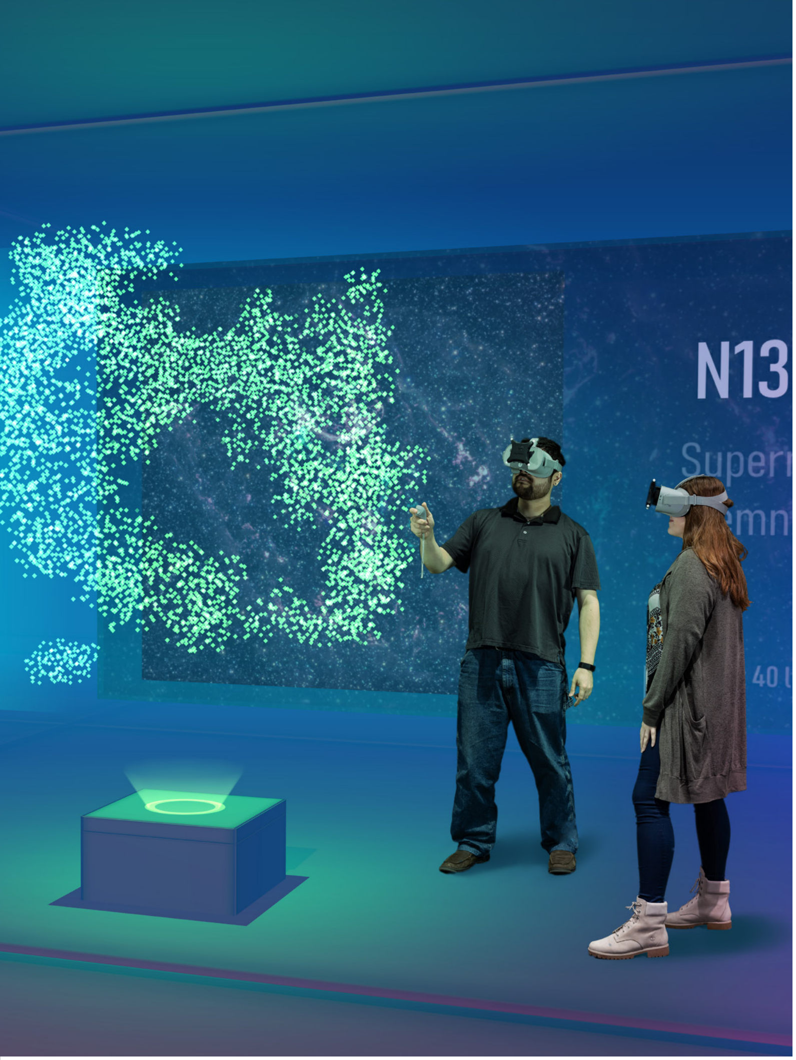


Black Hole Breakthrough

Within minutes of its public release in April 2019, the image streaked around the globe, captivating seasoned scientists and the uninitiated public alike. Suddenly what had been described as “unseeable” was there before our eyes: a black hole, evident in all its light-bending glory, viewed across more than 53 million light years of space.

The image was produced by the global network of radio telescopes known as Event Horizon Telescope with contributions from hundreds of scientists. Almost all the steps leading up to the achievement required intensive computation, from simulations suggesting what a black hole might look like and where to hunt for them, to collecting and interpreting massive amounts of radio telescope data, to aligning simulations, observations and theoretical physics in order to confirm the discovery.

Pivotal to these efforts were the Stampede 1 and Stampede 2 supercomputers at The University of Texas at Austin’s Texas Advanced Computing Center (TACC), as well as Jetstream, a large-scale cloud environment at TACC and Indiana University. Researchers from numerous CASC member institutions, including Harvard University, the University of Arizona, University of Illinois at Urbana-Champaign, Boston University, Cornell University and the University of California, Berkeley, participated in the collaboration ■



Reconstructing an Exploded Star

Purdue University researcher Danny Milisavljevic and colleagues developed this immersive 3D simulation to help piece together the chain of events that creates a supernova. Supernovae, among the most important energy sources in the universe, produce black holes and create the raw materials that make life possible. Simulating them with virtual reality allows researchers to collaboratively probe their structures and explore the powerful forces behind their titanic explosions. The work also contributes to a broader effort to ramp up cyberinfrastructure for processing and interpreting data from the Large Synoptic Survey Telescope, set to come online in 2022 ■

Envisioning the Flying Car

The aerospace company Boeing set an ambitious goal with its GoFly challenge: to crowdsource the design of a safe and practical personal flying device. But before people started launching themselves into the air, the company wanted to provide contestants with the data and tools to test their designs virtually. Ray Leto and his team at TotalSim, LLC repurposed TS Aero, an app for modeling the fluid dynamics that aircraft encounter, to create a flight simulation environment tailored to the GoFly parameters. The Ohio Supercomputer Center (OSC) of The Ohio State University provided the computational might to power the portal and app for GoFly contestants, allowing each contestant to run simulations for free. The simulations run on AweSim, OSC's platform dedicated to helping industrial collaborators harness the power of simulation-driven design ■

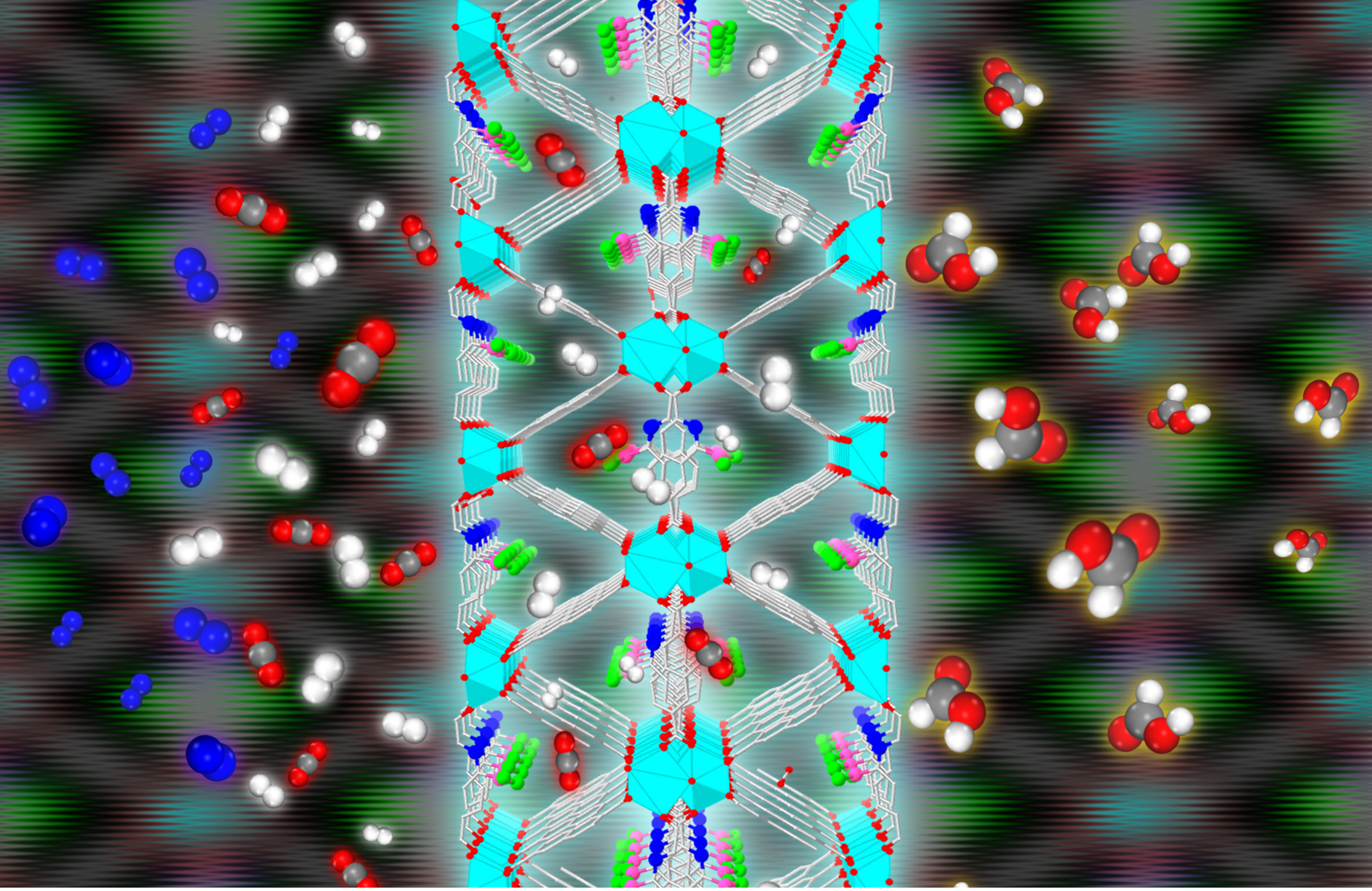


IMAGE REPRODUCED BY PERMISSION OF KARL JOHNSON AND THE ROYAL SOCIETY OF CHEMISTRY FROM CATAL. SCI. TECHNOL., 2018, 8, 4609-4617, DOI:10.1039/C8CY01018H.

TRANSFORMATIONAL TECHNOLOGY

Turning Pollution into Products

Karl Johnson and colleagues at the University of Pittsburgh are working to invent materials that can not only capture carbon dioxide from the air but turn it into commercially valuable products like chemicals and fuels. This image shows how a new synthetic material could convert carbon dioxide into formic acid, a chemical used to make methanol fuel. The material, a metal oxide framework with many tiny pores inside, performs well in simulations; the next step is to see if it works in the lab and factory. Simulations were performed at the Center for Research Computing at the University of Pittsburgh and on the XSEDE-allocated Bridges-2 Supercomputer of the Pittsburgh Supercomputing Center, a joint research center of Carnegie Mellon University and the University of Pittsburgh ■

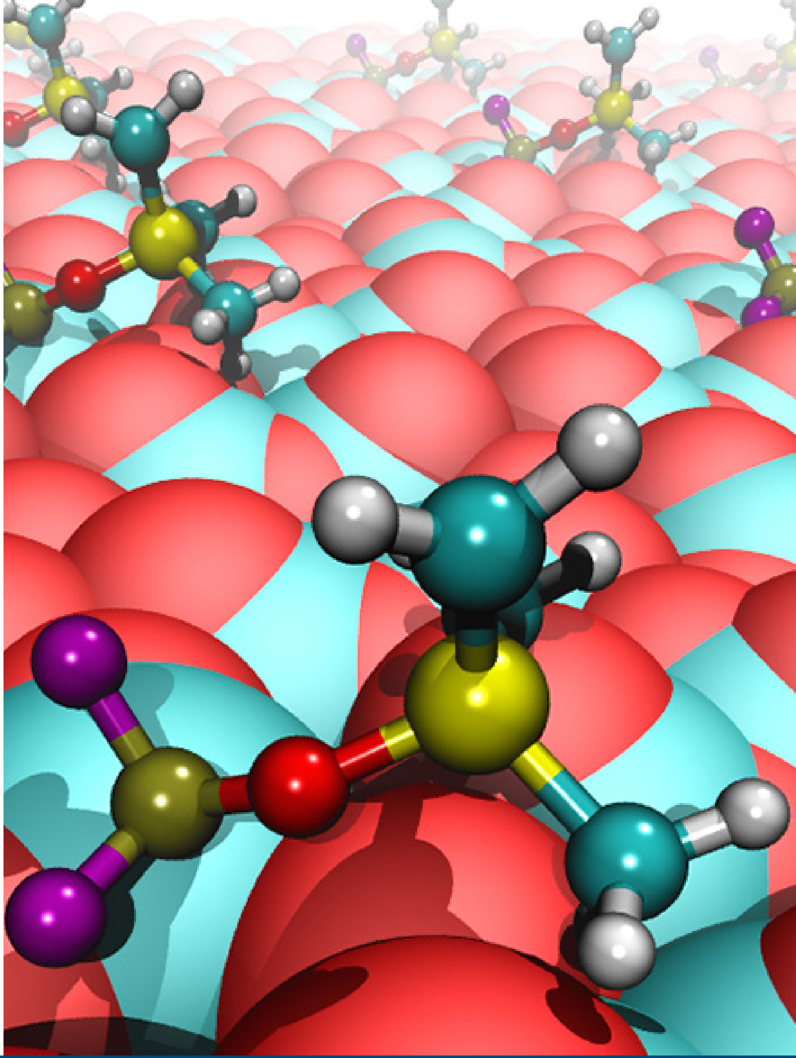


IMAGE COPYRIGHT JUAN GARCIA AND HAKIM IDDIR, ARGONNE NATIONAL LABORATORY

Better Batteries

If pickling can preserve vegetables, can it also work on batteries? Surprisingly, the answer is yes. Seeking ways to extend the life of lithium-ion batteries, Hakim Iddir and colleagues from Argonne National Laboratory modeled the chemical reactions that occur on the cathode surface. They found that mixing an additive, trimethylsilyl phosphite, into the battery's liquid electrolyte creates a chemical derivative that helps stabilize the interface between liquid electrolyte and solid electrodes in a reaction similar to pickling. The result is that battery performance, like a good gherkin, improves with age.

While the additive was previously known to extend battery life, understanding how it works could help researchers further improve this process. The image shows "pickled" electrolyte molecules binding to reaction centers on the cathode surface, keeping it from degrading. Uncovering this process took about 41,500 computing hours—equivalent to one regular computer running for five years straight—at the National Energy Research Scientific Computing Center at Lawrence Berkeley National Laboratory ■

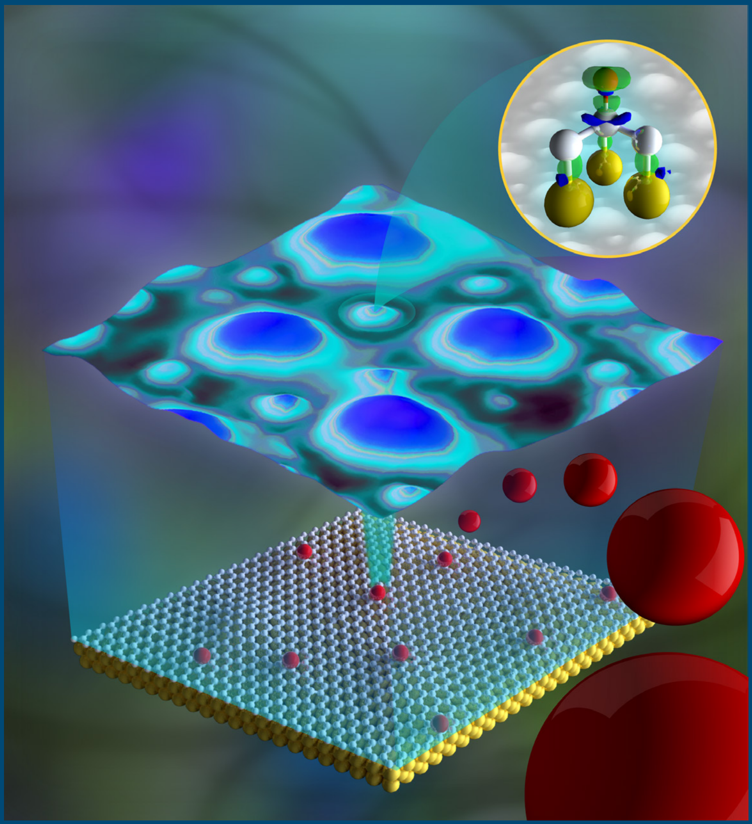
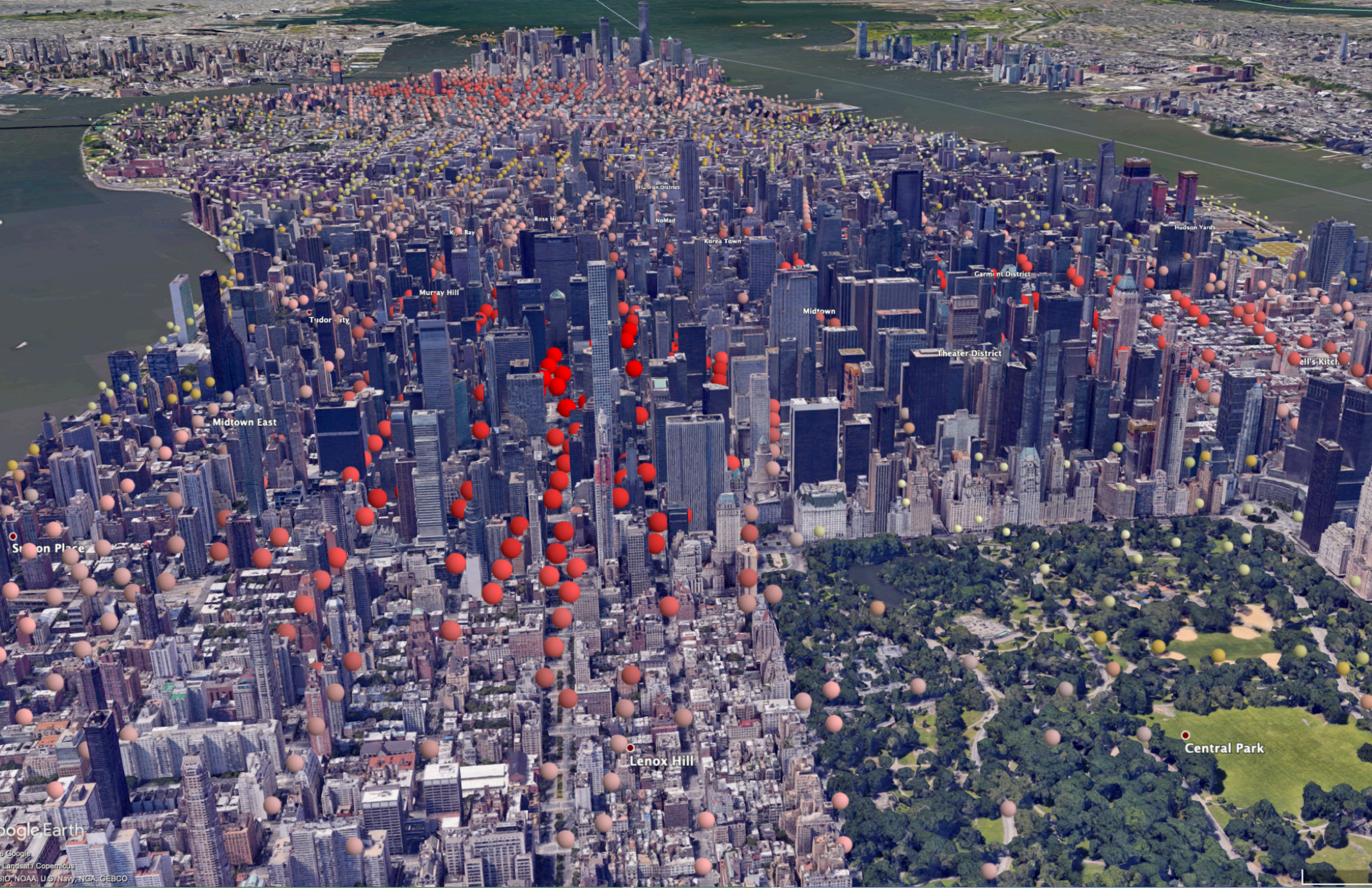


IMAGE CREATED BY CORTLAND JOHNSON AND VASSILIKI-ALEXANDRA GLEZAKOU OF PACIFIC NORTHWEST NATIONAL LABORATORY AND PUBLISHED IN J. AM. CHEM. SOC. 2018, 140(15), 5102-5109, DOI: 10.1021/JACS.7B12791.

Magic Carpet Ride

In chemistry, catalysts are where the magic happens. With the right catalyst, a stubbornly slow process becomes a zippy reaction that can efficiently produce valuable outputs like fuels, plastics and other materials. Manh Thuong Nguyen and colleagues at Pacific Northwest National Laboratory are using innovative computational techniques to design new catalysts from the bottom up, reducing the need for trial-and-error experimentation.

This image shows a simulation in which an ultra-thin material called graphene is spread over a sheet of ruthenium metal like a carpet. According to the model, the resulting structure will cause oxygen atoms to bind to only one carbon at a time, instead of the usual two. Researchers can use this insight to manipulate the placement of oxygen and metal atoms in order to build better catalysts. The modeling was performed at the National Energy Research Scientific Computing Center ■

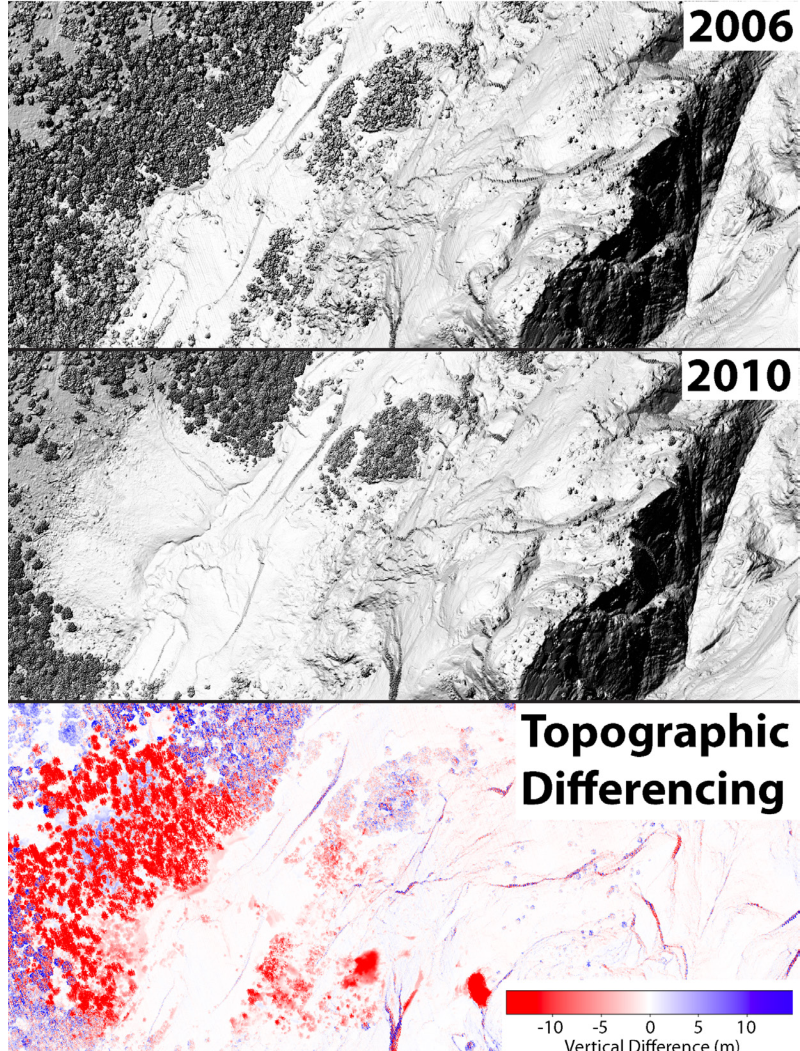


TRACKING ENVIRONMENTAL CHANGES...AND DANGERS

How's the Air on Your Block?

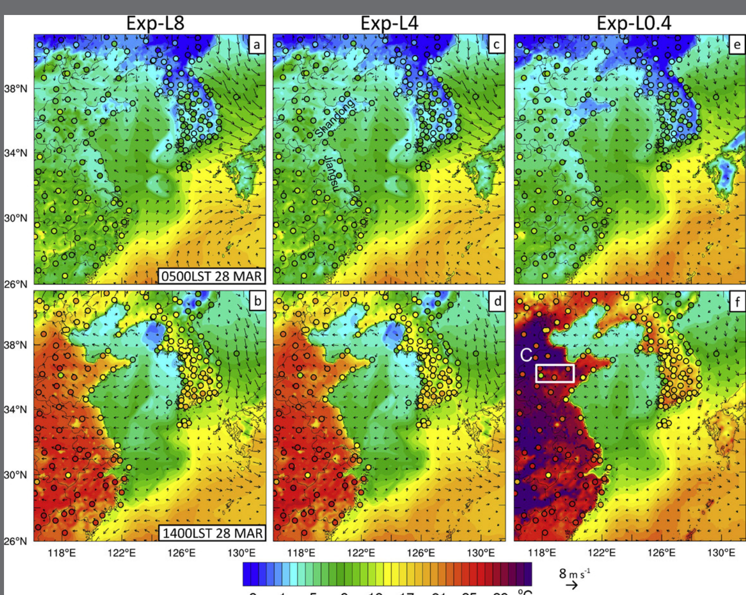
In general, the air is more polluted in cities than in the countryside. But how does it vary block by block? With this image, Princeton University researchers Maider Llaguno-Munitxa and Elie Bou-Zeid, in collaboration with William Guthe and Eliot Feibush, represent the hyper-local variation of the concentration of 2.5 micron particulate matter—the type of air pollution considered most harmful to human health—in New York City.

The visualization uses data collected from a network of stationary and mobile air quality sensors that can perform street-by-street air quality surveys, and displays them spatially utilizing the Google Earth map of Manhattan. Pollution is highest around the most densely developed areas, but as you stroll over to Central Park, the concentration plummets, underscoring how emissions from traffic and buildings influence the air we breathe. Making the invisible threat of air pollution visible can help researchers and the public better understand pollution sources and how to control them ■



Beware of Falling Rocks

The sheer rock faces and towering mountains of Yosemite National Park may be beautiful, but they're also dangerous. The area has experienced more than 1,000 rockfalls in the past 150 years, posing a threat to people and buildings. Arizona State University researcher Chelsea Scott mapped where rocks and trees fell at Yosemite between 2006 and 2010. The bottom image shows the movement of rock from areas that lost height (red) to those that gained height (blue). Scott used lidar imaging data from OpenTopography, a National Science Foundation funded project that facilitates access to Earth science topography data based at San Diego Supercomputer Center and operated in collaboration with Arizona State University and UNAVCO. Getting a clearer picture of the most unstable areas can help park managers keep visitors out of harm's way ■



Focusing on Fog for Safer Shipping

Sea fog shrouds the Yellow Sea between China and the Korean peninsula for about 50-80 days per year, making one of the world's busiest shipping areas also one of the most dangerous for vessels. Better predictions could improve both safety and shipping efficiency, but the conditions that cause sea fog are poorly understood.

To improve forecasts, University of Oklahoma researcher Xiao-Ming Hu and collaborators from Ocean University of China used data from a 400-mile-wide sea fog event in the Yellow Sea to develop a computer simulation modeling how sea fog forms and behaves. These images show how researchers optimized the model by adjusting its vertical resolution to best capture how moisture and temperature gradients combine to create dangerous fog. The model's configurations can also be useful for improving predictions of other meteorological events. Computations were performed at the San Diego Supercomputer Center ■

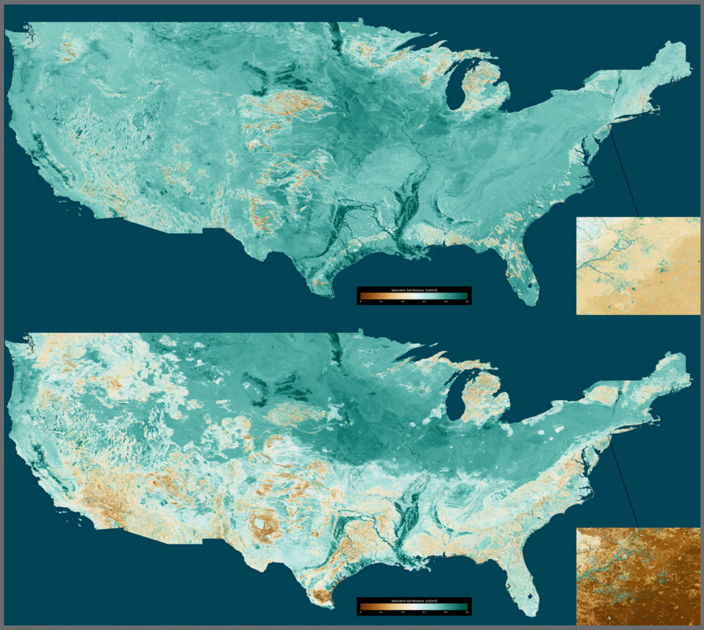


IMAGE COPYRIGHT NOEMI VERGOPOLAN AND ELIOT FEIBUSH, PRINCETON UNIVERSITY

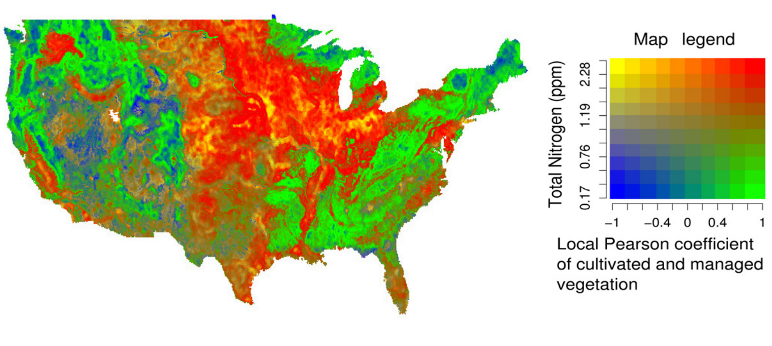
Mapping Soil Moisture

Soil moisture reveals a lot about a place, from which areas of a farm need irrigation to which neighborhoods are likely to flood. Satellites and in-ground sensors provide valuable data on soil moisture, but these methods can be expensive and scarce when it comes to getting detailed information about frequently-changing conditions. To complement these data sources, Noemi Vergopolan of Princeton University combined satellite and model simulations to provide high-resolution soil moisture estimates across the entire continental U.S.

These images show the distribution of moisture in the top 5 centimeters of soil during wet winter conditions (top) and dry summer conditions (bottom). With a resolution of 3 hours and 30 meters, the methodology allows users to easily zoom in for an estimate of the conditions at particular places and times (inset boxes show a 33-kilometer area at native 30-meter resolution). The results were simulated using the HydroBlocks land surface model, which aggregates big data from various Earth science data sets into a format that can be efficiently accessed and used ■

Accounting for Nutrient Pollution in Streams and Rivers

IMAGE COPYRIGHT LONGZHU SHEN, UNIVERSITY OF CAMBRIDGE AND GIUSEPPE AMATULLI, YALE UNIVERSITY



Nitrogen and phosphorus are essential nutrients for plants and key components of fertilizer, but the flow of excess nutrients from farms into downstream bodies of water can cause serious problems. Nutrient pollution chokes rivers and lakes with an overgrowth of algae that can release toxins, sickening people and killing fish.

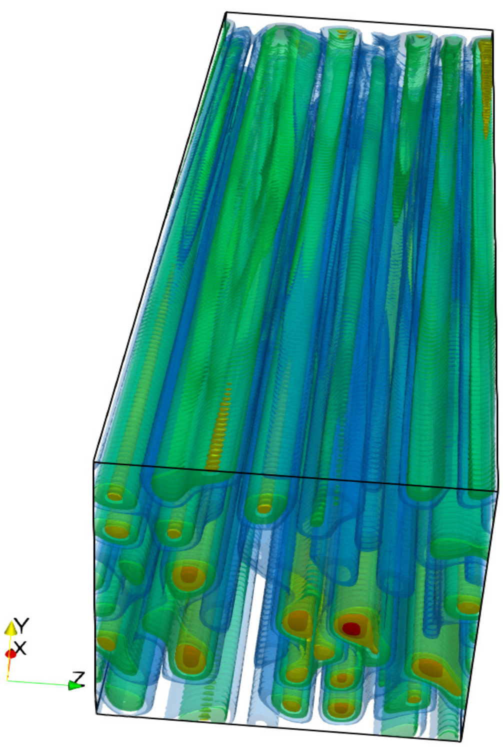
To get a handle on nutrient pollution sources and impacts, researchers Longzhu Shen, University of Cambridge, and Giuseppe Amatulli, Yale University, and colleagues use machine learning to model how nutrient concentrations relate to areas of farmed land at different times of the year. This map from their model shows nitrogen concentrations in streams and rivers during the fall. Areas of red and green reflect a strongly positive correlation (indicating nitrogen concentrations are strongly correlated with cultivated vegetation), while areas of blue and yellow indicate a strong negative correlation (mainly forested and desert areas). This national-level view can help inform local agricultural and resource management practices to reduce the toll of nutrient pollution ■

ADVANCING ENERGY FRONTIERS

IMAGE COPYRIGHT MAITREYA VENKATASWAMY, REETESH RANJAN, AND SURESH MENON, GEORGIA INSTITUTE OF TECHNOLOGY

Combustion Up Close

Combustion may be one of the oldest energy technologies, but there's still room for improvement. With an eye toward increasing efficiency and reducing emissions, Georgia Institute of Technology researchers Maitreya Venkataswamy, Suresh Menon and Reetesh Ranjan (now at the University of Tennessee Chattanooga) took an up-close look at the complex interactions between fuel and air inside a combustion chamber. This image shows the flame and chemical species formed as the liquid fuel enters the combustion chamber, disperses, evaporates and interacts with swirling air. Colors reflect temperature gradients, while lines indicate the direction and velocity of the flow. Researchers use sophisticated simulations like this to virtually experiment with new fuels and engine designs ■



Ferreting Out the Flaws in Fusion

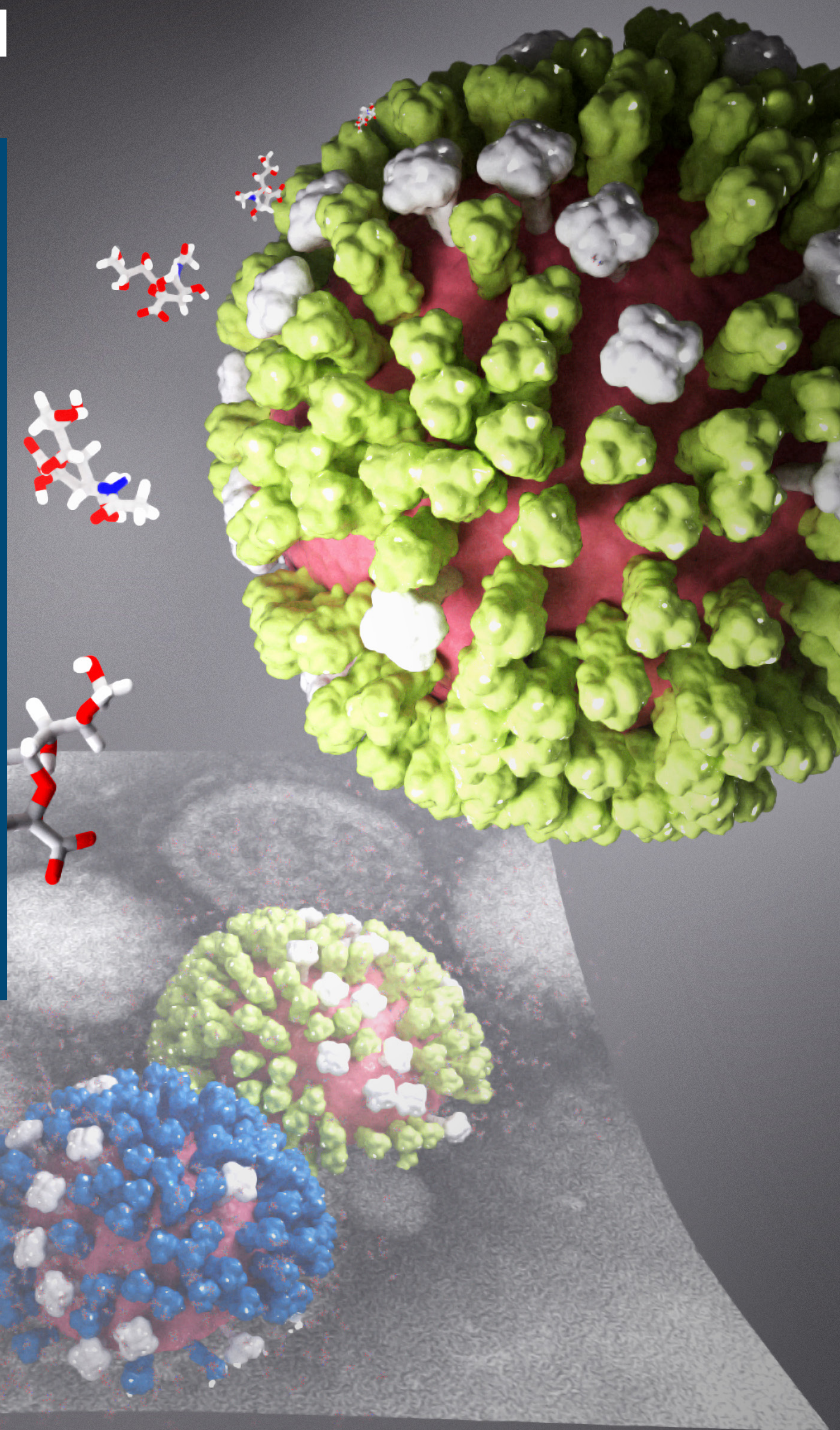
For nearly a century, researchers have sought safe, reliable methods to generate essentially limitless amounts of energy through nuclear fusion. The technology has come a long way, but there are still important roadblocks. One problem is the instabilities that arise in the inertial fusion lasers used in many fusion experiments. This image depicts the tiny filaments—just a few microns wide—that make up the laser profile and likely play a role in the generation of these instabilities. Frank Tsung and colleagues at the University of California, Los Angeles are working to understand the role and behavior of these filaments in order to better control instabilities ■

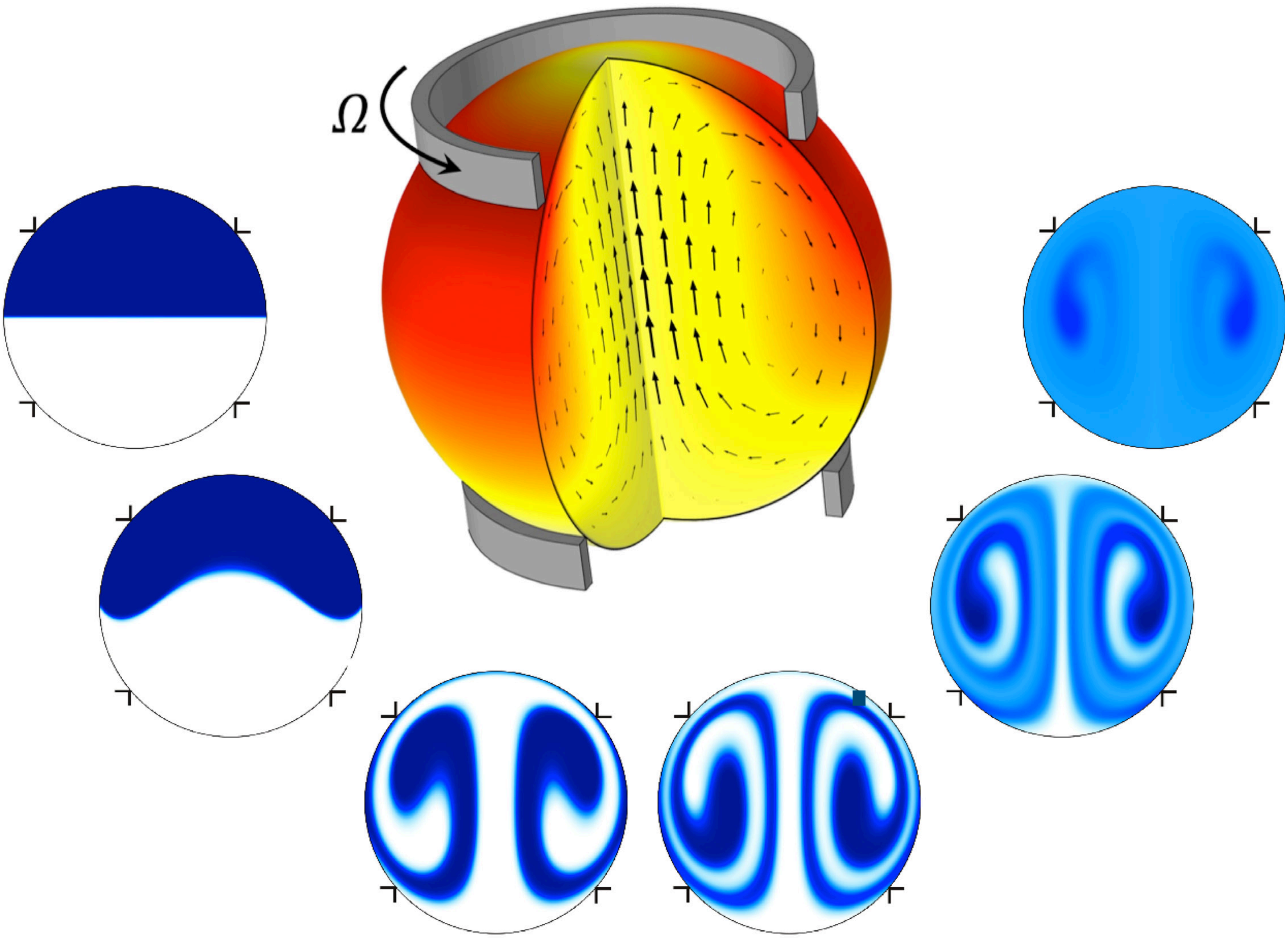
IMAGE COPYRIGHT HAN WEN, LABORATORY FOR LASER ENERGETICS AND UNIVERSITY OF ROCHESTER AND FRANK TSUNG, UNIVERSITY OF CALIFORNIA, LOS ANGELES

INSPIRING MEDICAL INNOVATION

Fighting Flu

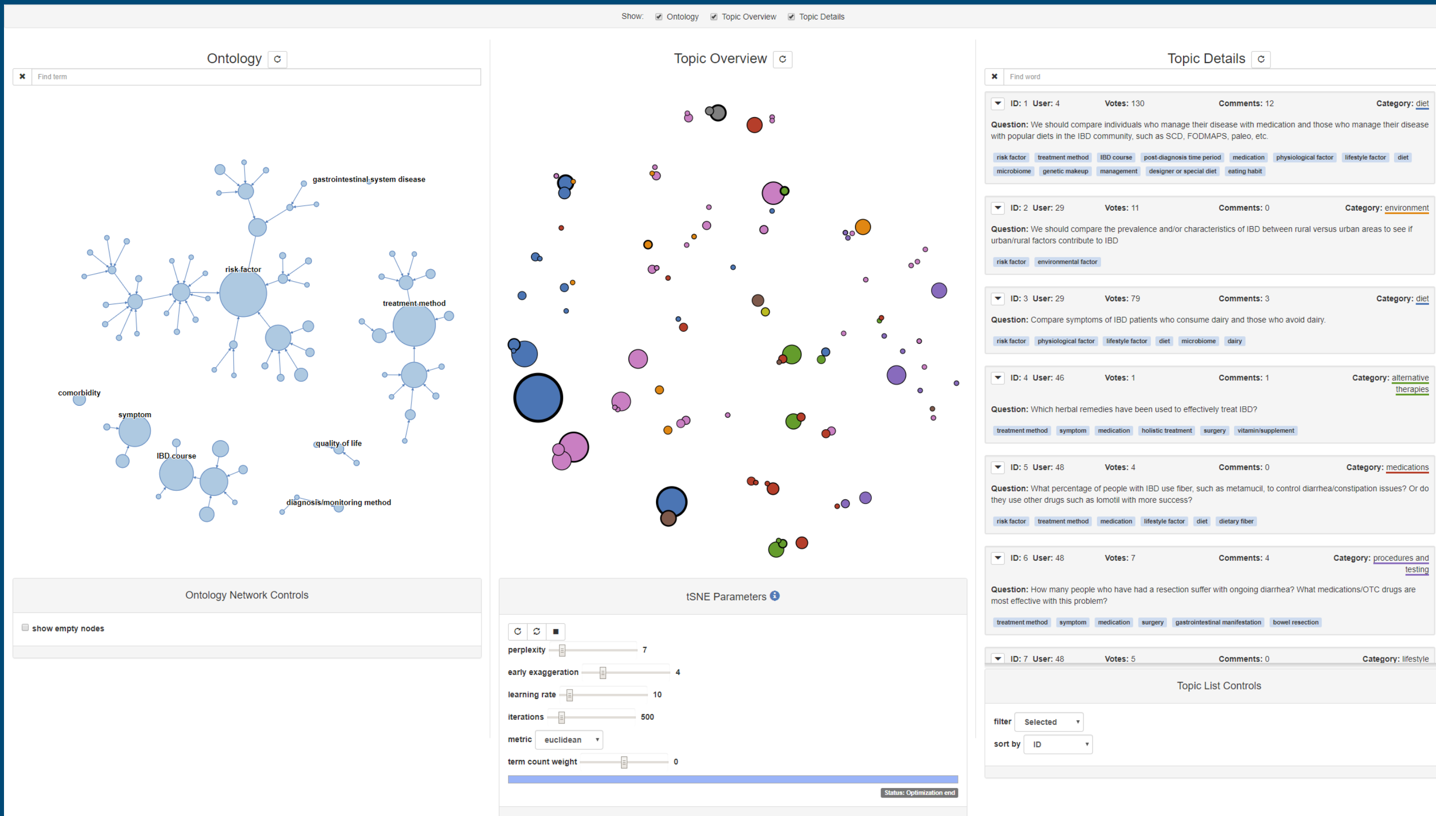
The ancient military maxim to "know your enemy" is fitting when it comes to infectious diseases. Although researchers have studied influenza for decades, mysteries remain. Meanwhile, the virus continues to evolve and spread. Rommie Amaro at the University of Califonia, San Diego and Jacob Durrant of the University of Pittsburgh used the computational might of the San Diego Supercomputer Center to combine insights on the virus from two imaging techniques, x-ray crystallography and electron microscopy. The resulting model of influenza, shown here, helped researchers explore two proteins involved in how the flu interacts with its host. It's an important step forward in uncovering the secrets of the virus—and possibly, its vulnerabilities ■





Exploring Alzheimer's via Zero Gravity

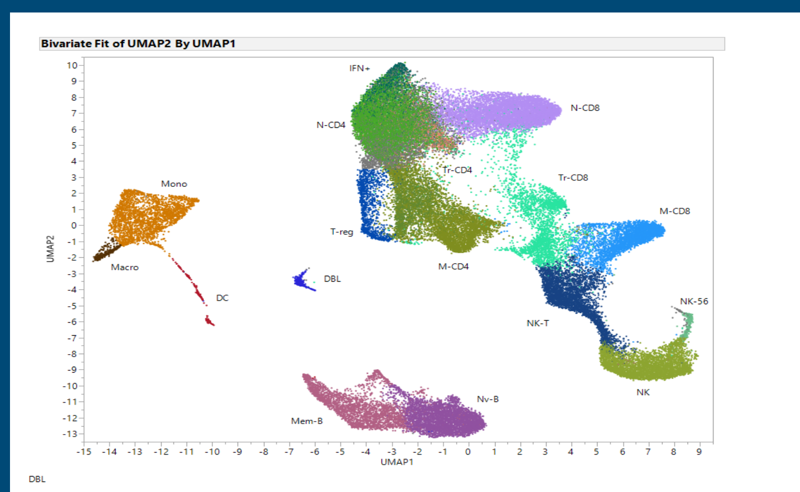
Alzheimer's disease is becoming more prevalent in the U.S., yet a cure remains elusive. Researchers at Rensselaer Polytechnic Institute and Arizona State University are taking an unusual approach to get a better handle on the disease: sending proteins to space. The team developed a hydrodynamic model to explore the amyloid plaques that form in the brains of patients with Alzheimer's. This image shows the shearing and mixing in a drop of their model protein solution, which ultimately forms into amyloid fibrils. Next, the team plans to expand their experiments aboard the International Space Station. Unfettered by gravity, the drops should grow to several centimeters across, facilitating in-depth study of the hydrodynamics involved in fibril formation ■



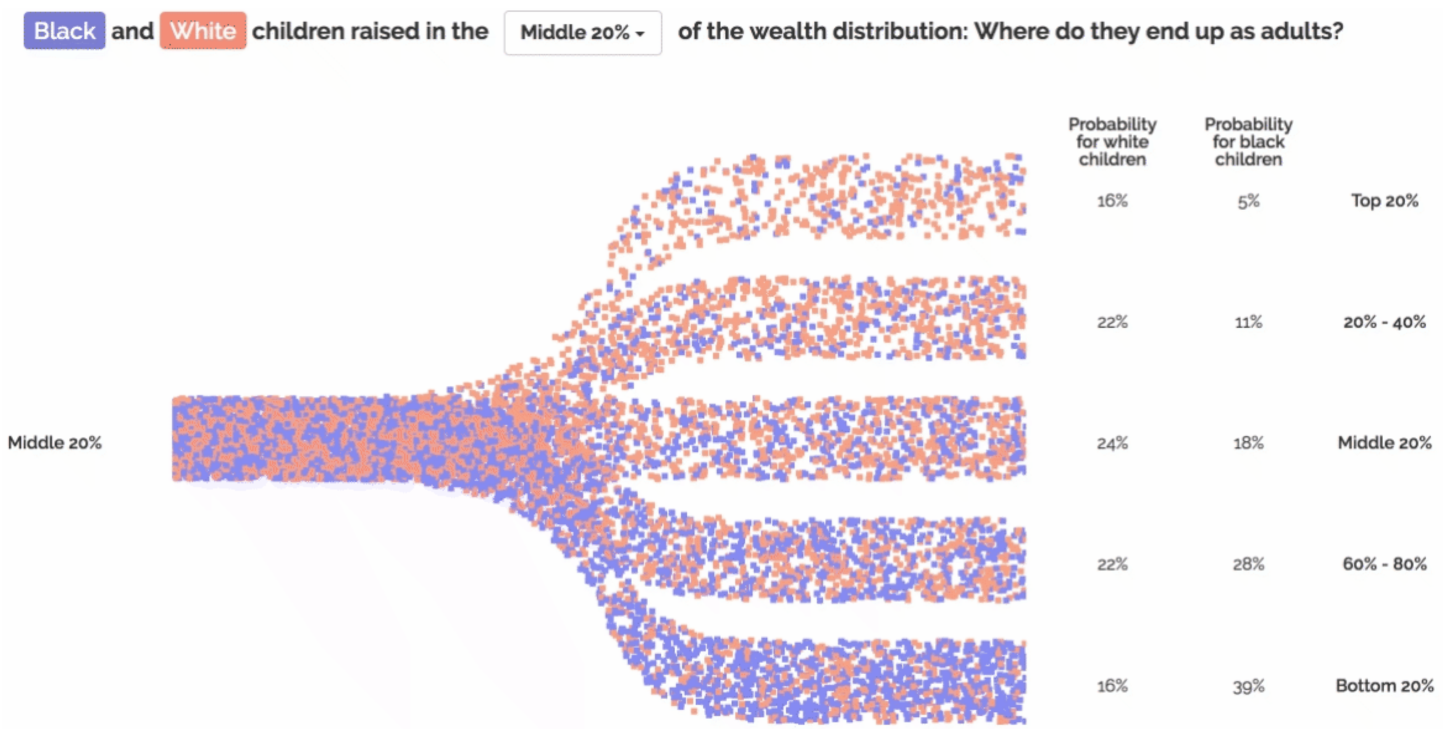
Drawing on the Power of the Crowd for IBD Insights

Rates of inflammatory bowel disease (IBD, which includes both Crohn's disease and ulcerative colitis) have risen markedly in recent decades. While researchers search for better treatments, about 3 million U.S. adults suffer from chronic abdominal pain and diarrhea associated with the disease.

Two research groups are setting machines to work to find new leads. The top image shows an innovative visualization tool that captures themes from an online patient discussion forum. The IBD Partners online community, created as a way for researchers to listen to patients about their daily experience with IBD, includes more than 15,000 patients. By highlighting patient concerns and tracking how discussion themes relate to each other, the visualization helps researchers identify patterns and generate promising research topics. The tool was developed by David Borland of the Renaissance Computing Institute at the University of North Carolina at Chapel Hill.



The second image shows results from a study by Georgia Institute of Technology researcher Greg Gibson that tracked how different genetic signatures relate to IBD outcomes. Gibson and colleagues use high-performance computers to parse vast collections of genetic data and health records for clues on IBD causes and potential new treatments. Their studies also advance a more tailored approach to IBD treatment by helping to predict how patients will respond to available therapies based on genetic factors ■



THE NUANCES BEHIND THE NUMBERS

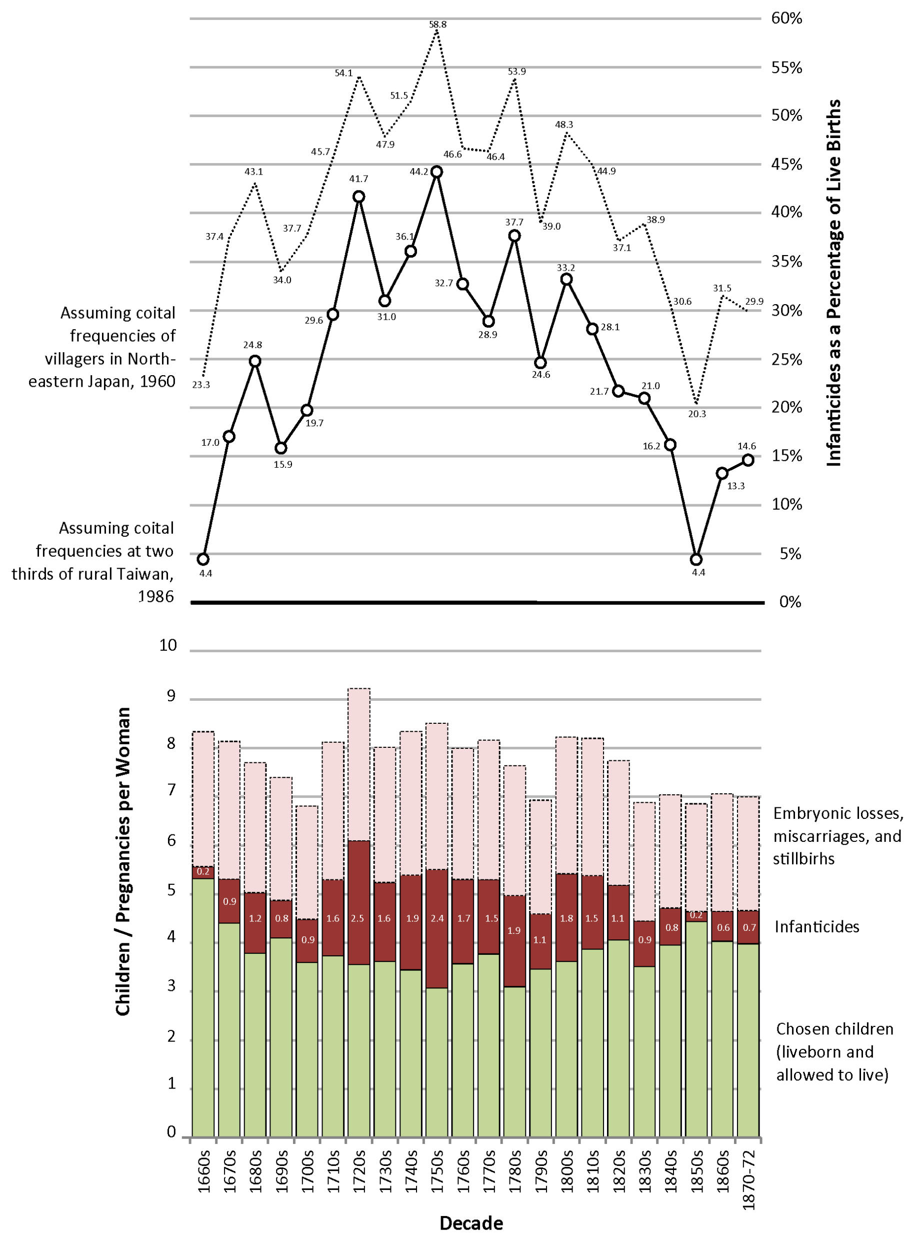
Race and the American Dream

The idea that people can work hard and achieve greater economic success than their parents is central to the American ethos. But research by Fabian Pfeffer at the University of Michigan's Center for Inequality Dynamics and Alexandra Killewald of Harvard University suggests climbing the economic ladder is a lot harder for black Americans. The researchers draw on more than 50 years of survey data from the Panel Study of Income Dynamics to investigate social inequality. This visualization shows that black children born into the middle of the wealth distribution are far more likely than their white counterparts to wind up in a lower wealth position than their parents, underscoring how the racial wealth gap persists across generations ■

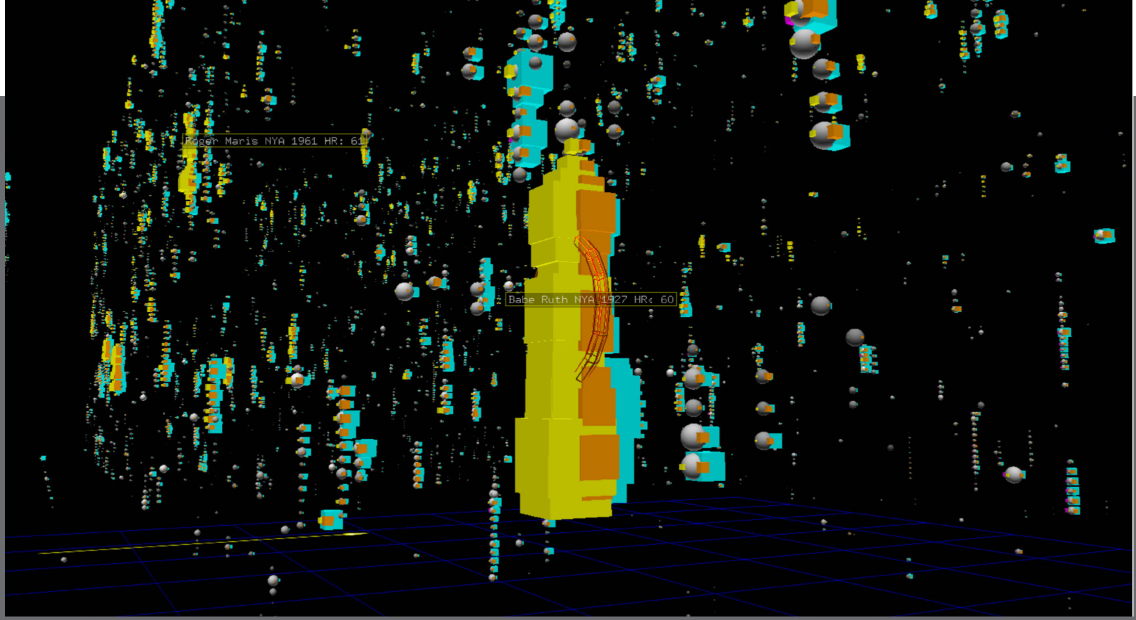
A Search for Missing Children

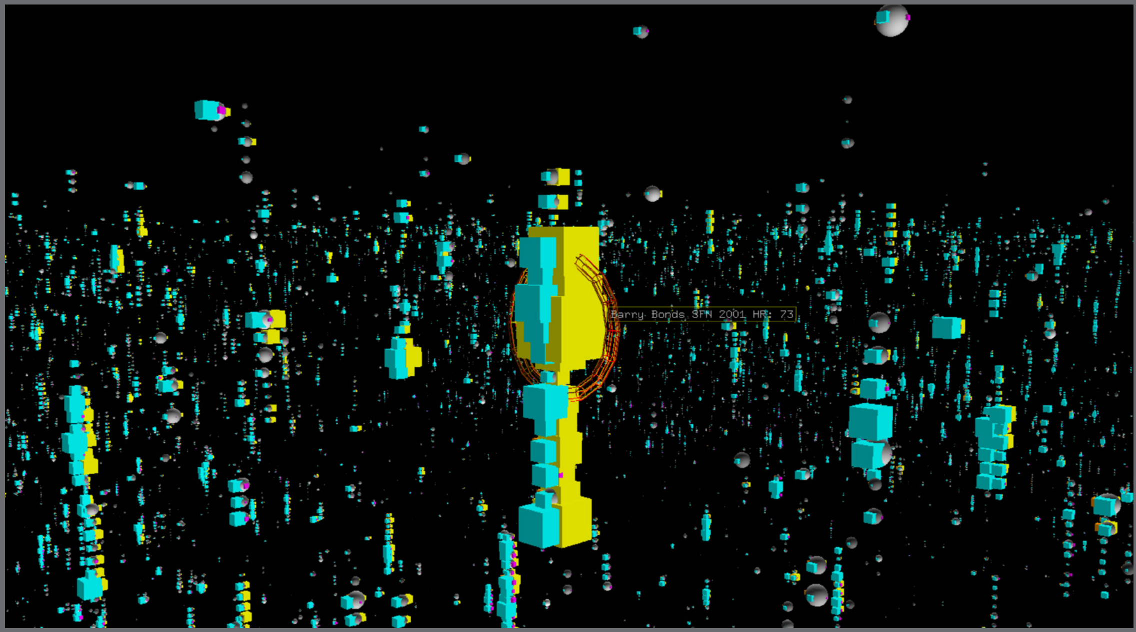
Families were unusually small in parts of Japan in the 18th and 19th centuries. Why? Using the resources of Yale University's Center for Research Computing, historian Fabian Drixler simulated how often women in this population should have given birth considering everything we know about their circumstances and human reproductive physiology. It turned out that even under the most pessimistic assumptions about factors like sterility and coital frequency, the expected number of children far exceeded that actually recorded. Observers at the time noted that couples routinely used infanticide and abortion to plan their families, but modern scholars have long disagreed about whether they were rare or common. Upon integrating these forms of family planning into the model, the Monte Carlo simulation revealed that during some decades, at least 40 percent of pregnancies must have ended in an infanticide or an abortion.

Qualitative sources suggest that infanticide was a well-accepted form of family planning in many historical societies, but because most of these lack Japan's detailed demographic data, such evidence has often been dismissed. Showing that one large, sophisticated, and well-documented society relied so heavily on infanticides and abortions can inform what we consider plausible for other reproductive cultures, such as those of the Ancient world, for which the evidence is more fragmentary ■



Infanticides required to explain the fertility observed in Japan's Deep East in the absence of contraception and abortions.





Hits and Homers Reveal Hidden Influences

Fans love to pore over baseball stats, but the human brain can only glean so much from a sea of numbers. A powerful type of visualization called a hyper glyph makes it much easier to extract meaning from millions of data points. These hyper glyphs show the hits and home runs of Babe Ruth (top) and Barry Bonds (bottom) from their early careers (bottom of each image) to retirement (top of each image). While the Ruth visualization shows relatively consistent performance throughout his career with an expected tapering toward the end, the Bonds visualization shows a late-career surge reflecting his alleged use of performance-enhancing steroids. Comparing hyper glyphs across multiple players, the visualizations also reveal that when baseball fields became smaller, the number of home runs ballooned. University of California, San Diego researcher Jeff Sale created the visualizations at the San Diego Supercomputer Center using data from the Lahman Baseball Database ■

FROM CURIOSITY TO CAREERS

Finding Inspiration Where Art Meets Tech

With a significant shortfall in the technology workforce expected in the coming years, researchers are looking for ways to attract more people—particularly women—to information and communication technology careers. AR Girls is a National Science Foundation funded collaboration to engage middle school-aged girls in technology through a digital arts-focused summer camp and afterschool program.

Using ARIS, an augmented reality authoring tool, participants create their own augmented reality experience that tells a science story relevant to their local community. By giving participants a chance to experience how technology can help them unleash their creative potential, the program aims to inspire girls to see themselves in science and tech careers. The program is free to attend at locations throughout Maine, making it accessible to girls from rural communities and all economic backgrounds. The program is led by the Maine Mathematics and Science Alliance in partnership with the University of Maryland, Harvard Graduate School of Education, University of Oregon and University of Wisconsin ■

UTC STEM EDUCATION GRADUATE PASCALE HAUG TEACHES MATH AT BRAINERD HIGH SCHOOL. (IMAGE COPYRIGHT UNIVERSITY OF TENNESSEE CHATTANOOGA)

Teachers: A Key Ingredient for a Strong Workforce

Often, a single individual plays a pivotal role in a young person's decision to pursue a science, technology, engineering or mathematics (STEM) career: a teacher. At the University of Tennessee Chattanooga (UTC), a cross-disciplinary partnership is helping to support the future STEM workforce on multiple fronts. The STEM Education program lets students simultaneously earn a degree in education and in science, math or computer science. Graduates are qualified to enter the STEM workforce directly or teach STEM subjects. By providing this dual path, the program aims to increase the math, science and computer science expertise of tomorrow's teachers and offer greater flexibility as graduates embark on their careers. A National Science Foundation funded scholarship program further incentivizes students to pursue high school STEM teaching careers

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