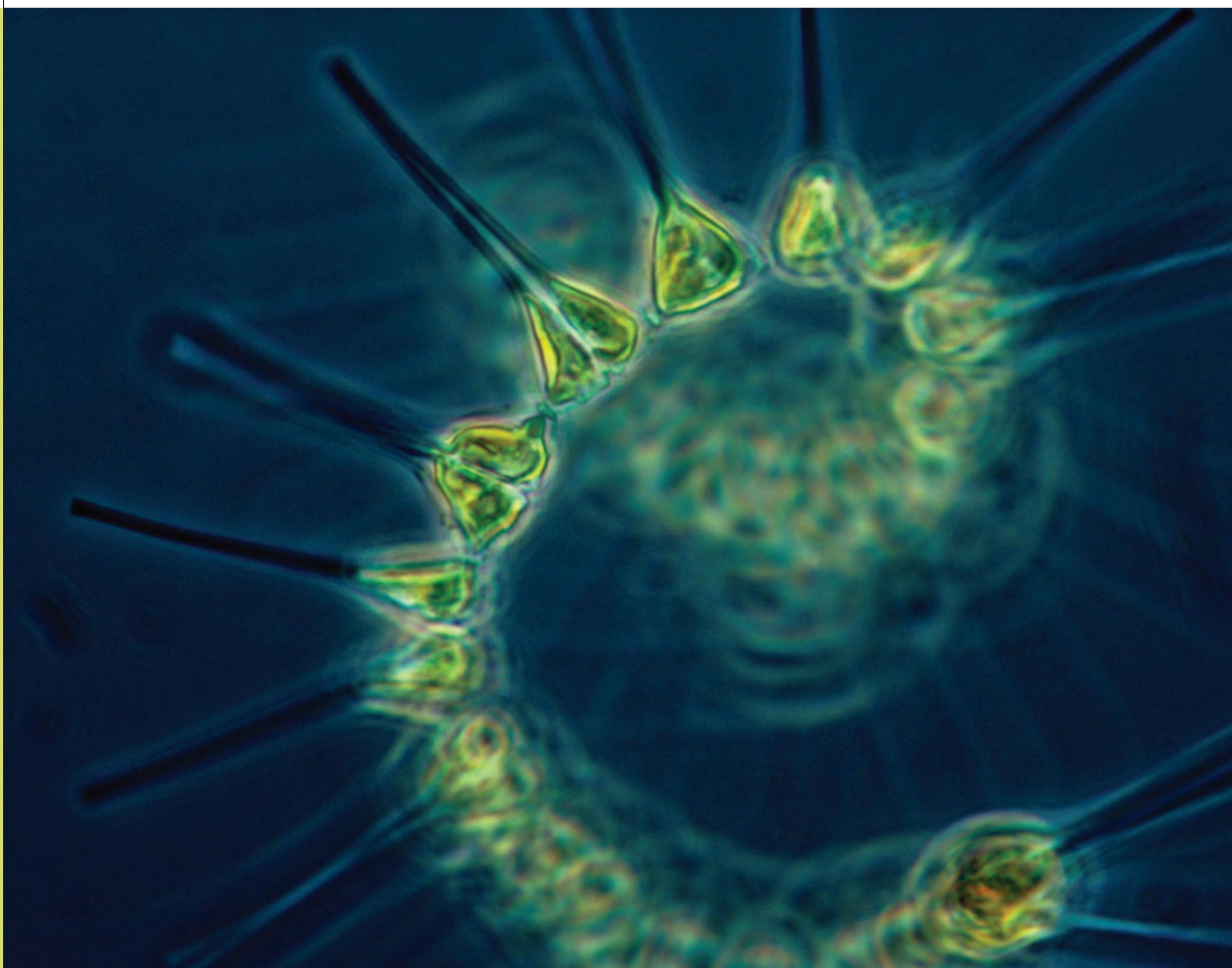
Carnegie Year Book

Fiscal Year July 2022 – June 2023

CARNEGIE SCIENCE



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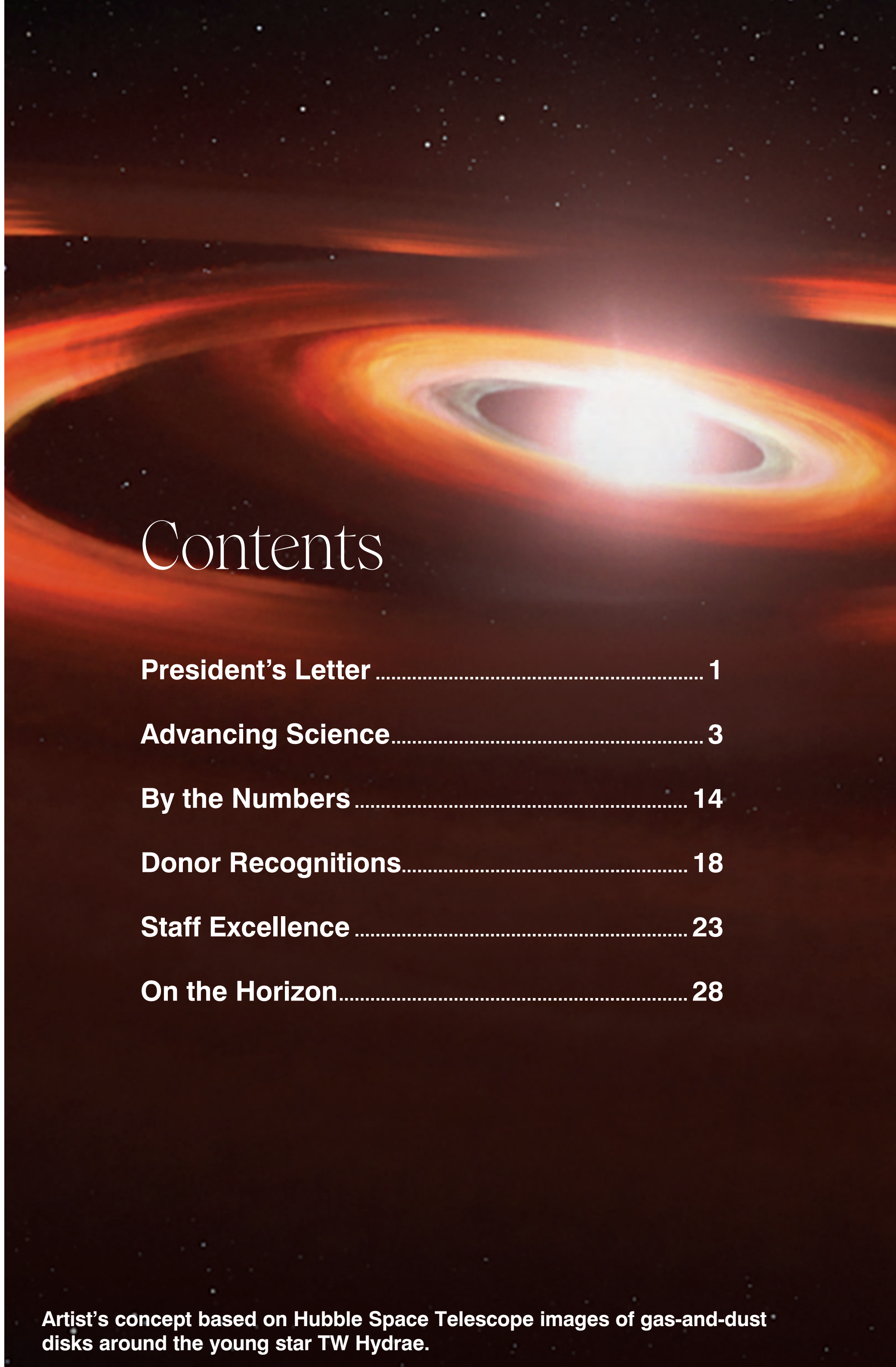


NASA, AURA/STSCI FOR ESA, LEAH HUSTAK (STSCI)

Contents

Artist's concept based on Hubble Space Telescope images of gas-and-dust disks around the young star TW Hydrae.

This publication is a selection of materials from our complete Year Book, which is online at: https://yearbook.carnegiescience.edu/2023.

A Message from Our President

The spirit of “building” is at the core of Carnegie Science’s history, mission, and work. The need for safe and durable infrastructure required the steel at the heart of our founder’s legacy. Careful stewardship of our endowment has built up the nest egg that still funds much of our research. And breakthrough after breakthrough at each of our divisions has allowed Carnegie Science to continually build our understanding of life, the universe, and our place in it, forming a strong foundation for answering the big questions that remain.


John Mulchaey

Our transformative research is dependent on the collaboration of our Staff Scientists, postdocs, administrative and technical staff, and community of supporters. As we advance on our Path to Pasadena, we are strongly positioned to expand our impact. Investments in collaborative initiatives like the Carnegie Science Climate and Resilience Hub, and enhanced partnerships with other research organizations, including Caltech, will cement Carnegie Science’s reputation as a center for scientific innovation. We move forward carrying the legacy of legendary scientific minds like Don Brown and Kent Ford, whose tenures at Carnegie Science were marked by achievement. Together, we’re building a stronger Carnegie Science and, with it, a brighter future for free and flexible science.

This Fiscal Year 2023 Year Book offers a sampling of the breadth of work done across our three research divisions. I invite you to follow your curiosity and build your understanding of our cutting-edge investigations. Learn about Carnegie cosmochemists’ pivotal role in advancing the study of pristine asteroid samples, which sheds new light on Earth’s formative history. Explore how Carnegie biologists leverage CRISPR/Cas9 technology to complement the symbiotic coral-algae relationship and conserve reefs in the wake of climate change. Discover how Carnegie astronomers are capitalizing on state-of-the-art technology in the Observatories VizLab and are using the James Webb Space Telescope (JWST) to explore the origins of ancient galaxies and the atmospheres of distant exoplanets.

Each of these projects and initiatives reflects Carnegie Science’s long legacy of scientific excellence. I look forward to seeing where our scientists’ curiosity takes us next, and I am sure you do too.

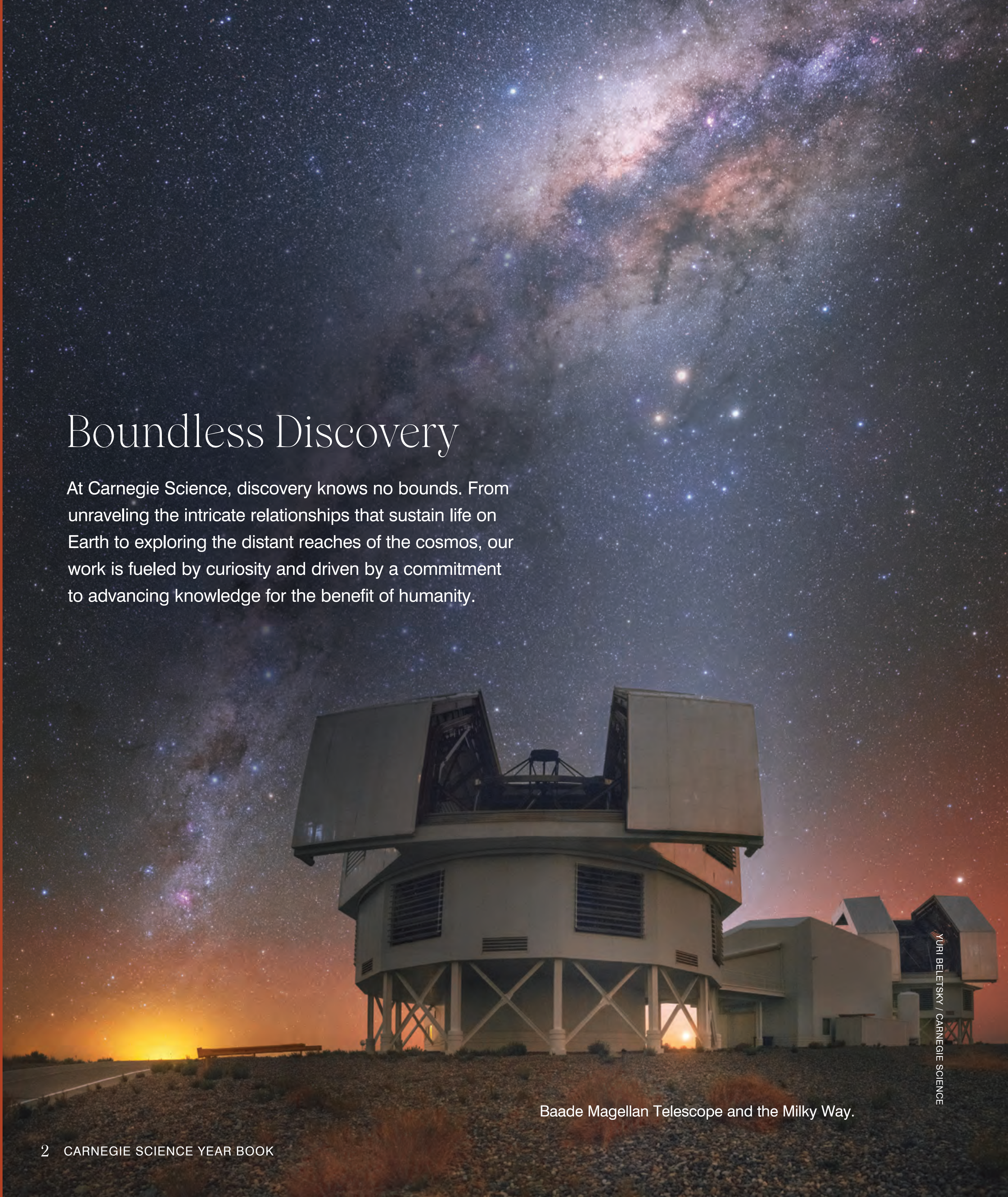
Thank you for your commitment to building a future shaped by bold inquiry and transformational discovery.

Sincerely,

John Mulchaey
President, Carnegie Science

Boundless Discovery

At Carnegie Science, discovery knows no bounds. From unraveling the intricate relationships that sustain life on Earth to exploring the distant reaches of the cosmos, our work is fueled by curiosity and driven by a commitment to advancing knowledge for the benefit of humanity.



YURI BELETSKY / CARNEGIE SCIENCE

Baade Magellan Telescope and the Milky Way.

Carnegie Scientists Reveal the Cosmos with JWST

Carnegie Science astronomers have showcased the institution's creativity and propensity for bold research ideas using JWST. Since the space telescope began taking research observations in the summer of 2022, Carnegie-affiliated scientists have led 13 projects, which were selected across three cycles of time allocations. These initiatives represent the breadth of astrophysical research at the Carnegie Science Observatories and the Earth and Planets Laboratory, ranging from probing star formation in ancient galaxies to elucidating exoplanet atmospheres.

Foundational Role

Carnegie Science has been a part of JWST's story since its inception. In the early 1990s, Observatories astronomer Alan Dressler was asked by the Associated Universities of Research in Astronomy, or AURA, to head up a committee of astronomers that would come up with questions that technological advances could help answer in the coming decades.

The group recommended an "Origins" program for what Dressler described as a "once-in-a-species" opportunity to witness "cosmic cradles." They indicated that this would require a space telescope bigger than Hubble that could maintain an extremely cold temperature and would be positioned very far from Earth. This would enable it to use infrared cameras to observe our cosmic beginnings.

"We are understanding our own place in the universe and how we came to be," said JWST Senior Project Scientist Jane Rigby, who was a Carnegie postdoc between 2006 and 2010. She shared her JWST story with a packed house at The Huntington Library, Art Museum and Botanical Gardens in the spring of 2023 as part of the Observatories' Astronomy Lecture Series. "The Webb telescope was built to do four things and we showed that it could do all four of those on the first day that we released images."

Galaxies

Observatories astronomer Andrew Newman has had two projects on star formation in ancient galaxies selected for JWST telescope time. In the first round of allocations, he led a project that pointed the space telescope at a galaxy about 10 billion light-years from us in order to probe the long-standing question of why some galaxies stopped forming stars very early on, even though the universe at the time was a very active place and most galaxies were just bursting with star formation.

Then earlier this year, he and recently departed postdoc Meng Gu—who started a new position at the University of Hong Kong—were selected to use JWST to study four giant galaxies from the early universe that grew very quickly for 1 to 2 billion years and then suddenly stopped.

The ejection of gas from these galaxies—potentially accelerated by enormous black holes at their centers—could be the key to understanding why star formation ended. If Newman and Gu are able to map this gas and measure the masses of these black holes, it could provide a major breakthrough in understanding how galaxies evolve.

Observatories astronomer Gwen Rudie also used JWST to probe star formation in early galaxies. She and former Observatories postdoc Allison Strom—now a professor at Northwestern University—used JWST to observe a carefully selected set of 33 “teenaged” galaxies that experienced remarkable growth in the universe’s youth.

In 2023 they shared their findings, revealing that galaxies that formed just 2 to 3 billion years after the Big Bang are unusually hot and glow with light from surprising elements, like nickel. They accomplished this by taking spectra of these distant galaxies—separating their light into its component wavelengths. Looking at the light in this way helps astronomers measure the temperature and chemical composition of cosmic sources. By averaging together spectra from all 33 galaxies, they were able to create an atlas, of sorts, that will inform future JWST observations of very distant objects.

Using the spectra, the researchers were able to identify eight distinct elements: Hydrogen, helium, nitrogen, oxygen, silicon, sulfur, argon and nickel. Although their presence was not a surprise, JWST’s ability to measure them was. By revealing the presence of certain elements in these early galaxies, astronomers like Rudie and Strom can learn about how star formation changes over the course of their evolution.

Exoplanets

On the exoplanetary side of things, Earth and Planets Laboratory astronomer Johanna Teske has had three

NASA, ESA, CSA, STSCI

What looks much like craggy mountains on a moonlit evening is actually the edge of a nearby, young, star-forming region NGC 3324 in the Carina Nebula. Captured in infrared light by the Near-Infrared Camera (NIRCam) on NASA’s James Webb Space Telescope, this image reveals previously obscured areas of star birth.

JWST proposals selected. Most recently, she and current postdoc Nicole Wallack were chosen for an archival project that is seeking to account for and eliminate sources of "noise" in observations of small exoplanet atmospheres that could be caused by JWST's suite of highly engineered instruments.

This was based on Wallack's work with the data from Teske's first round of JWST observations, which really pushed the space telescope's capabilities to their limits. In cases like theirs—looking for the signals from small planets—it's absolutely crucial to glean every drop of information from the data to confidently answer questions about which small planets have atmospheres, and what are their compositions.

Wallack worked very hard to accomplish this with the observations in Teske's previous JWST program, co-led with Natasha Batalha of NASA Ames, which aimed to improve our understanding of the most-common type of planets in the Milky Way—called super-Earths or sub-Neptunes. But now, after the first two cycles of JWST, there will be almost 30 such small planet atmosphere datasets taken by the entire community, which will be publicly available for further analysis. Their plan is to conduct a deep dive into all of this information to both potentially improve the precision, as well as look for trends in the "noise" properties in data that could be useful for planning future observations.

Earth and Planets Laboratory astronomer Peter Gao also led two projects that deployed JWST to probe exoplanet atmospheres. The first focused on understanding a rare type of ultra-low-density planets, which have masses of only a few times that of Earth, but sizes like those of the giant planets in the Solar System.

For his Cycle 2 program, Gao undertook a theoretical project to help interpret JWST data related to photochemical hazes. These are structures in planetary atmospheres composed of small particles that originate from photochemistry or being "pulverized" by ultraviolet light from the host star. Previous observations have shown that many of the exoplanets that JWST will study are hazy. So, Gao's work will be useful to astronomers who are looking to better understand their data about these planets or to put it into models.

Teske, Wallack, and Gao are all members of the revolutionary space telescope's Transiting Exoplanet Community Early Release Science Team—along with several other current and past Carnegie postdoctoral fellows. This group has made many exoplanet breakthroughs, including detecting carbon dioxide, water vapor, and photochemistry-derived sulfur dioxide in the atmospheres of distant worlds.

Looking Ahead

The infrared instruments that are enabling Carnegie Science researchers to conduct exciting experiments using JWST will be complementary to the instrument suites being developed for the next generation of ground-based telescopes, including the Giant Magellan Telescope (GMT), currently under construction at the Carnegie Science Las Campanas Observatory.

The difference in mirror size between a space-based and ground-based telescope will enable astronomers to use GMT to characterize the first stars and galaxies detected by JWST in greater detail. Likewise, optical capabilities of GMT—as compared to the infrared instruments deployed on JWST—will enhance astronomers' capacity to detect biosignatures such as oxygen in exoplanet atmospheres.

From Apollo to OSIRIS-REx: Carnegie Science and the Dawn of a New Era in Cosmic Exploration

For centuries, humanity's quest to understand the cosmos has relied on distant observation and serendipitous discovery. Astronomers observed objects from afar while planetary scientists relied on studying the meteorites that found their way to Earth's surface. These methods, however, presented an incomplete narrative, obscured by vast distances and selective processes that allow only certain materials to reach our planet's surface.

Nothing can compare to the depth of information we can collect from going directly to the source. Imagine the difference between piecing together a story from fragmented pages and having entire chapters of the Solar System's saga in hand. These missions both groundtruth our observations and allow us to compare the composition of Earth-side samples to that of the celestial objects themselves—all while providing vast new sets of data that help us piece together the early history of our Solar System.

The Apollo program marked the beginning of this new age of exploration, starting with our closest celestial neighbor—the Moon. Between 1969 and 1972, Apollo brought back 840 pounds of lunar samples.

Carnegie Science's involvement in analyzing these materials led to groundbreaking discoveries, such as the late Eric Hauri's discovery of water content in the Moon's magmas and Director Emeritus Richard Carlson's use of isotopic dating to establish a revised, younger age for the Moon. Both discoveries transformed our understanding of the lunar landscape and early history of the Solar System.

Today, Carnegie researchers continue to play an essential role in studying samples from the near-Earth asteroids Ryugu and Bennu—returned by JAXA's Hayabusa II and NASA's OSIRIS-REx missions, respectively.

In August 2021, Larry Nittler, a former Carnegie cosmochemist, now a professor at Arizona State University, received samples of Ryugu at the Carnegie Science Earth and Planets Laboratory (EPL) in Washington, D.C. Nittler was one of only nine U.S. scientists selected by NASA to be a "participating scientist" on the mission. Carnegie researchers Richard Carlson, George Cody, Conel Alexander, and former postdoctoral fellow Jens Barosch, were also involved in teams analzying the samples for isotopic composition, organic material, and presolar grains.

While still at Carnegie Science, Nittler and Barosch made an exciting discovery within the Ryugu samples: the presence of presolar grains—ancient microscopic specks of dust that predate our Sun. These grains provide a glimpse into our Solar System's starting materials, and their presence can serve as a chronological marker aiding in constructing a more accurate timeline of the Solar System's history.

Similarly, NASA's OSIRIS-REx mission returned samples of the asteroid Bennu to Earth in September 2023, and Carnegie scientists were among the first to receive them.

Dionysis Foustoukos studying samples from Bennu returned by the OSIRIS-REx mission.

Thanks to our world-class instrumentation and our reputation for efficiency, NASA rushed the samples to EPL for a preliminary analysis of their carbon content, among other features. The team, which included Alexander, Cody, and Research Scientist Dionysis Foustoukos, thrilled the scientific community with their first carbon measurements—showing the highest abundance of carbon ever measured in an extraterrestrial sample.

This early analysis confirms the exceptional nature of the Bennu samples and underscores Carnegie's legacy of excellence when it comes to the chemical analysis of space samples.

These investigations are just the start. As we continue to study samples from Ryugu and Bennu, we stand on the brink of a new golden age of sample return. The coming decade holds promises of missions to the metallic asteroid Psyche, Mars' moon Phobos, Earth's Moon, and more.

Among the most anticipated and perhaps most ambitious, are potential plans to return samples from Mars in the next decade. Carnegie astrobiologist and remote Raman spectroscopy expert, Andrew Steele, is a member of the Mars Sample Return Campaign Science Group, which aims to bring back samples collected by the Perseverance rover, offering unprecedented insights into Mars's geology, climate history, and potential for past life. As we stand at the threshold of this new era, Carnegie Science remains at the forefront of unraveling the mysteries of our Solar System. With a history of groundbreaking contributions and a future filled with promise, Carnegie scientists continue to illuminate the pathways through which our universe has shaped the conditions for life.

ADVANCING SCIENCE

Visualization Laboratory Enhances Collaboration Opportunities

One of the most famous photos of Albert Einstein was taken in the library at the Carnegie Science Observatories. Under the watchful eye of George Ellery Hale's portrait, the legendary physicist looks over his shoulder at an unseen audience and writes an equation on a dusty chalkboard.

In a pre-computing age, communal areas such as the library often served as idea laboratories, where concepts could be debated and fleshed out collectively. Although, the scientific enterprise is still highly collaborative, astronomers' workspaces are often solitary and siloed today.

This is why Juna Kollmeier, Founding Director of the Carnegie Theoretical Astrophysics Center (CTAC), designed and developed a fully immersive visualization environment, or VizLab, where Observatories scientists could come together to interrogate novel data sets and probe the mysteries of the cosmos.

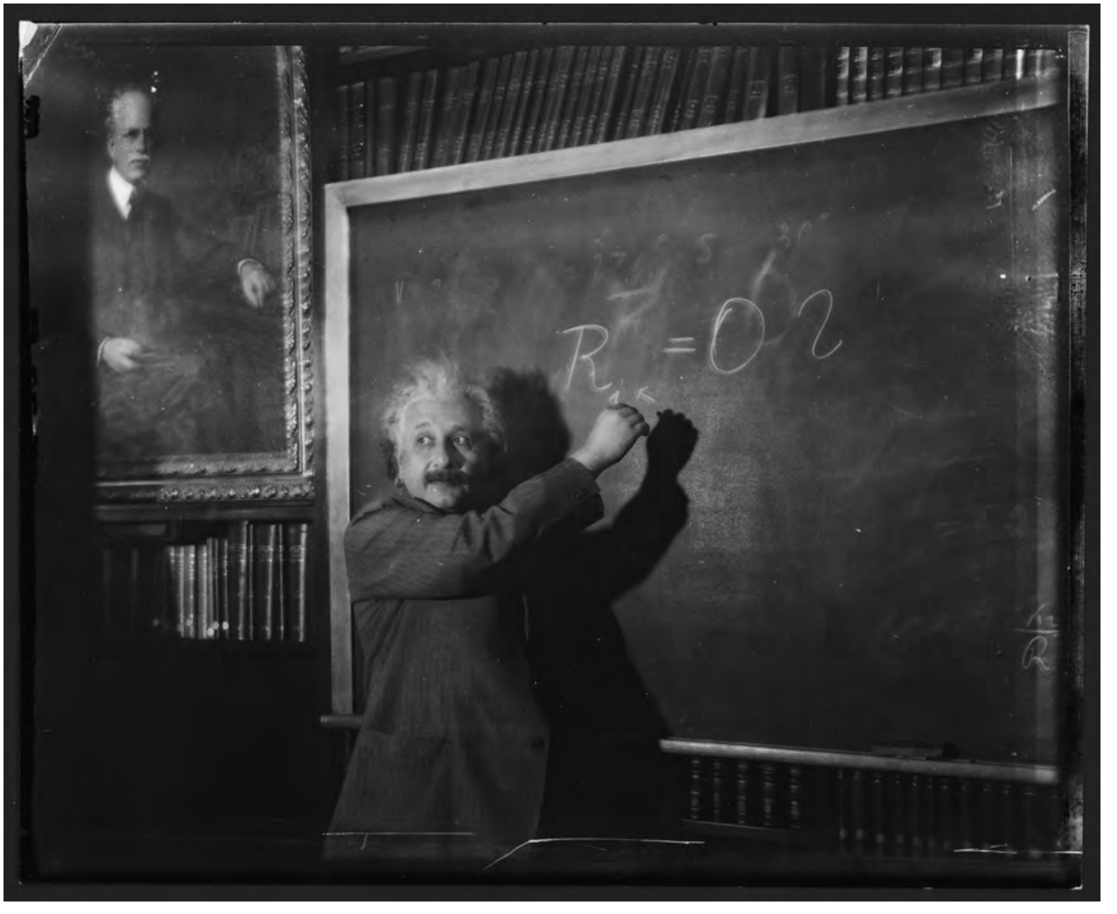
The VizLab grew directly from the computational infrastructure that Carnegie Science theorists built over the past decade at the Observatories, thanks to the generous support of NASA and The Ahmanson Foundation, the latter of which was also a major funder of the Viz Lab.

"I envisioned a space where teams could work together as they synthesize an unprecedented amount of data. Twenty-first century data require twenty-first century laboratories," she said when the VizLab launched in a refurbished campus garage in 2020. "I wanted to capture the collaborating that is often done together in front of blackboards, but with the capability of interrogating huge simulations and datasets."

The lab was built around an immersive visualization display system with 35 2D- and 3D-capable flat panels in the shape of a cresting wave. This screen configuration was designed to represent the tsunami of data rushing into the astronomical field. Thanks to advances in instrumentation and the next generation of astronomical surveys, more data is available than any time in history.

In order to keep pace with the software needs of theorists using the VizLab to advance their science, the CTAC team brought onboard Chris Couto from Caltech's Schmidt Academy for Software Engineering (SASE). This program aims to accelerate discovery by connecting recent graduates in computer science and related fields with scientists who increasingly rely on software innovation to push the boundaries of their fields.

With Couto's guidance, CTAC researchers have been developing new tools to take advantage of the VizLab's capabilities. Couto is expanding off of the VizLab's Unity game engine system, which can display and manipulate point-cloud data sets,



Albert Einstein at the blackboard during a talk in the Mount Wilson Observatory's Hale library, Pasadena, California.

to implement more sophisticated visualization capabilities, rendering of hydrodynamics simulations, instrument CAD models, IFU data, and more. This can produce both fixed snapshots and full animations. Other areas of development for Couto include adding more ways to interact with data and improving ease of use of the system via user interface (UI) design, data management, and accessibility.

"I'm very proud of all the ways we've been able to enhance the VizLab experience since I arrived in 2022 and have more planned improvements on the horizon," said Couto.

"So far, I've mainly used the VizLab for interactive visualizations of simple datasets," said Ethan Nadler, a Carnegie-USC joint postdoctoral fellow and a member of CTAC. "I would like to scale this up to visualize full cosmological simulations, including as a function of time."

Nadler also taps into the VizLab's capabilities to connect with local students, many from historically underrepresented groups. He used support from Carnegie Science's DEI Mini-grant program to develop a 10-week course for USC Hybrid High School students in collaboration with local arts organization Create Now.

High school students participate in the USC Hybrid High School Introventure week. They create models that are projected on the VizLab as part of learning about different careers.

The course not only introduced students to dark matter concepts but also provided coding and data visualization training, skills applicable to many careers beyond theoretical astronomy. And it has continued long past its original mandate. For the past three years, he has hosted the students from the school for their “Introventure” week, which enables participants to learn about different career options.

“The students run interactive Jupyter notebooks to create models of stellar streams, and they project these onto the VizLab screen to explore,” Nadler said. “They’re always amazed by seeing their data in 3D!”

Nicole Sanchez, a joint Carnegie-Caltech National Science Foundation MPS-Ascend Postdoctoral Fellow also used the VizLab for outreach efforts. Her FAST Workshop provided a weeklong research training program for local community college students to learn coding and introductory research skills.

“The extra-large screen available in the VizLab made it an ideal teaching location, and the students had a great time working in the space,” Sanchez explained.

As part of Staff Scientist Andrew Benson’s research group, Sanchez and her colleagues have used the VizLab space for regular check-ins.

“The space is well-designed and set up for scientific collaboration with white boards, monitors, and a lot of moving parts that allow you to set up the perfect space for different types of scientific gatherings,” she adds. “Whether it’s discussing a new paper over coffee or having a group meeting at the white board, it’s well set up to create multiple connection points between different members of the community.”

Pioneering Symbiosis Research for a Better Future

In the realm of biological research, symbiosis stands as a captivating and complex phenomenon that has long intrigued scientists. Carnegie Science is at the forefront of unraveling the mysteries of symbiotic relationships and their profound implications for human health, agriculture, and ecosystem resilience. Through cutting-edge research and innovative techniques, Carnegie scientists are making groundbreaking discoveries that could transform our understanding of the natural world and pave the way for sustainable solutions to some of the planet's most pressing challenges.

Symbiotic relationships are essential for many biological processes, including nutrient cycling, reproduction, and protection, and they play a crucial role in maintaining the balance of ecosystems.

Coral Conservation: Unraveling Symbiotic Secrets

Carnegie Science's Division of Biosphere Sciences and Engineering is leading the charge in studying the intricate relationship between coral and algae. Coral reefs, often referred to as the "rainforests of the sea," are vital to marine biodiversity and human livelihoods. However, they are under severe threat from climate change-induced ocean warming, which leads to coral bleaching.

Corals are marine invertebrates that build large exoskeletons from which reefs are constructed. But this architecture is only possible because of a mutually beneficial relationship between the coral and various species of single-celled algae called

What is symbiosis?

Symbiosis is a biological concept referring to the close and often long-term interaction between two or more different species. The term encompasses a wide range of relationships, which can be mutualistic, commensal, or parasitic:

- **Mutualism:** Both species benefit from the relationship. For example, the symbiosis between bees and flowers, where bees get nectar as a food source while pollinating the flowers.
- **Commensalism:** One species benefits without significantly affecting the other. An example is barnacles that attach themselves to the shells of sea turtles. The barnacles get a place to live and feed, while the turtle is typically unaffected.
- **Parasitism:** One species benefits at the expense of the other. For instance, tapeworms living in the intestines of animals, where they absorb nutrients from the host's food, often harming the host.

dinoflagellates that live inside individual coral cells. These dinoflagellates are photosynthetic, which means that, like plants, they can convert the Sun's energy into chemical energy. An alga will share the sugars it synthesizes with its coral host, which in turn provides the alga with the inorganic carbon building blocks it needs, as well as phosphorous, nitrate, and sulfur.

By investigating how corals establish and maintain their symbiotic relationships with algae, Carnegie researchers, including Phillip Cleves, Chen-Ming Fan, Arthur Grossman, and Yixian Zheng, aim to understand the mechanisms behind coral resilience and develop strategies to mitigate the impacts of environmental stressors. Their efforts are funded, in part, by The Pew Charitable Trusts and the Gordon and Betty Moore Foundation.

Agricultural Innovation: Harnessing the Power of Symbiosis

Beyond the oceans, Carnegie scientists are exploring the potential of symbiosis in transforming agriculture. Staff Scientist Brittany Belin and her team are studying the symbiotic exchange between legumes and rhizobia, soil bacteria capable of converting atmospheric nitrogen into plant-fertilizing ammonia. This research holds promise for developing sustainable alternatives to synthetic nitrogen fertilizers, which are critical for reducing the environmental footprint of agriculture. Belin believes that harnessing this powerful interconnection could one day help to naturally and sustainably feed the world's rapidly growing population.

"We're a microbiology lab, but we are interested in which genes make rhizobia better for one host versus another," explains Belin. "Can you improve the strain to make it more useful for agriculture? What would be the consequences of having this GMO bacterium in the environment—is that long-term a good thing to do? That's the kind of stuff we think about."

Nematodes: Unlocking the Secrets of Soil-dwellers

The soil is teeming with microbial life that plays a crucial role in plant health and ecosystem functioning. Carnegie Staff Associate Mengyi Cao is pioneering the use of one such organism, the *Steinernema* nematode, as a genetic model to study microbial symbiosis. Nematodes are among the most abundant and diverse groups in the soil fauna, and they play a significant role in soil ecology. In partnership with their mutualistic bacteria, these microscopic roundworms offer a unique window into the complex interactions within soil ecosystems due to their multi-faceted antagonistic effects on agricultural pests. Their potential applications in pest control highlight the importance of understanding symbiotic relationships in developing eco-friendly solutions to the devastation caused by invasive species.

Gut Ecology: Exploring the Microbial Universe Within

The human body is a complex ecosystem, home to trillions of microbes that influence our health in myriad ways. Staff Scientist Will Ludington's lab is delving into the gut microbiota of the fruit fly, *Drosophila melanogaster*, to uncover the intricate dynamics of microbial community interactions. This research not only sheds light on gut ecology but also provides insights into how these microbial communities impact host health.

Despite its importance, researchers have historically lacked a mechanistic understanding of how the gut microbiome as a whole is greater than the sum of its parts. In other words, to what extent do individual


ED HIRSCHMUGL / CARNEGIE SCIENCE

Green & Pink thin birdsnest coral (Seriatopora hystrix) is a stony coral that grows in fore-reef slopes in the Red Sea.

microbes influence us, and to what degree are these impacts determined by the interconnected and overlapping interactions between unique species? Studying the underlying biology that governs these relationships is absolutely critical to advancing our understanding of human health. However, the sheer number of different microbes in our gut presents a challenge to cataloging and understanding the effects of their synergy.

Using the natural simplicity of the fruit fly gut microbiome as a model system, the Ludington Lab is starting to untangle this complex web of interactions.

“When people have done other kinds of microbiome experiments, they are asking ’what’s there?’ But we know exactly what’s there,” explains Ludington. “We’re not just being descriptive. We’re saying, ’we have this specific system, and when we put this in or take that away, we can see the effect come and go.’ So, you can really establish causation of the specific bacteria.”

A Symbiotic Future

Carnegie Science’s research into symbiosis and species-species interactions is not just about understanding the natural world; it’s about leveraging this knowledge to address global challenges. From preserving coral reefs and advancing sustainable agriculture to exploring the human microbiome, the insights gained from these studies have the potential to transform our approach to health, food security, and environmental conservation. As we continue to unravel the secrets of symbiosis, we edge closer to a future where humans and nature thrive in harmony.

BY THE NUMBERS

Capital Science Evenings

Carnegie Science's Capital Science Evening lecture series brings together leading scientists, researchers, and innovators to share their groundbreaking discoveries and insights with the public. These events provide a unique platform for exploring the most pressing scientific questions of our time, from the mysteries of the cosmos to the complexities of climate change, neuroscience, and more. Capital Science Evenings aim to inspire curiosity, spark innovation, and promote a deeper understanding of the natural world and the challenges we face by fostering a dialogue between experts and our audiences.

Our 2022–2023 season brought together a diverse array of high-profile scientists who shared their cutting-edge research and visionary insights, creating a vibrant narrative of discovery across multiple scientific fields.

The season began with an exploration of the brain's mysteries with Kavli Prize Laureate **Cori Bargmann.** In her lecture, **"One Brain, Many Behaviors: The Fascinating World of Circuit Neuroscience,"** Bargmann invited the audience into the complex world of neural circuits, revealing how these intricate networks give rise to a vast array of behaviors. Her discussion on the latest research in circuit neuroscience provided a deeper understanding of how the brain functions and offered new perspectives on mental health and neurological disorders.

Next, **Lee R. Berger**, a paleoanthropologist and National Geographic Explorer-in-Residence, took the audience on a thrilling journey into the past with his talk, **"The Future of Exploration in the Greatest Age of Exploration."** Berger, known for his groundbreaking discoveries of new hominin species, shared his vision for the future of exploration, driven by technological innovations that are opening up previously inaccessible regions of the world. His narrative underscored the idea that we are living in a new golden age of discovery, where the boundaries of human knowledge are expanding at an unprecedented rate.

The narrative then took a turn towards the microscopic with **Margaret McFall-Ngai**, a biologist at Carnegie Science. In her lecture, **"Squid Pro Quo: Insights from a Hawaiian Denizen about Living with Our Microbial Partners,"** McFall-Ngai shared the fascinating story of the Hawaiian bobtail squid, a creature whose symbiotic relationship with microbes offers profound insights into the broader implications of symbiosis in biology. Her exploration of this unique partnership shed light on the essential roles that microbes play in animal health and opened up new avenues of understanding in the study of life's complexity.

Shifting from the complexities of life to those of our planet Earth, **J. Marshall Shepherd**, a climate expert

Carnegie Science hosted a Capital Science Evening lecture by Dr. Aomawa Shields titled “Life on Other Planets: Finding My Place in the Universe” at the AAAS Headquarters Building in Washington, D.C.

and distinguished professor at the University of Georgia, took the stage with his presentation, **“Cloudy with a Chance of Science.”** Shepherd delved into the intricate science of weather and climate, demystifying the challenges of predicting extreme weather events. His talk highlighted the vital role that climate science plays in shaping public policy and preparing for the impacts of climate change, emphasizing the need for informed action in an era of increasingly volatile weather patterns.

Through these lectures and discussions, the Carnegie Science events of 2022-2023 season wove together a rich tapestry of scientific exploration, from the smallest microbes to the farthest reaches of space, offering a glimpse into the future of discovery and the endless possibilities that lie ahead.

BY THE NUMBERS

Venture Funding Promotes Bold, New Research Directions

Launched in 2015, the Carnegie Science Venture Grants program was designed to provide seed funding for high-risk, enterprising research projects that eliminate silos and break disciplinary boundaries. Since its inception, 26 grants have been awarded, launching several exciting initiatives. Past successes include unraveling a long-standing mystery about how genetic material is organized in a diverse group of algae called dinoflagellates and the development of a framework for understanding the interiors, and potential habitability, of super-Earths.

"I am very proud of our scientists' audacious and creative ideas that have been enabled by Venture Grants," said Carnegie Science President John Mulchaey. "These grants give our staff opportunities to explore exciting new directions and push at the boundaries of their science."

Recently, a grant was awarded to Adrien Burlacot, a plant biologist with expertise in photosynthesis, and Lorenzo Rosa, an environmental engineer with expertise in global agricultural modeling. They will measure how light affects the nano-scale temperature inside plant cells during photosynthesis, including the impact of changing light conditions on this process. They will then use machine learning and statistical regressions to translate these results from the molecular scale to the global scale, quantifying how heat and light stress will impact agricultural productivity under future climate scenarios.

Previously, Carnegie biologists Phillip Cleves and Yixian Zheng partnered with Jianhua Wang, who oversees the Earth and Planets Laboratory's nanoscale secondary ion mass spectroscopy facility to probe 120 coral genes that could be involved in enabling coral polyps to obtain nutrients from their symbiotic algae. This relationship is fundamental to coral health but is threatened by ocean warming due to climate change. Using this sophisticated equipment, the researchers are working to reveal the molecular processes by which algae supplies food to the coral and how this important function may be lost during bleaching events.

Cleves has been awarded several Venture Grants for his marine biology research, including a project in collaboration with plant scientists Arthur Grossman and Frej Tulin that is improving our knowledge of kelp reproductive biology. By better understanding the mechanism by which kelp generates and releases spores into the environment, scientists can improve our ability to develop kelp as an aquaculture crop, as well as inform rewilding conservation efforts.

"Every year, our staff and postdocs put forward interdisciplinary approaches to address big scientific questions and solve research challenges," added

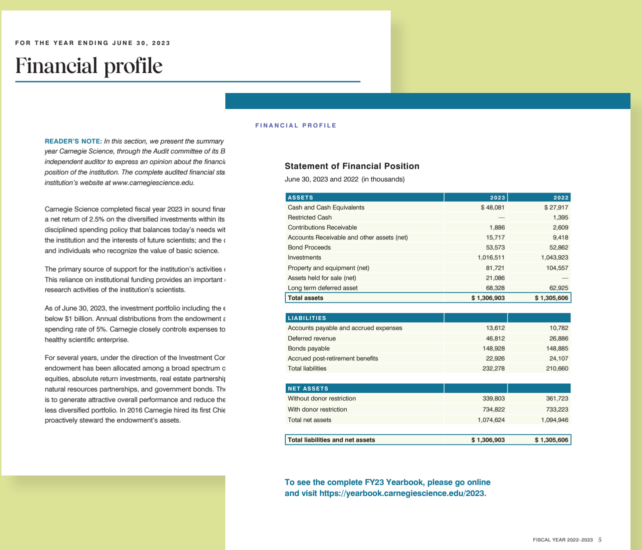
Mulchaey, who oversaw the program in his former Deputy for Science role.

The interdisciplinary focus of the program enables people to tap into the expertise of Carnegie Science colleagues to answer long-standing questions. For example, plant biologist David Ehrhardt partnered with astrobiologist Andrew Steele to understand how plants form and maintain "molecular memories." Ecologist Anna Michalak, recently departed evolutionary geneticist Moises Exposito-Alonso, and microbiome specialist Will Ludington received funds to conduct a first-of-its-kind study to understand how climate change and evolutionary pressures are driving genetic changes in the phytoplankton species that form dangerous algal blooms.

Other Venture Grant efforts cross geographic, rather than disciplinary, boundaries to bring together experts in similar fields who work at different Carnegie Science campuses—or experts from partner organizations—to push the boundaries of their research. For example, Earth and Planets Laboratory theorist Peter Gao and Observatories theorist Tony Piro are working together to develop a method for discovering exomoons using evidence of lunar volcanism.

"Our Venture Grant allowed us to launch a new program to study the internal structure of super-Earths using state-of-the-art facilities at the National Laboratory, leading to high-impact publications on melting and density at extreme pressure," said Earth and Planets Laboratory Staff Scientist Yingwei Fei. "Through the program we have established close collaborations with scientists at the National Laboratories and continue projects focusing on materials properties under extreme conditions."

The Carnegie Science Venture Grant program is generously supported by The Ambrose Monell Foundation. We are grateful for their long-time investment in our research.



FOR THE YEAR ENDING JUNE 30, 2023

Financial profile

READER'S NOTE: *In this section, we present the summary*
year Carnegie Science, through the Audit committee of its B
independent auditor to express an opinion about the financi
position of the institution. The complete audited financial sta
institution's website at www.carnegiescience.edu.

Carnegie Science completed fiscal year 2023 in sound finan
a net return of 2.5% on the diversified investments within its
disciplined spending policy that balances today's needs wit
the institution and the interests of future scientists; and the
and individuals who recognize the value of basic science.

The primary source of support for the institution's activities
This reliance on institutional funding provides an important
research activities of the institution's scientists.

As of June 30, 2023, the investment portfolio including the
below $1 billion. Annual distributions from the endowment
spending rate of 5%. Carnegie closely controls expenses to
healthy scientific enterprise.

For several years, under the direction of the Investment Co
endowment has been allocated among a broad spectrum o
equities, absolute return investments, real estate partnershi
natural resources partnerships, and government bonds. Th
is to generate attractive overall performance and reduce the
less diversified portfolio. In 2016 Carnegie hired its first Chi
proactively steward the endowment's assets.

FINANCIAL PROFILE

Statement of Financial Position

June 30, 2023 and 2022 (in thousands)

ASSETS	2023	2022
Cash and Cash Equivalents	$ 48,081	$ 27,917
Restricted Cash	—	1,395
Contributions Receivable	1,886	2,609
Accounts Receivable and other assets (net)	15,717	9,418
Bond Proceeds	53,573	52,862
Investments	1,016,511	1,043,923
Property and equipment (net)	81,721	104,557
Assets held for sale (net)	21,086	—
Long term deferred asset	68,328	62,925
Total assets	**$ 1,306,903**	**$ 1,305,606**
LIABILITIES		
Accounts payable and accrued expenses	13,612	10,782
Deferred revenue	46,812	26,886
Bonds payable	148,928	148,885
Accrued post-retirement benefits	22,926	24,107
Total liabilities	232,278	210,660
NET ASSETS		
Without donor restriction	339,803	361,723
With donor restriction	734,822	733,223
Total net assets	1,074,624	1,094,946
Total liabilities and net assets	**$ 1,306,903**	**$ 1,305,606**

To see the complete FY23 Yearbook, please go online and visit https://yearbook.carnegiescience.edu/2023.

FISCAL YEAR 2022–2023 5

Financial Profile

Each year Carnegie Science, through the Audit committee of its Board of Trustees, engages an independent auditor to express an opinion about the financial statements and the financial position of the institution.

The financial profile is made available at: https://carnegiescience.edu/2023-year-book/by-numbers.

Testimonials

Paul and Mary Spiewak

Paul and Mary Spiewak stand in front of their custom-made bar celebrating their love of science (above).

The thread of science has always run as a central theme to Paul and Mary Spiewak's life. From a young age, Mary remembers her father's passion for astronomy—from taking her and her brother to Mount Palomar the year of the first Moon landing to grinding his own lens for a telescope, science was always a part of her life.

Paul's love of science began in the fifth grade, sparked by a teacher who made the subject clear-cut and endlessly fascinating. This passion stayed with him, guiding him through a career in pharmaceuticals and chemistry. He relished the precision of science, the definitive answers it provided—so different from the gray areas of life.

And so, when the two met early in their college years—Paul, a student at Northwestern University and the brother of Mary's good friend—they immediately hit it off. Throughout their relationship their travels often revolved around science and the history of past scientific legends. Together Paul and Mary traveled the world visiting labs and homes of famous scientists. From Marie Curie's lab in Paris to Earnest Rutherford's "den" in New Zealand, their travels deepened their appreciation for the pioneers of science and the importance of ongoing research.

Their journey with Carnegie Science began in 2016. Paul's initial connection to the legacy of Carnegie was through the famed Carnegie libraries, which he admired for their embodiment of Andrew Carnegie's vision. After retiring, he rediscovered Carnegie Science and appreciated its commitment to independent, meaningful research. Mary was inspired by the broad range of discoveries made by Carnegie scientists and the institution's dedication to shaping the future of science through fellowship programs.

Now that Paul and Mary are retired, they find that Carnegie Science provides them with the continued connection to cutting-edge science that thrills them. "We try to take advantage of all the public lectures," Paul said. And they feel that being involved in Carnegie helps them to stay abreast of the latest scientific discoveries.

"If you are going to give to an organization, you want to make sure that your money is put to good use and applied to great research—that is what Carnegie does," said Mary about their giving to the institution.

And the Spiewaks would be remiss if they did not mention the incredible science room they have built in their home, complete with a bar in the shape of a molecule and a 40-foot long "timeline wall" listing all of their scientific heroes chronologically, both past and present. To say that their passion for science runs deep would be an understatement. "Science keeps me warm," Paul said joyfully.

Sam and Barbara Dyer

To Sam and Barbara Dyer, few endeavors in life hold as much significance as trying to answer the biggest questions about our natural world. Fueled by their own curiosity growing up, both Sam and Barbara found themselves in careers that challenged them to think outside the box.

Sam, an architect by trade, was born into a family with a deep-seated appreciation for learning and discovery. His father, an acoustical physicist, received his Ph.D. from MIT—a journey that inspired Sam at a young age to follow his own inquisitive mind and appreciate the scientific process to better understand the world in which we live.

Barbara attributes her love of science to her brother, who was a high school science teacher and who helped nurture her curiosity. Her own journey started in the arts where she found that the creative process mirrored the scientific method. This approach to inquiry guided her through her career, which spanned multiple fields in the public, private, and nonprofit sectors, and finally landed her at MIT.

Sam and Barbara Dyer attending the Capital Science Evening lecture by Dr. Margaret McFall-Ngai: Squid Pro Quo (below).

The Dyers' love for science extended to their son, who followed in his grandfather's footsteps and became a theoretical physicist, receiving his Ph.D. at MIT. Their family's collective enthusiasm for discovery and understanding the natural world found a perfect ally in Carnegie Science.

Their journey with Carnegie Science began when the Nobel Prize-winning biologist Andrew Fire, who was a family friend, stayed with them as he began his research career at Carnegie. Later, they started attending the public lectures and neighborhood events at Carnegie and were impressed by the depth of the scientists' research and the freedom and support they received from the institution. They could also see that it was a collegial and energetic place to conduct research. During these public events and lectures Sam and Barbara appreciated how Carnegie scientists and speakers discussed their research, embraced innovation, and worked to break down societal barriers to science, making it approachable for everyone. "We are in a golden age of science," said Sam, "and being able to share that with the broader public is so important."

Sam and Barbara's story is a testament to the transformative power of science and the importance of supporting institutions like Carnegie. Through their generosity, they hope to inspire others to join them in supporting the groundbreaking research and outreach efforts of Carnegie Science.

More donor recognitions are online at https://carnegiescience.edu/2023-year-book.

Simon and Charlotte Harrison

Growing up, Simon Harrison found himself fascinated by science, especially physics. After completing an undergraduate degree from London University, he obtained a Ph.D. from Oxford University in low-temperature physics, but then decided to leave academia for the business world. He and his wife Charlotte emigrated to the U.S. in 1974 to start a new life in Pasadena where Simon then went on to start five different companies.

Though his professional path led him to venture into the business side of technology, he continued to pursue his love for science through his hobby of astrophotography. Capturing images of distant galaxies, like the Sombrero galaxy, became a thrilling hobby. “What I love about astrophysics is that you don’t get to determine the starting conditions. With most physics the conditions of the experiment can be configured and controlled, but not with astrophysics. All we get is a twinkle of starlight—but from that we have figured out everything we have so far about the universe. It really is absolutely fascinating,” Simon shared.

Through a scholarship program established 12 years ago, Simon and Charlotte have sponsored a total of 20 Ph.D. students in a wide array of scientific research areas at Oxford. But when he was introduced to Carnegie Science by a friend, Simon saw an opportunity to fund the postdoctoral stage of a scientist’s career and also rekindle his early interest in astrophysics. “I was quite ashamed that I took so long to discover that Carnegie Observatories, with its rich history of astrophysics, was right on my doorstep in Pasadena!” After getting to know some of the people at Carnegie and a quick trip to Las Campanas in Chile, Simon and Charlotte decided to establish a postdoc fellowship in astrophysics.

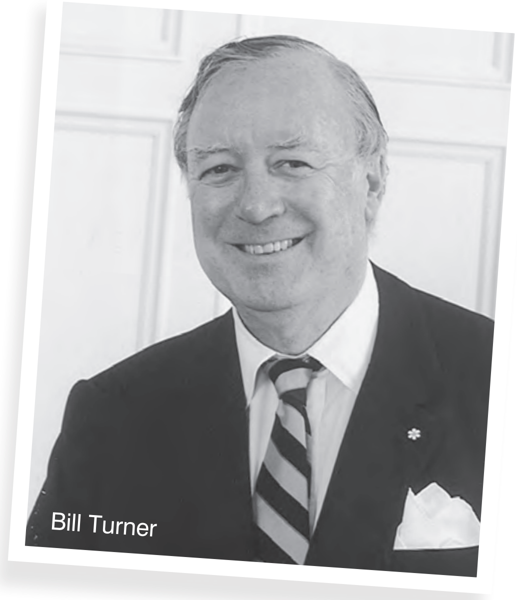
Simon and Charlotte Harrison pose for a photo together (above).

Being a part of the Carnegie Science community has enriched Simon’s life by encouraging him to continually expand his understanding of the universe. Though having a world-class institution like the Carnegie Science Observatories nearby is a bonus, his support is not just about proximity. He is inspired by outreach efforts, like lunchtime talks and other lectures, that make complex science accessible and engaging. He enjoys, in turn, taking friends to lectures and visiting Mount Wilson Observatory to look through the same telescope that Edwin Hubble used to discover the universe outside our galaxy and marvel at the incredible history of this location.

At Carnegie, Simon has found a group of like-minded individuals who are dedicated to groundbreaking research and sharing that knowledge with the world, as well as an opportunity to help support the next generation of scientific talent. We are grateful for the Harrisons generosity and their involvement with our great institution.

Carnegie Canada and Carnegie Science Help Bridge Gaps for Researchers

The Carnegie Institution of Canada is dedicated to "conducting, promoting, encouraging, and supporting investigation, research, and discovery across scientific fields," including astronomy, Earth sciences, and biology. This mission aligns closely with our own, and over the past 30 years, Carnegie Canada has been a crucial partner.


Bill Turner

Established in 1993 by William "Bill" I. M. Turner—a former Carnegie Science trustee and proud Canadian citizen—Carnegie Canada has fostered the deep connections between scientific research in Canada and the United States. Bill, who was CEO of an international natural resources corporation, brought people together from diverse backgrounds and industries throughout his professional career. Later in life he desired to use his network and resources in order to give back to the scientific community.

For Canadian researchers, postdoctoral fellowship opportunities can be limited, often leading them to seek options abroad. Carnegie Science has helped bridge this gap, offering essential support and funding for Canadian citizens since 1995. The range of funded projects reflects a breadth of scientific endeavors, from climate change and observational cosmology to geophysical sciences and the search for exoplanets.

"We're always thrilled to see how our contributions create a lasting impact," says Elvie Cates, the current president of Carnegie Canada. "Bill was a visionary who truly believed in the power of science. Our mission is to carry forward his legacy of support and generosity."

The partnership between Carnegie Canada and Carnegie Science has strengthened bonds between Canada and the United States, promoting collaboration across borders and making significant advancements possible. We're deeply grateful for Carnegie Canada's longstanding support and look forward to continued success together.

Inaugural Pew Marine and Biomedical Science Fellowship Awarded to Carnegie Coral Biologist

Carnegie biologist Phillip Cleves was selected by The Pew Charitable Trusts as one of seven recipients of the 2023 Pew Fellowship in Marine Conservation and the first researcher to receive the organization's Marine and Biomedical Science Fellowship.

The Pew Marine and Biomedical Science Fellowship supports research that applies techniques or technologies more commonly used in biomedical science to enhance marine conservation. Cleves uses genome editing technology to study the genetic basis of bleaching in coral reefs in hopes of informing new conservation strategies, such as the selection and propagation of bleaching-resistant coral populations. Coral reefs around the world have suffered significantly due to warming ocean temperatures associated with climate change.

Carnegie's Phillip Cleves scuba diving on the Great Barrier Reef in Australia. Cleves uses cutting-edge biology techniques to better understand the risks coral face due to climate change.

"Coral reefs are biodiversity hotspots in decline due to stressors associated with climate change. Despite this decline, we still know very little about cellular and genetic mechanisms underlying how corals and their intracellular symbiotic partners cope with a changing climate," Cleves said. "Just as it has been essential to understand the genetic basis of human disease to develop novel therapeutics, we hope to provide a deeper understanding of the coral stress response to inspire new conservation strategies to preserve the reefs."

Cleves joins Pew's global community of 202 marine fellows from 42 countries all working to expand knowledge of the ocean and advance the sustainable use of marine resources. The Pew Fellows Program in Marine Conservation supports mid-career scientists and other experts seeking solutions to challenges affecting the world's oceans.

Cleves is a leader in applying molecular genetics to study corals and coral bleaching. Among his breakthroughs was the successful CRISPR-mediated gene editing of reef corals. This award perfectly encapsulates his interdisciplinary expertise—deploying techniques that were developed for biomedical research to tackle the greatest environmental challenges facing our planet today.

The Pew Marine and Biomedical Science Fellowship is jointly administered by the Pew Fellows Program in Marine Conservation and the Pew Scholars Program in the Biomedical Sciences with support from the Herbert W. Hoover Foundation.

Fellows are selected by an international committee of marine science experts with a range of expertise following a rigorous nomination and review process.

Honors & Awards

Carnegie's Ana Bonaca wins AAS Warner Prize

Carnegie's Ana Bonaca was awarded the American Astronomical Society's Helen B. Warner Prize in recognition of her work, which uses our own Milky Way as a cosmological laboratory to explore the evolution of the universe. Each year, the organization selects an astronomer within eight years of completing a Ph.D. who is significantly advancing theoretical or observational astronomy research.

Bonaca specializes in stellar dynamics and aims to uncover the structure and evolution of our Milky Way galaxy and the dark matter halo that surrounds it.

Moises Exposito-Alonso receives Tansley Medal, is selected for inaugural class of HHMI Freeman Hrabowski Scholars, and is recognized by ASPB for early career excellence

Recently departed Carnegie evolutionary geneticist Moises Exposito-Alonso has won the 2022 New Phytologist Tansley Medal for outstanding contributions to plant science by an early career researcher.

Exposito-Alonso was selected by the Howard Hughes Medical Institute as one of 31 inaugural Freeman Hrabowski Scholars—outstanding early career faculty in science who can become leaders in their research fields and create diverse and inclusive labs.

He was also selected for the American Society of Plant Biologists' 2023 Early Career award—which recognizes "outstanding research" and "exceptionally creative, independent contributions" to plant science.

In his role as a Carnegie Staff Associate, he deployed a combination of computational and experimental methods to describe fundamental principles of evolution and adaptation of plants to different climates. His findings can be used to anticipate biodiversity loss and inform conservation strategies.

Carnegie's Anna Michalak Honored by Max Planck Society

Carnegie's Anna Michalak has been named an External Scientific Member of the Max Planck Institute for Biogeochemistry and a Scientific Member of the Max Planck Society in recognition of her scientific excellence and leadership.

Over the course of her career, Michalak has developed novel approaches for quantifying greenhouse gas emissions and for characterizing how climate change impacts the biosphere's ability to sequester carbon. She has also advanced our knowledge of how a warming planet and shifting precipitation patterns impact coastal, lake, and river water quality around the world. This work has positioned Michalak as a thought leader for policymakers, for example leading the development of the U.S. Carbon Cycle Science Plan and serving on multiple committees for the National Academies of Sciences, Engineering, and Medicine.

Carnegie's William Dwyer selected as Knight-Hennessy Scholar at Stanford University

Carnegie's William Dwyer was selected for the 2023 cohort of

New Staff

Mengyi Cao joined Carnegie Sciences as a Biosphere Sciences and Engineering Staff Associate based in Pasadena in the spring of 2023. Cao's research focuses on establishing *Steinernema* nematodes as an emerging genetic model to study microbial symbiosis. These soil-dwelling roundworms naturally associate with mutualistic bacteria in the genus *Xenorhabdus*. Further development of genetic tools in *Steinernema* nematodes will help biologists better understand the molecular mechanisms underlying host-microbe interactions.

New Promotion

Alycia Weinberger has been appointed as Associate Division Director by EPL. Weinberger works closely with EPL Director Michael Walter to set and execute the Division's overall scientific and cultural vision. She also manages the postdoctoral fellowship program and oversees the Division's colloquia and internship programs, serving as a mentor to the next generation of researchers and helping to maintain a long-standing legacy of scientific excellence.

Knight-Hennessy Scholars—who are chosen for demonstrating "independence of thought, purposeful leadership, and a civic mindset."

Dwyer joined former-Carnegie plant biologist Sue Rhee's lab, where he has contributed to research aimed at uncovering the molecular strategies plants use to sense and respond to their surroundings and at improving the performance of algorithms for predicting the functions of genes.

Peter Gao awarded Scialog grant for biosignature research

Peter Gao is one of 19 researchers from across the U.S. and Canada who were awarded a $50,000 Scialog grant. The initiative was launched by the Research Corporation for Science Advancement (RCSA), the Heising-Simons Foundation, the Kavli Foundation, and NASA to advance interdisciplinary research that will advance the search for life beyond Earth by deploying a basic science approach. The Scialog program, short for "science + dialog" was created in 2010 by RCSA to support new research directions by stimulating intensive interdisciplinary conversations and community building around a globally important scientific theme.

Together with Renyu Hu of the Jet Propulsion Laboratory and Chenguang Sun of the University of Texas at Austin, Gao will use a combination of modeling and observations to better understand how geologic processes happening in the interiors of exoplanets could be detected and understood from studying their atmospheres.

Shaunna Morrison recognized by AGU for early career excellence

Carnegie mineralogist Shaunna Morrison was awarded the American

Geophysical Union's Ronald Greeley Early Career Award in Planetary Sciences, which recognizes significant contributions from researchers within six years of receiving their Ph.D. Presented annually, the Greeley Award is named in honor of a prolific planetary geologist who trained and mentored many early career researchers during his lifetime.

Morrison combines her expertise in crystallography and crystal chemistry with cutting-edge machine learning and data visualization methods to advance the field of mineralogy. As a co-investigator on NASA's Curiosity Mars Rover mission, Morrison predicted the location of previously unknown mineral deposits and Mars analog environments on Earth, and uncovered mineralogical signs of life.

Carnegie's Ryan Hulett recognized by HHMI for early career excellence

Postdoc Ryan Hulett was selected by the Howard Hughes Medical Institute for the 2023 cohort of Hanna Gray Fellows, a group of 25 outstanding early career researchers in the biomedical sciences. The Hanna Gray program was designed to give fellows "the freedom to explore new scientific territory and follow their curiosity, while seeking answers to challenging scientific questions."

Working in Phillip Cleves' lab at Carnegie, Hulett's research focuses on how climate change is impacting interactions between animals and microbes. He uses symbiotic marine invertebrates, like anemones and corals, which take up algae into their own cells, to understand how intracellular microbes reprogram their host cell's responses to heat stress conditions. This work will illuminate fundamental cellular and molecular mechanisms underlying animal resilience in response to global warming.

Carnegie's Anirudh Prabhu recognized for early career excellence

Carnegie Research Scientist Anirudh Prabhu was recognized for early career excellence in Earth and space science informatics by the European Geosciences Union.

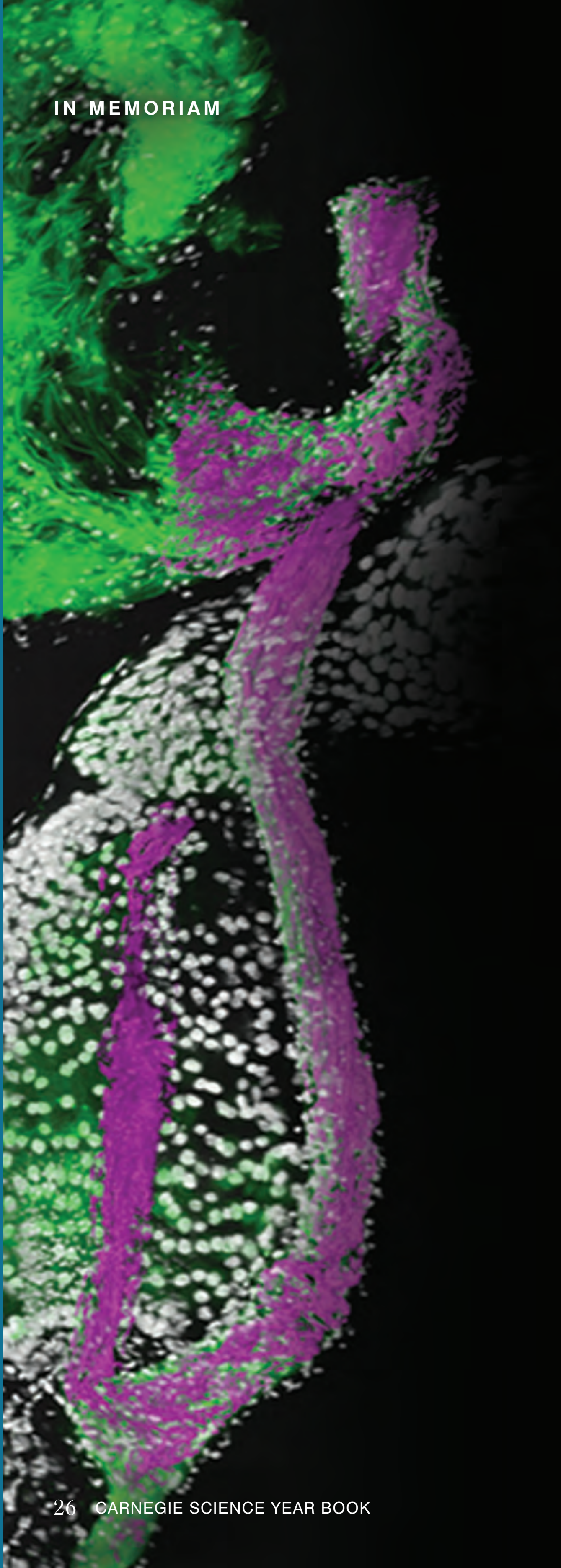
Prabhu's research focuses on advancing data science by developing and applying analytics and machine learning techniques to answering some of the biggest questions in science.

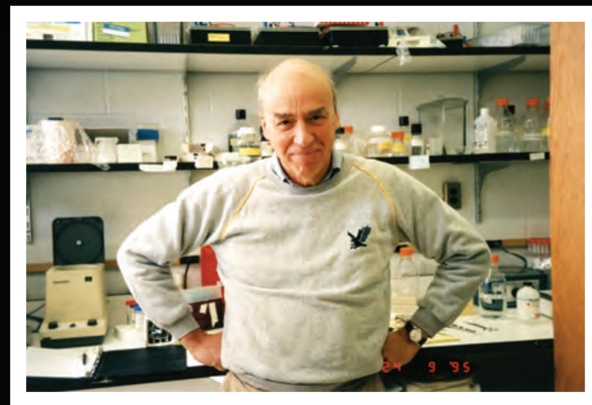
Carnegie's Lorenzo Rosa recognized for early career excellence

Carnegie Staff Associate Lorenzo Rosa was recognized by the Leonardo da Vinci Society for his contributions to science and society in the field of engineering. The Leonardo da Vinci Award was created in 2019 to honor Italian and Italian American early career researchers in the San Francisco Bay Area.

His work aims to analyze environmental challenges and solutions in our food, water, and energy systems.

The complete Fiscal Year 2023 Yearbook is online at https://yearbook.carnegiescience.edu/2023.



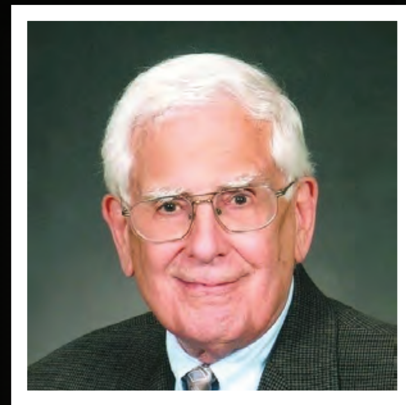


Donald Brown

Carnegie Science developmental biologist Donald Brown died in May 2023 at the age of 91. His pioneering molecular biology research advanced our understanding of the fundamental nature of genes and led to early breakthroughs in genetic engineering. Brown served as the director of Carnegie's former Department of Embryology from 1976 through 1994. He is widely recognized for his role in spearheading and championing the ability to manipulate genes in a laboratory environment. His work played a leading role in transforming biology from a primarily observational pursuit, in which researchers relied on microscopic observations of processes, to a mechanistic discipline in which investigators used novel techniques to study the interlocking functions of genes and cellular components.

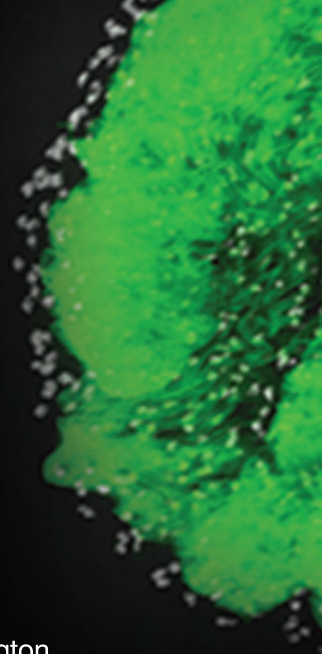
Kent Ford

Carnegie Science astronomer and instrument developer Kent Ford died in April of 2023 at the age of 92. A ham radio hobbyist growing up, his tinkering with electronics and tubes led to a career as an instrumentation specialist. He developed the Carnegie Image Tube spectrograph that enabled him and legendary Carnegie Science astronomer Vera Rubin to confirm the existence of dark matter by studying the rotation curves of galaxies. This incredible tool is on display at the Smithsonian's Air and Space Museum, where it is identified as one of "The 101 Items That Made America."



Paul Kokulis

Paul Kokulis was a prominent Washington, D.C.-area patent attorney with a background in chemical engineering. Over the course of an impressive career, he represented many clients in the chemical, pharmaceutical, and textile industries, and worked on products ranging from pantyhose to home pregnancy tests, and flu medication to permanent press fabric. A longtime friend of Carnegie Science, Paul Kokulis represented the institution's IP interests for many years, including patents and licensing for critical Carnegie-led breakthroughs like RNAi and the chemical vapor deposition process associated with the fabrication of diamonds. He was also a regular attendee of the popular Capital Science Evenings public lecture series and an enthusiastic advocate for Carnegie among his social circles.



ON THE HORIZON

New Climate and Resilience Hub to Tackle Sustainability Across Disciplines

Carnegie Science is building on our decades-long leadership in climate, energy, and Earth systems research to launch the Climate and Resilience Hub, which will meet the urgency of the moment with a cross-disciplinary approach that incorporates the expertise of dozens of Carnegie Science principal investigators, ranging from ecology to volcanology to astronomy.

Our organization is devoted to supporting some of the world's leading scientists in addressing humanity's most pressing problems in an atmosphere of expansive intellectual freedom. This hallmark flexibility makes Carnegie Science an ideal venue for the cross-disciplinary collaboration needed to take on one of the greatest challenges of our time—climate change.

Headed by Anna Michalak, a Staff Scientist who led Carnegie Science's former Department of Global Ecology between 2020 and 2023, the Hub is a new organization-wide center that will help to coordinate our broad expertise to facilitate, enable, and scale work in climate and sustainability.

"Much as we are at an 'all-hands-on-deck' moment in terms of the urgency of the climate crisis, we also recognize that we need 'all-disciplines-on-deck' if we are to identify and seek creative solutions," Michalak said. "I want to bring in those with experience studying atmospheric chemistry of exoplanets or the climate effects of geophysical phenomena as well as those who have spent their careers developing high performance computing and engineering skills in astronomy and the geosciences."

This effort includes researchers from across all three Carnegie Science divisions with the necessary technical and scientific expertise for tackling problems in climate resilience and sustainability. More than a third of Carnegie Science's Principal Investigators—representing disciplines as varied as aquatic ecology, climate science, volcanology, and astronomy—have already joined the Hub and are committed to lending their time and expertise to its mission.

Members of this Hub community have identified some early areas of focus that are well-matched to the breadth of their expertise. These include studying volcanic activity as a window into both atmospheric climate processes and ecosystem resilience in the oceans; developing approaches for more deeply integrating computational modeling with data from multiple field sites at scales spanning from genomes to ecosystems; and expanding our understanding of resilience in the context of climate and sustainability by viewing it from perspectives as diverse as food, water, energy, infrastructure, adaptation, geohazards, and early warning systems.

The Hub is designed to amplify scientific impact by facilitating partnerships between Carnegie Science researchers and external groups, including non-traditional research partners such as private sector groups, NGOs, philanthropies, and international research organizations. It will also serve as a training ground for a cohort of postdoctoral fellows looking to leverage skills and expertise acquired as part of Ph.D. programs across a variety of science and engineering disciplines to challenges in climate and resilience.

Former Presidents

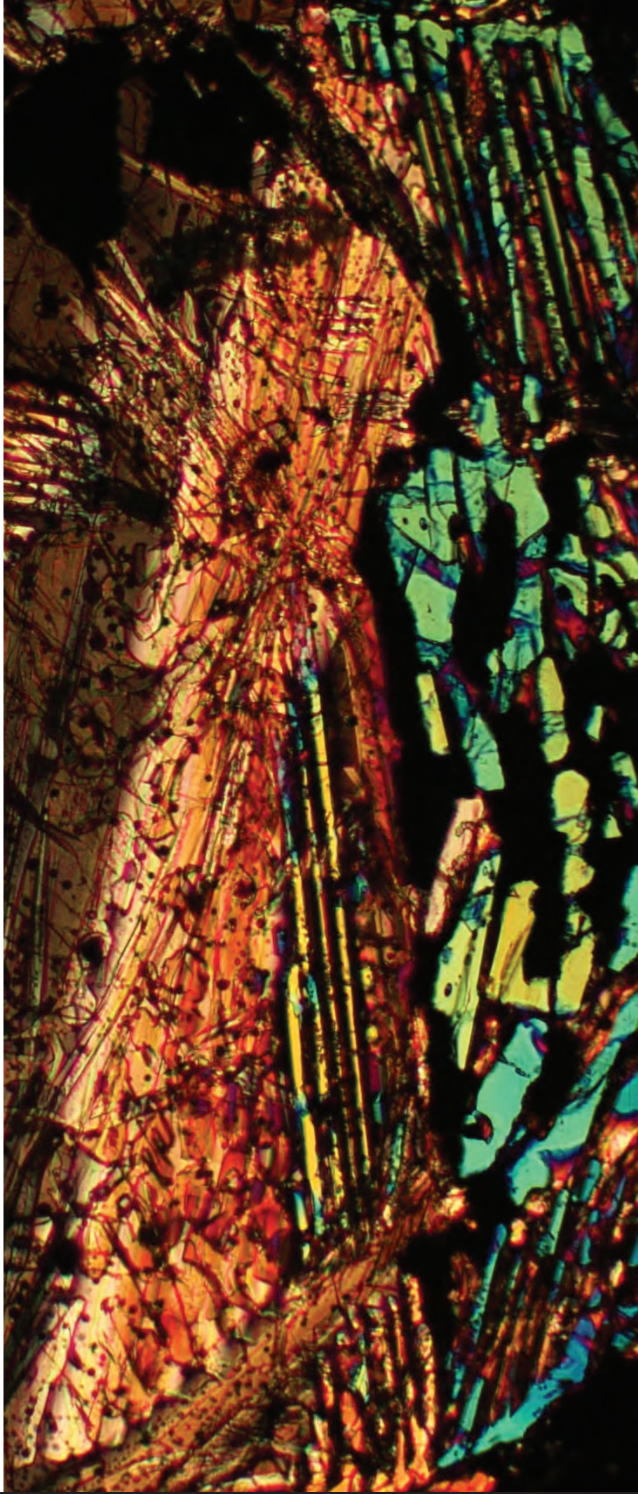
Former Trustees

A gift for the future

One of the most effective ways to support the work of Carnegie Science is to include the Institution in your estate plans. By doing so, you can support cutting-edge, independent scientific research well into the future.

Leaving a gift to Carnegie Science in your will, or by bequest or beneficiary designation, can honor the values you hold most dear. You may also generate significant tax savings for your estate. You can designate your gift to support staff positions and fellowships, specific research projects, or other programs and can be endowed in perpetuity. For more information, please contact the Office of Advancement at giving@carnegiescience.edu.

The complete Fiscal Year 2023 Year Book is online at https://yearbook.carnegiescience.edu/2023.



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