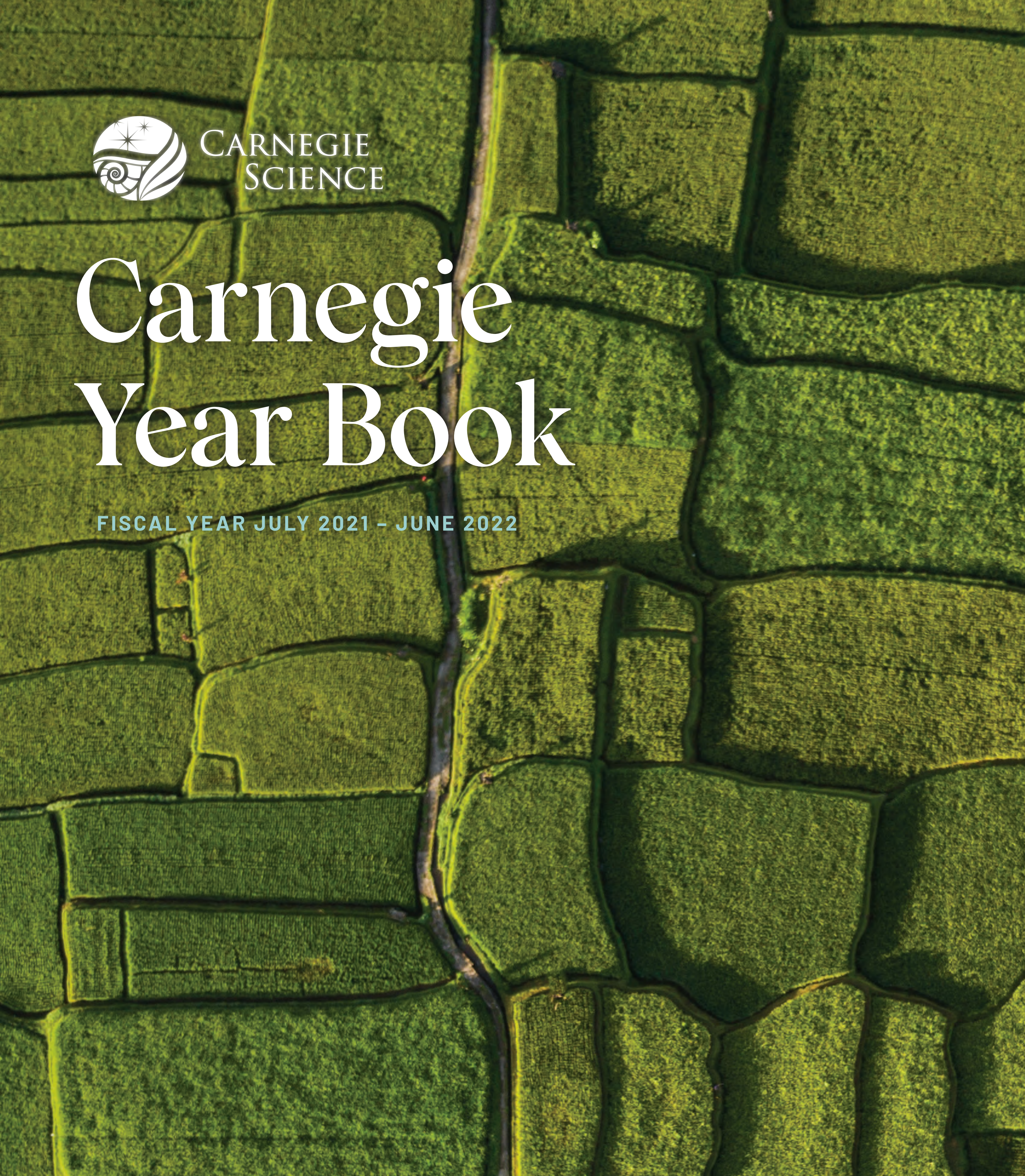

Carnegie Science

Carnegie Year Book

FISCAL YEAR JULY 2021 – JUNE 2022

Carnegie Science

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This is a selection of materials from our annual report, which is online at: https://yearbook.carnegiescience.edu/2022.

A Message from Our President

Driving the Future of Science

This year, Carnegie Science captured several transformative gifts and grants that have positioned us for continued leadership and success. These new contributions to our programs will significantly enhance Carnegie's research capabilities across multiple exciting projects.

Eric D. Isaacs

A notable achievement is the Carnegie-led effort to secure $205 million toward the completion of the next-generation Giant Magellan Telescope (GMT) currently being constructed at our Las Campanas Observatory in Chile. When completed, the GMT will enable breakthrough astronomy—from revealing the fundamental physics underpinning the cosmos to advancing our ability to search for life on distant worlds.

In support of Carnegie Science's expansion in Pasadena, the state of California designated $20 million for ecology and environmental sciences. This support recognizes the importance of our research to the state of California and helps us to establish an enhanced research footprint in Pasadena. This interdisciplinary space will foster collaboration among scientists from various fields to address the most pressing challenges facing humanity today. Drawing upon our extensive expertise in exploring the natural world across scales, Carnegie life and environmental science researchers will investigate the intersections of climate, ecosystem dynamics, and resilience.

Additionally, Carnegie received word late in the fiscal year that we would be receiving a nearly $35 million, anonymous bequest to support astronomical instrumentation at the Observatories. This gift—the largest to the Institution since its founding by Andrew Carnegie—will enhance Carnegie Science astronomers' capacity to develop state-of-the-art instrumentation.

At Carnegie, we strive to cultivate an environment where creativity and ambitious pursuits drive scientific discovery. This commitment fosters a lasting sense of community among our scientists, reverberating throughout their careers and lives, even after they have moved on to other positions. An example of this lifelong connection is the recent $4.2 million bequest from former Carnegie Staff Scientist Louis Brown and his wife, Lore, to support cosmochemistry research at our Earth and Planets Laboratory. The gift will specifically focus on the formation, evolution, and dynamic processes of our planet and the Solar System, ensuring their legacy lives on in perpetuity.

Looking ahead, I am deeply inspired by the dedication to our scientific endeavors embodied by these investments. And, as always, I am energized by the bold research happening throughout Carnegie. I eagerly anticipate sharing with you the next breakthroughs that these investments will enable Carnegie scientists to make.

Sincerely,

Eric D. Isaacs

Eric D. Isaacs

COSMOS

Transformative Gift Will Drive New Era of Astronomical Discovery

An anonymous bequest of $34.8 million will keep the Carnegie Observatories at the frontier of astronomy and astrophysics. This represents the largest single gift to the Institution since it was established by Andrew Carnegie in 1902.

Since George Ellery Hale and Andrew Carnegie first established the Mount Wilson Observatory, Carnegie scientists have transformed the ways in which we understand our universe. This philanthropy provides a foundation for the next era of breakthrough discoveries from Carnegie astronomers.

The gift will enable the first expansion of staff scientist positions at the Observatories since the days of Edwin Hubble. These new roles will be created for individuals who specialize in using or developing instruments for the telescopes at Carnegie's Las Campanas Observatory in Chile.

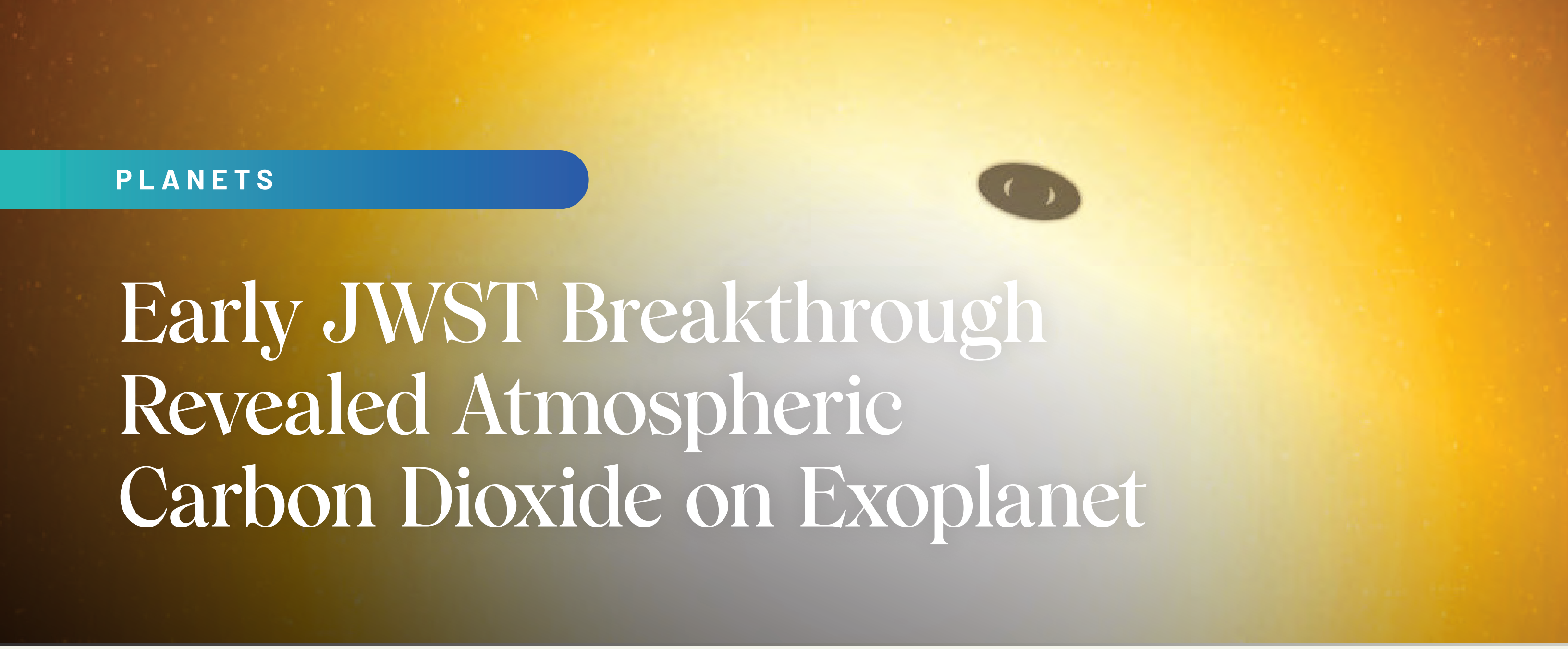
The Magellan Telescopes at Carnegie's Las Campanas Observatory in Chile.

"The gift will enable the first expansion of staff scientist positions at the Observatories since the days of Edwin Hubble. These new roles will be created for individuals who specialize in using or developing instruments for the telescopes at Carnegie's Las Campanas Observatory in Chile."

The funds will also support the design and construction of new instruments that will enhance the abilities of Carnegie's twin Magellan telescopes, as well as the Giant Magellan Telescope when it comes online. The Carnegie Observatories is a rare campus with an on-site machine shop, enabling observational astronomers, theorists, engineers, and machinists to work in close collaboration, developing the tools that will open new doors to discovery.

This bequest will empower generations of Carnegie scientists to reveal the cosmos in never-before-seen detail. It is an excellent example of the tremendous power of philanthropic giving—a single individual's investment in astronomy will be felt for decades to come, both at Carnegie and throughout the scientific enterprise.

Machine Shop Foreman and instrument maker Vince Kowal and instrument maker and machinist Jerson Castillo give a tour of the Observatories machine shop.



PLANETS

Early JWST Breakthrough Revealed Atmospheric Carbon Dioxide on Exoplanet

The James Webb Space Telescope captured the first clear, detailed, indisputable evidence for atmospheric carbon dioxide ever detected on a planet outside the Solar System. The discovery was announced in September 2022 by the mission's Transiting Exoplanet Community Early Release Science Team, which includes four Carnegie astronomers—postdoctoral fellows Munazza Alam and Anjali Piette and Staff Scientists Peter Gao and Johanna Teske.

As part of the Early Release Science (ERS) Team's efforts, JWST observed a gas giant planet, called WASP-39 b, which orbits a Sun-like star 700 light-years from Earth. Their finding offered thrilling evidence of JWST's capabilities and provided important insights into the link between planetary formation and composition.

First discovered in 2011, WASP-39 b is a hot gas giant with about the same mass as Saturn and a diameter 1.3 times greater than Jupiter. Its extreme "puffiness" is related in part to its high temperature of about 1,600 degrees Fahrenheit, or 900 degrees Celsius. Unlike the cooler, more compact, gas giants in our Solar System, WASP-39 b orbits very close to its star at a distance only about one-eighth that between the Sun and Mercury, completing its orbit in just over four Earth days.

WASP-39 b was initially discovered using ground-based detections of the subtle, periodic dimming of light from its host star as the planet passed in front of it. So-called transiting planets like this present astronomers with ideal opportunities to probe their atmospheres.

During a transit, some of the starlight is filtered through the planet's atmosphere. Depending on the atmosphere's composition, thickness, and cloudiness, it absorbs some colors of light more than others—making the planet appear larger. Researchers can analyze these miniscule differences in the size of the planet to reveal the atmosphere's chemical makeup.

“The James Webb Space Telescope captured the first clear, detailed, indisputable evidence for atmospheric carbon dioxide ever detected on a planet outside the Solar System. The discovery was announced in September 2022 by the mission’s Transiting Exoplanet Community Early Release Science Team, which included four Carnegie astronomers...”

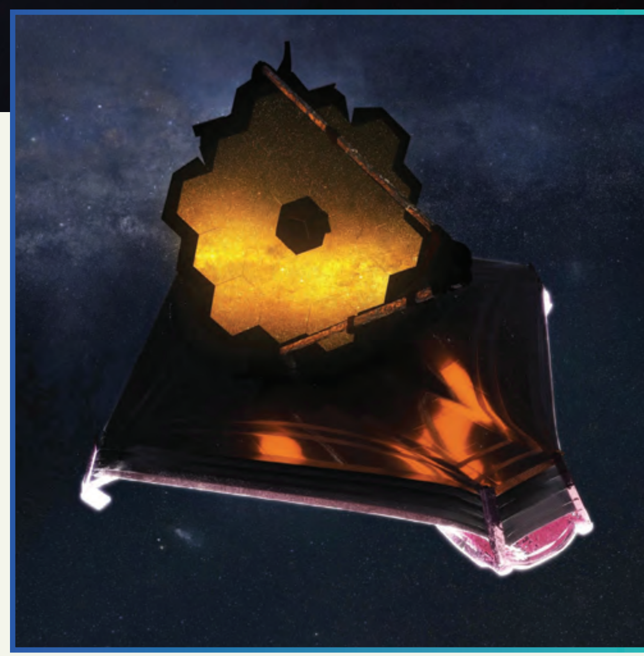


ILLUSTRATION IS COURTESY OF NASA GSFC/CIL/ADRIANA MANRIQUE GUTIERREZ

An artist’s conception of the James Webb Space Telescope.

An artist’s impression (above) of WASP-39 b, which orbits a Sun-like star 700 light-years from Earth. Illustration is courtesy of NASA, ESA, CSA, and J. Olmsted (STScI).

The ERS program, which represents 22 different research institutions, was designed to provide the research community with robust data from JWST as quickly as possible. This is one of several JWST teams involving Carnegie astronomers, including six projects headed up by Carnegie scientists—Gao and Teske are both leads on separate JWST investigations of exoplanet atmospheres—and several others on which Carnegie staff and postdoctoral students are team members.

ECOSYSTEMS

Improving Agricultural Resilience in a Changing Climate

As climate change shifts precipitation patterns, irrigation can be a powerful tool for increasing the world's food supply without converting natural spaces into farmland, according to Carnegie's Lorenzo Rosa, whose work aims to decarbonize the agricultural industry.

Population trends indicate that agricultural production will need to double by 2050. But climate change is expected to both shift precipitation patterns and increase heat stress on plants, meaning that relying on rainfall alone will not keep up with the increased demand for food.

Studies show that irrigated crops are twice as productive as those that rely on rain. However, irrigation already accounts for between 85 and 90 percent of human water consumption. Rosa set out to determine whether sustainable irrigation strategies could be expanded to maximize agricultural productivity and minimize the negative environmental impacts of water use. Sustainable irrigation relies on groundwater and locally available water sources, without harming freshwater ecosystems or depleting them beyond what precipitation can replace.

Rosa revealed that under current conditions, there is enough water available from local, renewable sources to expand sustainable irrigation over 35 percent of farmland around the world. However, climate change will make this calculus more complex. As the world warms, Rosa indicated that in addition to heat stress and changes in rainfall, climate change could also make water evaporate faster, decreasing the efficiency of irrigation.

That said, Rosa found that constructing long-term water storage reservoirs could enable sustainable irrigation to feed 1.2 billion more people than relying on renewable water resources alone.

In the past, big dams were the most common method for saving rainwater for agricultural irrigation. However, these projects inflicted harm on their local and regional ecosystems, and particularly on fish and migratory birds. Dams also lose water due to evaporation and necessitate transportation to get the stored water to farmers' fields. In collaboration with Stanford University researchers, Rosa showed that these drawbacks mean that big dams should be considered a measure of last resort.

Is Net-zero Food Production Possible?

Rosa studies challenges and opportunities related to food, water, and energy security from a variety of angles. Together with Carnegie Visiting Investigator Paolo Gabrielli of ETH Zurich, he also analyzed strategies for decreasing greenhouse gasses emitted by the synthesis of nitrogen fertilizers. Their research, which found that there's no one-size-fits-all solution for decarbonizing fertilizer production, was funded by the ClimateWorks Foundation.

Right now, nitrogen fertilizer manufacturing is responsible for 2 percent of global energy consumption and emits about 310 megatons of carbon dioxide pollution each year. Rosa and Gabrielli analyzed a variety of options for lowering the carbon footprint of the fertilizer industry to net-zero emissions without diminishing the global food supply, including:

- **Capturing the carbon produced from nitrogen fertilizer synthesis before it reaches the atmosphere and permanently storing it underground.**
- **Using biomass to capture and contain the carbon produced by nitrogen fertilizer production.**
- **Supplying the hydrogen molecules to create nitrogen fertilizer using a process based on carbon-free electricity.**

Rosa and Gabrielli found that while these solutions can reduce agriculture's dependence on fossil fuels, they will require more land, water, and energy than current methods of nitrogen fertilizer production. This means that approaches will need to be tailored on a case-by-case basis depending on local resources. The situation could also potentially be improved by restructuring the international chemicals trade to move fertilizer production from countries with large fossil resources to countries with abundant renewable energy infrastructure, land, and water resources.

A wind farm.

UNSPLASH

"Rosa and Gabrielli's work on reducing emissions from the fertilizer industry provided insights that are key to improving our global food system. We are pleased to have partnered with Carnegie on this important research to gain a better understanding of fertilizer's role at the intersection of food, energy, land, and climate."

—Avery Cohn, Program Director, Food & Agriculture, ClimateWorks Foundation

GENOMES

Developing a New Tool to Evaluate and Track Global Sustainability Targets

Climate change and habitat destruction may have already caused the loss of more than one-tenth of the world's terrestrial genetic diversity, according to research led by Carnegie evolutionary geneticist Moises Exposito-Alonso.

Human activity has impacted or shrunk half of Earth's ecosystems, affecting millions of species. The partial loss of geographic range diminishes population sizes and can prevent populations of the same species from interacting with each other. This has serious implications for an animal or plant's genetic richness and ability to meet the coming challenges of climate change.

PHOTOGRAPH COURTESY OF BENJAMIN BLONDER

Genetic diversity in Quaking Aspens can be seen from differences in autumn leaf yellowing.

Mutations represent small, random natural variations in the genetic code that could positively or negatively affect an individual organism's ability to survive and reproduce, passing the positive traits down to future generations. As a result, the greater the pool of mutations upon which a species is able to draw, the greater the chances of stumbling

“Climate change and habitat destruction may have already caused the loss of more than one-tenth of the world’s terrestrial genetic diversity...”

ARTWORK COURTESY OF MARK BELAN | ARTSCISTUDIOS.COM

Artist’s concept illustrating the rhino’s decreasing geographical range and loss of genetic variability.

upon that lucky blend that will help a species thrive despite the pressures created by habitat loss, as well as shifting temperature and precipitation patterns.

Exposito-Alonso and his collaborators set out to develop a population genetics-based framework for evaluating the richness of mutations available to a species within a given area. They analyzed genomic data for more than 10,000 individual organisms across 20 different species to demonstrate that Earth’s terrestrial plant and animal life could already be at much greater risk from genetic diversity loss than previously thought.

Protection of genetic diversity was a major topic of discussion at the 2022 United Nations Biodiversity Conference, COP15, at which Exposito-Alonso represented Carnegie. One of the meeting’s sessions, organized by the Group on Earth Observations’ Biodiversity Observation Network, G-BIKE, and the Coalition for Conservation Genetics discussed genetic diversity targets and projections, including Exposito-Alonso’s work.

INTERNSHIPS

Exceptional Opportunities to Work with Leading Scientists

Every summer the CASSI cohort visits this historic Mount Wilson Observatory, where Edwin Hubble and many other Carnegie astronomers made significant discoveries about the cosmos.

Carnegie Science offers a range of prestigious and highly sought-after undergraduate internship programs that provide students with exceptional research opportunities and a chance to work alongside leading scientists. Two prominent examples of these programs are the Carnegie Astrophysics Summer Student Internship (CASSI) program in Pasadena and the Summer Undergraduate Research Internship (SURI) program in Washington, D.C. Both programs are making an active effort to create opportunities for students from historically underrepresented backgrounds and contribute to changing the face of their respective fields.

Carnegie Astrophysics Summer Student Internship (CASSI)

CASSI is a competitive internship program designed to give undergraduates who are interested in astronomy and astrophysics the skills and confidence to pursue careers in and adjacent to scientific research. This immersive experience takes place at the Carnegie Observatories, which are renowned for their cutting-edge research and state-of-the-art facilities. Under the guidance of experienced mentors, CASSI students engage in groundbreaking original research projects across a variety of exciting topics including, galaxy formation, exoplanets, cosmology, and dark matter. In addition to their investigative

> "Under the guidance of experienced mentors, CASSI students engage in groundbreaking original research projects across a variety of exciting topics including, galaxy formation, exoplanets, cosmology, and dark matter."

> “Open to students from diverse backgrounds, SURI offers research opportunities in fields such as astronomy, planetary science, and geophysics.”

endeavors, students participate in a rigorous series of workshops to build their technical and communication skills. Professional development discussions cover topics such as impostor syndrome and diversity, equity, and inclusion in the scientific community. They also have opportunities to engage with other local scientific organizations, including Mount Wilson Observatory and the Jet Propulsion Laboratory.

Summer Undergraduate Research Internship (SURI)

The SURI program provides undergraduate students with an immersive research experience across multiple scientific disciplines at Carnegie’s Earth and Planets Laboratory. Open to students from diverse backgrounds, SURI offers research opportunities in fields such as astronomy, planetary science, and geophysics. Under the mentorship of leading Carnegie scientists, SURI interns gain hands-on research skills and contribute to the advancement of scientific knowledge in topics ranging from exoplanet atmospheres to planetary evolution and meteorites to deep Earth diamonds. The program encourages interdisciplinary collaboration, allowing interns to attend seminars and workshops delivered by distinguished researchers across all of the fields represented at Carnegie’s Washington, D.C., campus. The SURI program not only prepares students for future scientific endeavors, but also offers valuable networking opportunities and mentorship that can shape their careers.

Graduates of Carnegie’s internship programs have achieved remarkable success, with many advancing to prestigious graduate programs or pursuing thriving careers in academia, industry, and various scientific fields. They exemplify the institution’s commitment to nurturing the next generation of scientists and provide undergraduate students with the mentorship, skills, and network necessary to make significant contributions to their chosen disciplines.

The CASSI Program is funded in part by The Rose Hills Foundation and The Ralph M. Parsons Foundation and SURI is funded in part by the Alfred P. Sloan Foundation, The New York Community Trust’s Fund for Astrophysical Research, and the Marilyn Fogel Endowed Fund for Internships.

CASE

Empowering the next generation of science lovers and STEM professionals

In the city of Washington, D.C., science lovers from middle school, all the way through high school and beyond, are empowered through the Carnegie Academy for Science Education's (CASE) transformative outreach programs. CASE was founded in 1989 by Carnegie's President Emerita Maxine Singer, and since then has served more than 800 students and 1,000 teachers in the nation's capital—bringing fun and accessible science education to classrooms.

First Light: Saturday mornings at Carnegie's Broad Branch Road campus are bustling with eager students, who are ready to dive into a world of scientific wonders. This year, middle school students participating in CASE's flagship program, First Light, embarked on a cosmic journey, discovering a world of exoplanets beyond our own Solar System; studied jet propulsion, examining the barriers to space travel and the innovative methods required to overcome them; and embarked on an extraordinary adventure inspired by the James Webb Space Telescope, gazing up at the night sky, mapping constellations and studying awe-inspiring nebulae and galaxies.

Summer Stars: During the summer months, talented young students gather five days a week at Carnegie's Broad Branch Road campus for the Summer STARS program. Supported by the Washington, D.C., Marion Barry Summer Youth Employment Program, these participants embarked on a journey of scientific discovery and career exploration. During the 2022 program, they gained real-world college and workplace readiness skills while also learning biotechnology and laboratory research techniques. Their interactions with Carnegie scientists and STEM professionals provided invaluable insights and inspiration for their future endeavors.

CASE Internships: CASE Internships offer high school students an opportunity to immerse themselves in the world of science and science education. In the summer of 2022, student interns spent hours conducting lab experiments, preparing biotech kits, and assisting with First Light and other programs. Through their dedication, they learned essential skills, interacted with younger students, and gained insights into potential STEM careers.

Students participate in a science experiment.

CASE's commitment to excellence extends to teachers as well. In the summer of 2022, the MUSICA Outstanding Teacher Leadership program selected six passionate middle and high school teachers from Arizona, D.C., and Texas to participate in a week of geoscience fieldwork and laboratory experiences around Arizona. The intensive program supplied participants with hands-on knowledge and lesson plan development in the Earth sciences.

CASE continues to light the path for D.C. students, nurturing their curiosity, and igniting their passion for scientific exploration. For more information about CASE and its outreach programs, please visit their website at www.case.carnegiscience.edu.

Donor Stories

For the full FY22 donor recognition list please visit https://yearbook.carnegiescience.edu/2022.

Carnegie Science aims to transform the way we understand the world and the universe by empowering visionary investigators with the freedom to chart new fields and challenge conventional wisdom. When you support our Institution, you help provide the financial flexibility to meet immediate needs and seize opportunities that can have a lasting, long-term impact. Our mission—to advance investigation, research, and discovery, and apply that knowledge to the improvement of humankind—is now more important than ever.

Shirley Ross

I have had a life-long passion for astronomy and a desire to understand and keep abreast of several scientific disciplines. When I attended my first Carnegie lecture, I knew I had found "my people." Carnegie is a cause that I support as generously as I can because it has added so much richness to my life.

Brice Eldridge

Basic research fosters a path to answer human questions: Are we alone? How did we get here? Where is our place in the universe?

Carnegie Science excels at basic research from the microbial level to exoplanets. Not only does Carnegie provide fundamental contributions to these questions, but they do an admirable job communicating their efforts to the public. We believe in basic research which is why we are proud to support Carnegie.

Ron Scott

My support of the Carnegie Observatories means the world to me. It's my way of sustaining scientific exploration and uncovering the mysteries of the universe. I believe in the power of knowledge and want to be a small part of the incredible discoveries that lie ahead.


Michael & Jane Wilson

Michael Wilson

Michael Wilson has been an avid supporter of the arts and sciences for much of his life. A successful movie producer and screenwriter, he feels a sense of responsibility to give back to organizations that are having an impact on the lives of people in communities across the world. "I find it very satisfying to be able to help these institutions to achieve their goals and it is an honor to be part of their work," said Wilson during a recent conversation.

Before starting his career as a movie producer, Wilson received an engineering degree from Harvey Mudd College and a juris doctor from Stanford Law School, and then went on to work for the U.S. Department of Transportation in Washington, D.C. It was there that he met Carnegie Science's board member John Crawford who introduced him to the Institution's work.

"I always wanted to explore astronomy," said Wilson, "For the past 100 years, Carnegie has been at the forefront of astronomical discovery—without Hubble and the research he did while at Carnegie, without Vera Rubin and her exploration into dark matter we would be living in a very different world." Over his many years of involvement with Carnegie Science, he has become intimately aware of the many facets of our scientists' research having served on the Board of Trustees since 2010.

In 2019, he generously endowed three postdoctoral positions in honor of his three granddaughters. "I want my granddaughters to have role models that they can emulate and to have people who inspire them. I thought I would lead the way by starting a scholarship for women in astronomy. My granddaughters may be a little young now, but I hope, eventually, they will be inspired by what these women do," said Wilson.

Wilson went on to say of Carnegie's work, "Science is structured of small discoveries that are built upon one another and that is what Carnegie does so well. Carnegie has long been known as a launching pad for budding scientists because we give them the opportunity to work freely on the things they want to pursue—and that gives them the next leg up on their careers."

We are very grateful for Wilson's dedication to Carnegie Science through the giving of his time, expertise, and philanthropy.

Honors & Awards

Carnegie's Alan Boss Selected as AAS Fellow

Carnegie's Alan Boss was named one of 23 Fellows of the American Astronomical Society. The honorees were chosen for their "extraordinary achievement and service" to the field. Boss, whose contributions to the fields of astronomy and astrophysics are numerous, was specifically recognized for "innovative theoretical investigations of the formation of stars and exoplanets" as well as "tireless leadership within the exoplanet exploration community in ensuring that NASA executes a credible and successful exoplanet program."

Carnegie's Joseph Berry Selected as AAAS Fellow

The American Association for the Advancement of Science (AAAS) elected Carnegie ecologist Joseph Berry to the 2022 class of AAAS Fellows, among the most distinct honors within the scientific community and part of a tradition that started in 1874. Since joining the Institution in 1972, Berry has developed powerful tools to understand the exchange of carbon dioxide and water between plants and the atmosphere—a cycle that has shaped the Earth and made it possible for life as we know it to thrive. His models and methods are widely used to contextualize photosynthetic activity at local, regional, and global scales, and have important implications for agriculture and land management.

Marilyn Fogel Wins Geochemical Society's Highest Honor

Isotope geochemist Marilyn Fogel, who spent 33 years as a Staff Scientist at Carnegie's Earth and Planets Laboratory (formerly the Geophysical Laboratory)—was chosen to receive the Geochemical Society's highest honor, the Victor Moritz Goldschmidt Award, in recognition for her numerous and varied contributions to the field. "Marilyn has had a deep and lasting impact on important questions in Earth and planetary sciences. Her work at Carnegie echoes through our halls and will continue to do so for decades to come," said Carnegie President Eric D. Isaacs. Fogel died several months after the award was announced.

Carnegie's Marilyn Fogel Posthumously Honored by AGU For Legacy of Interdisciplinary Research

Isotope geochemist Marilyn Fogel was posthumously recognized with the American Geophysical Union's Eunice Newton Foote Medal for Earth-Life Science, which is awarded annually to "an exceptional senior scientist for outstanding creative achievements in research at the intersection of Earth and life sciences."

"The Foote Medal was created to highlight work being done that connects our understanding of the past, present and future of the Earth System, as well as the prospects for life on other worlds and the 'future of human well-being,'" said Carnegie Earth and Planets Laboratory Director Michael Walter. "Marilyn's research was impactful across every research area recognized by this prize."

Carnegie's Michael Walter Honored by American Geophysical Union

Earth and Planets Laboratory Director Michael Walter, an experimental petrologist who studies deep-Earth minerals and melts to elucidate the formation and evolution of our planet's dynamic interior, was honored with the American Geophysical Union's Norman L. Bowen Award at the organization's 2022 Fall Meeting. The Bowen prize is the top recognition for a scientist in AGU's Volcanology, Geochemistry, and Petrology section. It is presented each year to an individual who has made "outstanding contributions" to the field, either in the form of a single, groundbreaking paper, or a cumulative set of advancements over time.

Carnegie's Adrien Burlacot Selected for Forbes "Under 30" List

Carnegie algal physiologist Adrien Burlacot was selected for the 2023 class of Forbes' 30 Under 30 North America list in science. Honorees were chosen for their "unconventional thinking," Forbes said in its announcement of the new class, describing them as individuals "who have rewritten rules, reshaped industries, and are breaking ground towards a brighter future." The recognition spotlights Burlacot's efforts to fight world hunger and mitigate climate change by hacking the process plants use to convert the Sun's energy into chemical energy in the form of sugars and fats.

Carnegie's Stephanie Hampton Named President of Ecological Society of America

Deputy Director of Carnegie's Biosphere Sciences and Engineering Division Stephanie Hampton, a freshwater ecologist whose work has informed both conservation efforts and policymaking, has been elected President of the Ecological Society of America (ESA), the world's largest ecological professional society. She will serve a three-year term. A longtime member of ESA, Hampton's service to the organization includes chairing the Aquatic Ecology section between 2011 and 2013, as well as membership on the Science Committee between 2013 and 2015, and Sustainability Science Committee between 2014 and 2015.

Carnegie's Edgar Virgüez Named Duke University Trustee

Carnegie postdoctoral researcher Edgar Virgüez was named one of four new trustees of Duke University. He will serve a three-year term. Virgüez joined the Carnegie Institution for Science's Department of Global Ecology in February after completing his Ph.D. at Duke. He works with Carnegie's Ken Caldeira on modeling climate and energy solutions.

"As a rising scholar and emerging higher education leader, my experiences at Carnegie this year—and the guidance offered by Ken—have expanded my scientific vision and shown me how to contribute to comprehensively addressing the most-pressing societal issues facing humanity today," Virgüez added. "I will bring this knowledge to my work as a Duke trustee."

Inaugural Carnegie DEI Mini-Grants Awarded

In an effort to advance diversity, equity, and inclusion work throughout the organization and our surrounding communities, Carnegie has awarded 10 projects with inaugural DEI mini-grants. The mini-grant program provides up to $5,000 to support DEI-related projects, ideas, or collaborations.

"The mini-grant program launched in the fall of 2021 and was designed to enable Carnegie faculty, postdocs, and staff to obtain funding for small-scale projects that help advance our local and institutional DEI goals," said Associate Science Deputy Anat Shahar, who oversaw Carnegie's DEI efforts between 2020 and 2022 along with Deputy for Science and Observatories Director John Mulchaey.

Many of the grants focus on improving access to STEM programs and activities. Both Adrien Burlacot from the Department of Plant Biology and the Department of Global Ecology's Wu Sun received grants to support joint internships between the two Palo Alto-based departments and the Carnegie Academy for Science Education in Washington, D.C. At the Observatories, Allison Matthews used a grant to reach under-served Pasadena elementary school students with personalized, hands-on astronomy activity kits and at the Earth and Planets Laboratory (EPL) Johanna Teske used a grant for computing support for undergraduate interns.

Several grants focus on the intersection of art and science. Plant Biology's Selena Rice expanded the Plant Cell Atlas initiative's existing art exhibition partnership with HBCUs to showcase the work of historic Black plant researchers. Another Plant Biology program, run by Elena Lazarus, advanced an existing program to organize screenings of and panel discussions about science-related films. At the Observatories, Ethan Nadler partnered with Los Angeles-based arts education organization Create Now to make dark matter visualizations.

EPL's Suzy Vitale and the Observatories Jeff Rich both used their grants for community outreach. Vitale organized a Science in Your Backyard event for Washington, D.C. area science lovers and Rich expanded an existing program to bring local Pasadena students to the historic Mount Wilson Observatory.

The Observatories' Gwen Rudie's grant is also focused on strengthening community relationships, but with an inward gaze. Her project facilitated lunchtime conversations and trust-building between different cohorts of employees on campus.

"This is a great batch of recipients, and we look forward to hearing their reflections," Shahar concluded.

The complete FY22 Yearbook is online at https://yearbook.carnegiescience.edu/2022.

Financial Profile

for the year ending June 30, 2022

The complete audited financial statements will be made available on our website at https://yearbook.carnegiescience.edu/2022

***FY22 financials do not reflect the $35 million anonymous bequest. This will be included in the FY23 Financials.**

READER'S NOTE: *In this section, we present summary financial information. Each year the Carnegie Institution, 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 complete audited financial statements are made available on the institution's website at www.carnegiescience.edu.*

The Carnegie Institution for Science completed fiscal year 2022 in sound financial condition after generating a net return of –7.9% on the diversified investments within its endowment; maintaining a disciplined spending policy that balances today's needs with the long-term requirements of the institution and the interests of future scientists; and the continued support of organizations and individuals who recognize the value of basic science.

The primary source of support for the institution's activities continues to be its endowment. This reliance on institutional funding provides an important degree of independence in the research activities of the institution's scientists.

As of June 30, 2022, the endowment was valued at slightly above $1 billion. Over the period 1998–2022, average annual distributions from the endowment to the budget were 5.0%. Carnegie closely controls expenses to ensure the continuation of a healthy scientific enterprise.

For several years, under the direction of the Investment Committee of the Board, Carnegie's endowment has been allocated among a broad spectrum of asset classes including: global equities, absolute return investments, real estate partnerships, private equity, venture capital, natural resources partnerships, and government bonds. The goal of this diversified approach is to generate attractive overall performance and reduce the volatility that would exist in a less diversified portfolio. In 2016 Carnegie hired its first Chief Investment Officer to more proactively steward the endowment's assets.

The Chief Investment Officer and Investment Committee regularly examine the asset allocation of the endowment and readjust the allocation, as appropriate. The institution relies upon external managers and partnerships to conduct the investment activities, and it employs a commercial bank to maintain custody.

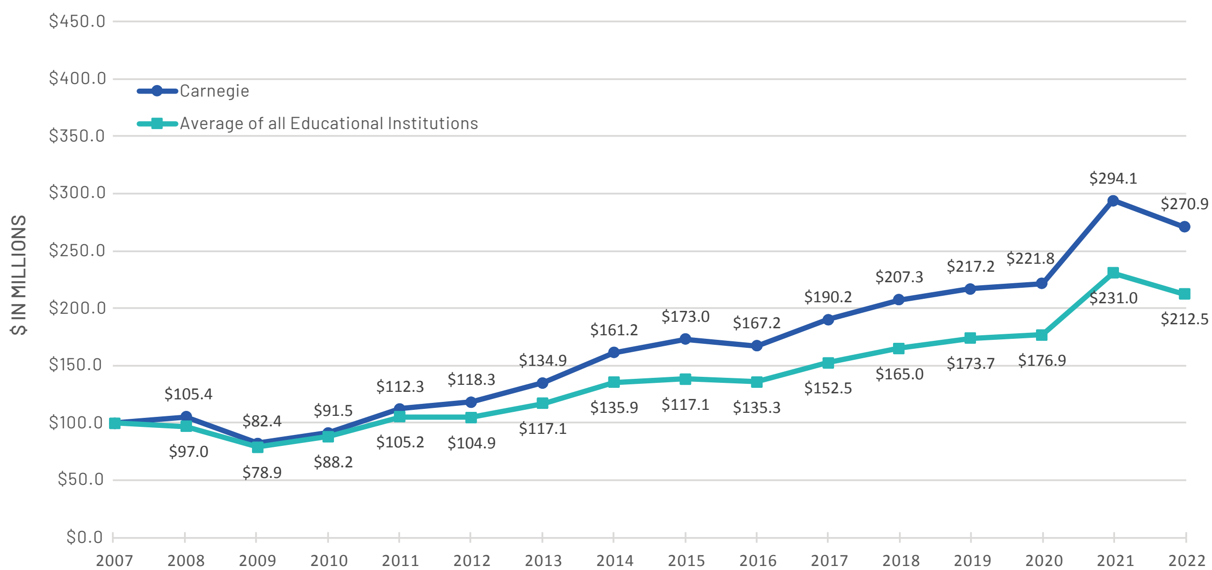
ASSET CLASS	TARGET	ACTUAL
Common Stock	45.0%	33.1%
Alternative Assets	43.0%	57.1%
Fixed Income and Cash	12.0%	9.8%

This chart shows the allocation of the institution's endowment among asset classes as of June 30, 2022.

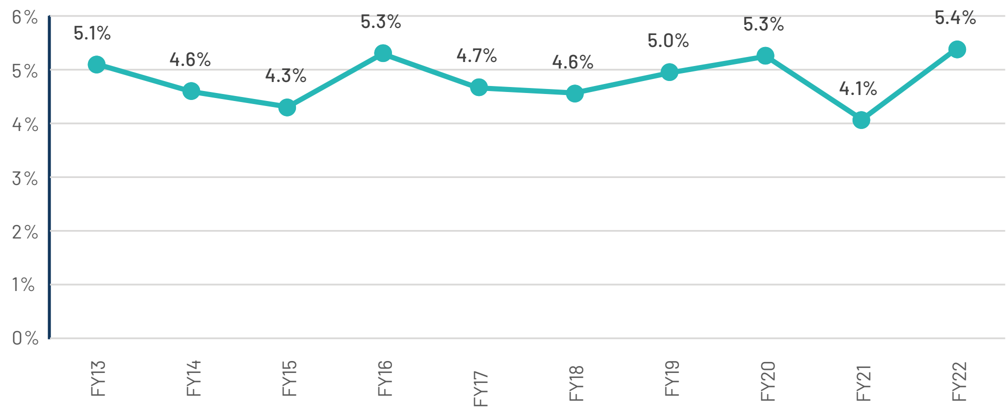
Carnegie's investment goals are to provide high levels of current support to the institution and to maintain the long-term spending power of its endowment. The success of Carnegie's investment

$100 Million Investment

Carnegie Returns vs. Average of all Educational Institutions (2007–2022)



Endowment Spending as Percentage of Endowment Value



strategy is illustrated in the preceding figure that compares, for a hypothetical investment of $100 million, Carnegie's investment returns with the average returns for all educational institutions for the last fifteen years.

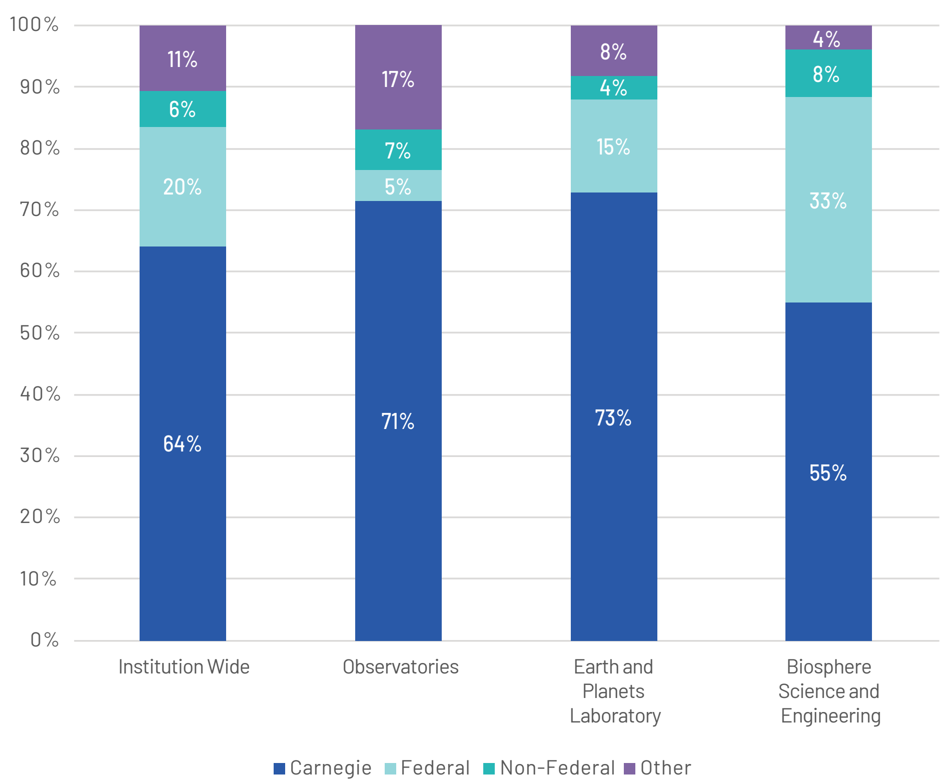
Carnegie has pursued a long-term policy of controlling its spending rate by using a hybrid spending rate, which in the long term contributes 5% of the endowment for annual use. Carnegie employs what is known as a 70/30 hybrid spending rule. That is, the amount available from the endowment in any year is made up of 70% of the previous year's budget, adjusted for inflation, and 30% of the most recently completed year-end endowment value, multiplied by the spending rate of 5% and adjusted for inflation and debt. This method reduces volatility from year-to-year. The preceding figure depicts actual spending as a percentage of ending market value for the last 20 years.

In fiscal year 2022, Carnegie benefitted from continuing support from federal and non-federal/private grants for specific research purposes. These types of funds make up more than 20% of

Carnegie's operating budget. This is a testament to the high quality of Carnegie scientists and their ability to compete successfully for federal funds.

Within Carnegie's endowment, there are several "funds" that provide support either in a general way or targeted to a specific purpose. The largest of these is the Carnegie Fund, begun with the original gift of $10 million. Mr. Carnegie later made additional gifts totaling another $12 -million during his lifetime. This tradition of generous support for Carnegie's scientific mission has continued throughout our history and a list of donors in fiscal year 2022 appears in the digital version of the Year Book (https://yearbook.carnegiescience.edu/2022).

Expenses by Funding Type By Division



Statement of Financial Position

June 30, 2022 and 2021 (in thousands)

ASSETS	2022	2021
Cash and Cash Equivalents	$ 27,917	$ 36,238
Restricted Cash	1,395	0
Contributions Receivable	2,609	3,571
Accounts Receivable and other assets (net)	9,418	7,807
Bond Proceeds	52,862	54,817
Investments	1,043,923	1,173,771
Property and equipment (net)	104,557	108,591
Assets held for sale (net)	0	7,056
Long term deferred asset	62,925	61,596
Total assets	**$ 1,305,606**	**$ 1,453,447**

LIABILITIES		
Accounts payable and accrued expenses	10,782	10,262
Deferred revenue	26,886	26,500
Bonds payable	148,885	148,851
Accrued post-retirement benefits	24,107	31,650
Total liabilities	210,660	217,263

NET ASSETS		
Without donor restriction	361,723	362,758
With donor restriction	733,223	873,426
Total net assets	1,094,946	1,236,184

Total liabilities and net assets	$ 1,305,606	$ 1,453,447

To see the complete FY22 Yearbook, please go online and visit https://yearbook.carnegiescience.edu/2022.

Statement of Activities

June 30, 2022 and 2021 (in thousands)

REVENUE AND SUPPORT	2022	2021
Grants and contracts	$ 19,056	$ 16,903
Contributions, gifts	4,027	4,627
Other Income	56,727	4,112
Net external Revenue	**79,810**	**25,642**
Investment income and unrealized gains	(134,495)	321,687
Total Revenue	**$ (54,685)**	**$ 347,329**

EXPENSES		
Program and Supporting Services:		
Biosphere Sciences & Engineering	28,801	26,336
Observatories	25,193	22,590
Earth & Planets Laboratory	21,185	20,303
Other Programs	778	821
Administration and general expenses	18,845	17,391
Total Expenses	**$ 94,802**	**$ 87,441**

NET ASSETS		
Change in net assets before pension related changes	(149,487)	259,888
Pension related changes	9,040	2,890
Other components of postretirement benefit expense	(791)	(828)
Net Assets at the beginning of the period	1,236,184	974,234
Net assets at the end of the period	**$ 1,094,946**	**$ 1,236,184**

In Memoriam

Members of our greater Carnegie Science community contribute to our legacy of research excellence in a variety of ways, including as alumni, advisors, and supporters. We are grateful to all the many ways these individuals have shaped our organization.

Marilyn Louise Fogel

At the age of 69, **Marilyn Louise Fogel**, an isotope geochemist whose work touched on a broad scope of subjects ranging from astrobiology to paleoecology and climate change to human health, died **May 13, 2022**, after a prolonged battle with Amyotrophic Lateral Sclerosis (ALS).

Fogel spent 33 years as a Staff Scientist at Carnegie's research campus in Washington D.C., at what is now the Institution's Earth and Planets Laboratory, as well as a short stint as a visiting scholar at Carnegie's Department of Plant Biology in California. She developed the use of stable isotopes to trace astrobiological, biogeochemical, and ecological processes, including the impact of climate variation on ancient ecosystems, species migration, diet, and organics found within meteoritic samples.

Her awards and accomplishments were many. They include Chair of the Life and Environmental Sciences Unit of the U.C. Merced School of Natural Sciences (2012); first woman selected for the Geochemical Society's Alfred Treibs Medal (2013); Director of the EDGE (Environmental Dynamics & Geo-Ecology) Institute at U.C. Riverside (2016); and recipient of the Geochemical Society's highest honor, the Victor Moritz Goldschmidt Award (2022). Additionally, she was a member of the National Academy of Sciences and a fellow of the American Association for the Advancement of Science and the American Geophysical Union.

Fogel is survived by her husband, Chris, and children Dana and Evan, as well as by her mother, Florence.

Thomas Lovejoy

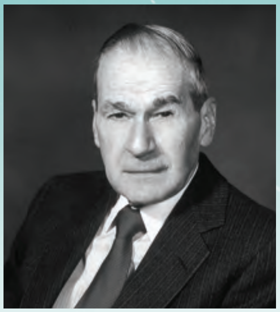
The founding chair of the Carnegie Scientific Advisory Council (CSAC), **Thomas Lovejoy**, a renowned ecologist and conservationist who is credited with coining the term "biological diversity," or "biodiversity," died **December 25, 2021**. He was 80.

In 1978, Lovejoy conceived of the world's largest and longest-running study of habitat fragmentation—the Biological Dynamics of Forest Fragments project—which has trained generations of conservation biologists and advocates and resulted in hundreds of scientific publications. Two years later, he published the first estimate of global extinction rates.

His many prestigious advisory roles included work for the Reagan, George H.W. Bush, and Clinton administrations and past chairmanship of the Scientific and Technical Panel for the Global Environment Facility. He also previously served as Senior Advisor to the President of the United Nations Foundation and Chief Biodiversity Advisor and Lead Specialist for the Environment for the Latin American region to the World Bank. He was also was the founder and past president of the Amazon Biodiversity Center and since 2010 he had been a professor of environmental science and policy at George Mason University.

Among many other notable achievements, he won the Tyler Prize for Environmental Achievement in 2001, the BBVA Foundation Frontiers of Knowledge Award in Ecology and Conservation in 2008, and the Blue Planet Prize in 2012.

Michael Gellert



Michael Gellert, co-founder of investment vehicle Windcrest Partners who oversaw a decade of major institutional initiatives as the Chairman of Carnegie's Board of Trustees, died **August 17, 2021**. He was 90.

Gellert joined the Board of Trustees in 1995 and was elected Chair in 2003. He served until 2018, after which he became an emeritus member.

He had a strong commitment to the life and environmental sciences, which positioned Carnegie researchers to affect the national and international discourse around the greatest challenge facing humanity today—climate change and its impacts on Earth's dynamic cycles and fragile ecosystems. Gellert also played a leading role in Carnegie's founding commitment to the Giant Magellan Telescope, which is under construction at our Las Campanas Observatory in Chile. "Mike's leadership was foundational to the creation of the GMT," said President Emeritus Richard Meserve, whose tenure coincided with Gellert's.

In 2000, he was recognized by the American Academy of Arts and Sciences, which elected him a fellow. In 2015, he was awarded the Harvard Medal for his work on the Harvard Club of New York's Board of Managers and other alumni affairs.

He is one of the largest donors in the Institution's history, supporting many projects and initiatives that span the breadth of our research. "His role at Carnegie was never about himself," concluded Suzanne Nora Johnson and Stephen Fodor, who succeeded Gellert as Co-Chairs of the Board. "It was always about advancing the good of the Institution and quality of the science inside the Institution."

Kazuo Inamori

Trustee Emeritus and 2003 Carnegie Medal of Philanthropy laureate **Kazuo Inamori** died **August 24, 2022**, after an illustrious business career in his home nation of Japan. He was 90.

As the founder of industrial ceramics giant Kyocera and telecommunications company KDDI, Inamori was one of a small handful of industrialists who helped build post-war Japan into an economic success story.

Inamori joined Carnegie's Board of Trustees in 1990 and served for 12 years before stepping down. He remained an emeritus trustee until his death.

"I was very impressed by the noble aim of your Institution, the advanced scientific works performed at your laboratories, and the personality and dedication of your board members and staff. I am honored you have asked me to join your distinguished Board of Trustees as a member," Inamori wrote in his letter of acceptance. "I was especially touched by your intent in making your institution a global organization dedicated to benefit all mankind, and that you have selected me to be the first Japanese trustee on the board."

In 1996, Inamori gave Carnegie $3.1 million to complete the first three Magellan Telescope instruments, which were installed four years later. In appreciation of his support, the Inamori Magellan Areal Camera and Spectrograph and The Magellan Inamori Kyocera Echelle Spectrograph were named in his honor.

Beyond Carnegie, Inamori's philanthropic efforts created the prestigious Kyoto Prize. Supported by the Inamori Foundation, the award recognizes individuals and groups worldwide who have made outstanding contributions to the progress of science, technology, the advancement of civilization, and enrichment and elevation of the human spirit.

William K. Gayden

Former Trustee **William Gayden** died **August 17, 2022**. He was 81. Gayden joined Carnegie's Board in 2002 and served on several key committees during his tenure.

Gayden was the founder, chairman, and chief executive officer of Merit Energy Company, a private firm specializing in direct investments in oil and gas assets. Prior to founding Merit Energy in 1989, Mr. Gayden was president of Petrus Oil Company and held many senior positions at Electronic Data Systems. Gayden began his career as a salesman with IBM.

During his time as a Carnegie trustee, Gayden's generous support advanced multiple efforts, including the Giant Magellan Telescope, capital funds for several Carnegie buildings, and outreach efforts at the Observatories.

The Path to Pasadena

Pasadena, California.

The state of California designated $20 million in its 2023 budget toward Carnegie's life and environmental science research vision.

Representing a proactive new investment in the fight against climate change, Carnegie is bringing a broad array of experts together in Pasadena where they will draw on the Institution's long expertise in exploring the natural world across scales to probe the intersection of climate, ecosystem dynamics, and resilience.

This new genomes-to-ecosystems approach will greatly expand our researchers' capacity to study these interrelated issues and to make a transformative impact on the most pressing challenges facing humanity today.

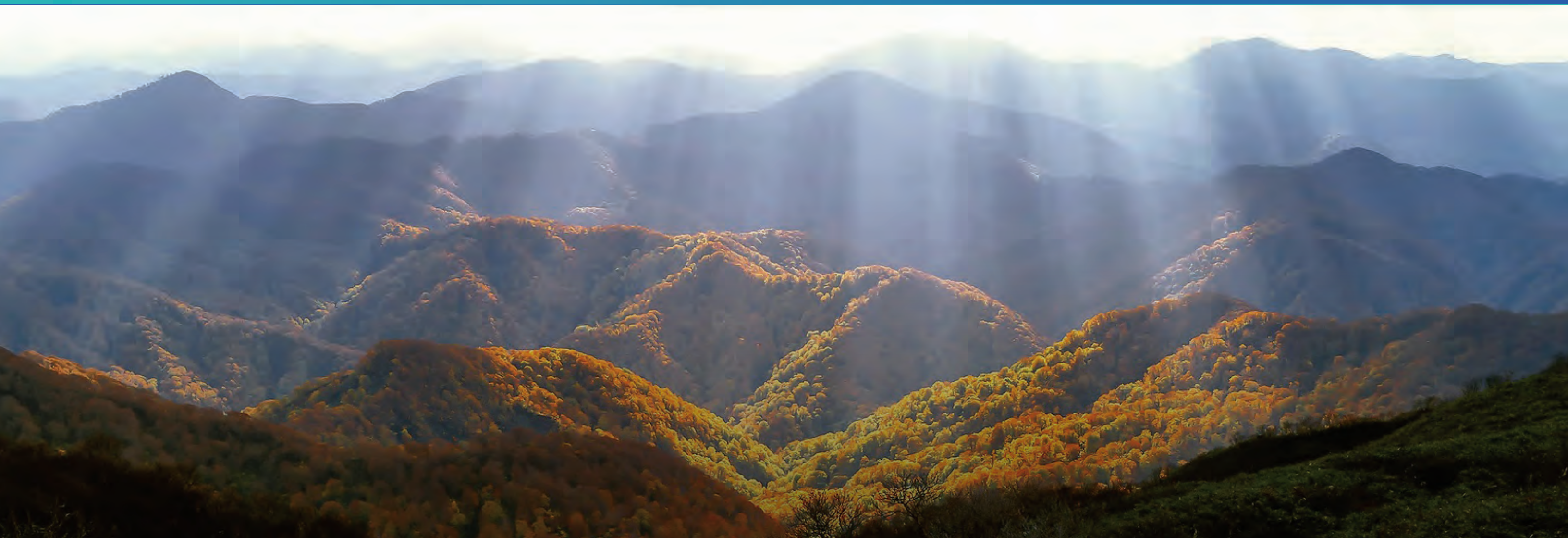
Carnegie experts are already enhancing our understanding of the science underpinning important issues such as sustainable agriculture, water quality, drought, clean energy, and biodiversity—and revealing how climate change is impacting them all.

- **We reveal the genetics underpinning hardiness and drought resistance in crop plants, which can help fight global hunger.**
- **We elucidate how human activity impacts our waterways, which could help mitigate risks to drinking water, fisheries, and recreational areas.**
- **We investigate how drought and warming affect the health of forests, which could help guide land management strategies.**
- **We probe species, community, and ecosystem resilience, which can inform conservation efforts.**

Carnegie's expanded presence in Pasadena will be near the Caltech campus and will provide exciting opportunities to build on decades of collaboration in astronomy and the physical sciences.

"California is leading the world in our efforts to combat climate change, with bold action to cut pollution, clean our air, and develop clean energy solutions," Governor Gavin Newsom said about the funding. "Scientific research is foundational to advancing these goals, protecting our communities, and promoting a sustainable future for California."

Fiscal Year 2022 Year Book is online at https://yearbook.carnegiescience.edu/2022



Carnegie Science is continually adapting—both in our research pursuits and in how we share these breakthroughs with the world. This is why we launched the latest evolution of our Year Book as a digital site. We are able to reach more people and provide our readers with the opportunity to explore our discoveries on an even deeper level. We invite you to sign up for this online publication by filling out the reply form below.

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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.

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