Bulletin of the American Academy of Arts & Sciences

A NIGHT AT THE MUSEUMS

A CONVERSATION WITH JAMES MANYIKA ON “AI & SOCIETY”

COMMUNICATION TO SPUR CLIMATE ACTION

Honoring Charles L. Bennett

with the Rumford Prize

SPRING 2022

WAYS TO ENGAGE
WITH THE ACADEMY

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On the cover: False color image of our Milky Way galaxy from WMAP measurements. Red regions suggest thermal emission from dust. Blue is dominated by free-free emission. Green illustrates contributions from synchrotron and spinning dust emission. C. L. Bennett, et al., "Nine-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Final Maps and Results," *The Astrophysical Journal Supplement Series* 208 (2) (2013).

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This 17-foot-7-inch Burmese python was captured in Everglades National Park in 2012. At the time, it was the largest Burmese python ever captured in Florida, and still holds the state record for the number of eggs it contained – 87. The skeleton was featured in the Florida Museum of Natural History's "Rare, Beautiful and Fascinating" 100th anniversary exhibit.

Features

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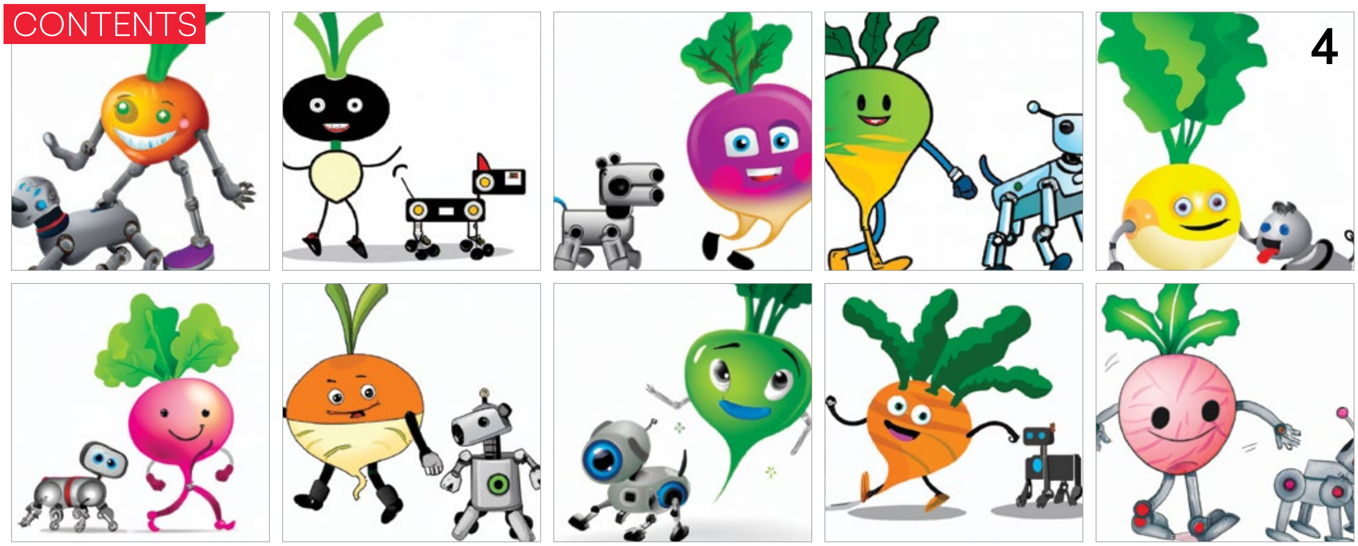

Our Work

Members

Departments

> In January 2021, a new chapter opened in the history of *Dædalus* when it became a fully open access publication. For the first time, faculty, students, researchers, and the interested public could access *Dædalus* content online without a password or payment.

From the President

One of the most important and defining features of the Academy's modern era is the journal *Dædalus*. In its first issue as a quarterly publication in Winter 1958, Editor Gerald Holton stated that the journal would be "a medium through which leading scholars in all fields can address one another." Each issue would focus on a single theme or subject, encompassing over the long run the full range of scholarly interests: the humanities, the sciences, the social sciences, and public affairs. The rationale for *Dædalus* was to fill a void created by the success of specialization that made communication between members of different disciplines and fields increasingly difficult.

In the decades since, the topics covered in *Dædalus* have reflected the intellectual life of the country and the questions and themes that have concerned the scholarly community. Some of the subjects that *Dædalus* has explored include race and racism, education in its broadest sense, research, humanistic scholarship, public policy, the arts, and the sciences.

In January 2021, a new chapter opened in the history of *Dædalus* when it became a fully open access publication. For the first time, faculty, students, researchers, and the interested public could access *Dædalus* content online without a password or payment. The data from the last twelve months show the success of this transition: *Dædalus* had more online readers in 2021 than in the prior four years combined. Citations in scholarly journals have increased. Links to essays and to entire volumes have been shared frequently on social media. And more and more essays are being assigned in classes.

And so it is during this exciting time for the Academy that we are pleased to feature in the pages of this *Bulletin* the newest issue of *Dædalus* on "AI & Society," one of the largest and most timely issues of the journal in recent years. Guest edited by Academy member James Manyika, the volume is freely available on the Academy's website. It features twenty-seven open access essays by leading AI scientists, technologists, social scientists, humanists, and public officials that explore the many facets of AI: its technology, its potential futures and benefits, its effects on labor and the economy, its relationship with inequalities, its role in law and governance, its challenges to national security, and what it says about us as humans.

I hope you will enjoy learning more about the "AI & Society" *Dædalus* issue that is featured in the conversation with James Manyika in the pages that follow and explore the essays yourself. And I encourage you to read about the many other areas of Academy activity detailed in the *Bulletin*, from our new Commission on Reimagining Our Economy, to our initiative on strengthening international cooperative responses to pandemics, to the work of the Commission on Accelerating Climate Action.

Perhaps the only aspect of Academy life more rewarding than engaging with our substantive work is engaging with one another as a community of members. Events such as "Honoring Charles L. Bennett with the Rumford Prize" and "A Night at the Museums," featured in this issue of the *Bulletin*, allowed members from around the world to come together virtually to celebrate high achievement and explore wide-ranging areas of knowledge. I hope you will join us at an upcoming virtual event, and I look forward to increasing opportunities to gather in person in the months and years ahead.

David W. Oxtoby

A Conversation with **James Manyika on "AI & Society"**

By **Heather M. Struntz**, *Assistant Editor at the Academy*

The Spring 2022 issue of *Dædalus* on "AI & Society," guest edited by Academy member James Manyika, explores the many facets of AI: its technology, its potential futures, its effects on labor and the economy, its relationship with inequalities, its role in law and governance, its challenges to national security, and what it says about us as humans. What follows are a few additional remarks and insight from the volume's guest editor on the collection.

What motivated you to organize this volume? Why is this moment significant, and what are the stakes of the questions being explored?

After the birth of AI in the 1950s, the field went through a period of excitement about the possibilities of this new technology. However, what followed was what many came to call AI's winter in the 1970s and 1980s, a period during which AI did not live up to expectations, even though many useful developments emerged. But the last decade has seen a rapid succession of breakthrough results in AI that suggest the possibility of more powerful AI, coupled with the adoption and use of its associated techniques in many arenas of society, including in products and services that individuals, organizations, and governments now increasingly utilize routinely: for example, recommendation systems, search, language translators, facial recognition, chatbots

OpenAI's latest text-image model, a successor to DALL·E and GLIDE, is trained to generate original images in response to text descriptions. Here the model iterates on the prompt "an armchair in the shape of an avocado." On page 2, the model generates images for the prompt "an illustration of a happy turnip walking a dog-robot." Given the same prompt repeatedly, the model produces novel responses. None of these designs or images existed until the model created them. For more, see Ermira Murati's essay, "Language & Coding Creativity," in the Spring 2022 issue of *Dædalus*.

for customer service, fraud detection, decision support systems, and tools for research. This has been the result of a series of progressions in AI's development that began to gather momentum in the early 1990s, and that accelerated in the 2000s as the algorithms got better, the data to train them became more available, and the computer hardware became more powerful. Today, we are at a particularly significant moment in AI's development: as the possibilities and benefits of more powerful AI grow for users and society, we are also confronting real questions and concerns about its varied implications. The stakes are high in both directions: The availability of more useful systems could assist users – individuals and organizations – in day-to-day activities, improve how things work across many sectors and facets of society, contribute to the economy, lead to new discoveries, and help tackle some of humanity's greatest challenges, such as in the life sciences and climate science. And in the other direction, we have concerns about bias, privacy, misuse, unintended consequences, and AI's impact on jobs and inequality, on the law and institutions, not to mention on security and great power competition. For all these reasons, and more, this seemed like a good moment to assess where we are in AI's development, and to consider its impact on society.

What consideration went into choosing the authors who would make up this issue?

When it came to inviting contributors to this volume, we sought authors whose expertise spanned the various aspects of AI's development, from machine vision, to natural language processing, to robotics, as well as the software and hardware systems, and those looking at AI's intersection with various aspects of society, such as the economy, law, policy, national security, and philosophy. At the same time, we did not want the volume to turn into a collection on "technology & society" more generally and so we tried to stay with topics and issues closely related to AI and its associated technologies. Second, we sought authors from among those considered to be at the frontier in their respective fields with respect to the topics in this volume, including leading AI scientists, technologists, social scientists, humanists, and public officials. In addition, we wanted authors who would bring a diversity of views on AI's progress and on its impact on society. There were many contributors I wanted to include, and this is how the volume grew until we just could not add anymore. I am grateful to this distinguished group of contributors – many of them members of the Academy – who accepted my invitation and made time for these essays – it was such an honor to work with them. With a subject as broad as "AI & Society," there are, without doubt, many more topics and views that are missing in this volume – for which I take responsibility. I hope the extensive bibliography and endnotes throughout this volume provide useful references for further exploration and views.

I should also say that I was quite envious when I discovered that for the 1988 *Dædalus* issue devoted to AI, the authors had met in person as a group for discussions and debates, including at the Los Alamos National Laboratory – doing this all through COVID afforded no such opportunities.

Expanding on a question you posed in your introduction, is it all worth it? What are one or two things that we need to get right in order to answer that question with a yes?

I believe it is worth pursuing AI for its exciting and beneficial possibilities. However, my affirmative view is contingent on us also getting several aspects right. There is indeed a long list of things we must get right, including those that many authors in this volume highlight and that I mention in the introduction. But here if I am limited to one or two, I'll mention two such challenges. First, that as we build more powerful AI, we ensure that it is safe and does not cause or worsen individual or group harms (such as through bias), and can earn public trust, especially where societal stakes are high. A second set of issues to get right is making sure we focus AI's development and use it where it can make the greatest contributions to humanity, such as in health and the life sciences, climate change, and overall well-being, and deliver net positive socioeconomic outcomes (such as with respect to jobs, wages, and opportunities). Here it is especially important, given the likelihood that without purposeful attention, the characteristics of the resulting AI and its benefits could accrue to a few individuals, organizations, and countries, likely those leading in its development and use. But it is also worth remembering that the issues to get right are not static and will continually evolve as AI becomes more capable, as our use of it evolves, and as we better understand its impacts, especially the second-order effects, on society.

What did the issue *not* include? Or, what other discussions need to be had?

There are so many more dimensions of artificial intelligence the issue could have focused on or devoted more time to, such as a discussion on the role that AI is playing in advancing research in the sciences and social sciences. Another discussion that is not fully explored is related to the governance of AI itself, especially with respect to safe and responsible development, deployment, and use, and especially when these involve individuals, organizations, companies, and governments. This is particularly important given the wide range of use scenarios, each involving different stakes, as well as normative considerations. We could have spent more time on the international dimensions of advancements in AI, especially for countries not at the current forefront of AI's development and use. Yet another would have been a deeper discussion on the foundational issues in AI's development, the numerous still-hard problems, including the development of more powerful AI, the sufficiency of the current approaches, and the possibility of artificial general intelligence.

Any final takeaways?

I have learned a lot from editing this volume, including from the authors and many others I talked to and whose work I read along the way (see the endnotes in my introduction to the volume). Perhaps one thought all this has reinforced for me is not only that we have to get AI right because the stakes in both directions are high, but that beyond the technologies themselves, much of getting AI right is really about the choices we as society make. Here I mean the choices we make as society inclusive of developers of AI and deployers or users of AI – individuals, companies, organizations, and governments – whether affected by it beneficially or otherwise. As well as what and who informs those choices, the goals we set, and the systems we put in place, including incentives, economic and otherwise, to guide to the outcomes we collectively want. And how these choices must have both beneficial uses and outcomes at their core, as well as purposeful attention to the potential harms, some already here, including uneven outcomes for society. This is what we have to get right.

James Manyika

James Manyika, a Fellow of the American Academy since 2019, is Chairman and Director Emeritus of the McKinsey Global Institute. He is a Distinguished Fellow of Stanford's Human-Centered AI Institute and a Distinguished Research Fellow in Ethics & AI at Oxford, where he is also a Visiting Professor. In early 2022, he joined Google as its first Senior Vice President for Technology and Society.

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"AI & Society" is available on the Academy's website at www.amacad.org/daedalus/ai-society. *Dædalus* is an open access publication.

Spring 2022 issue of *Dædalus* on "AI & Society"

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Communication to Spur Climate Action:
A New Commission Gathers Information

By **Sophia Charan**, *Hellman Fellow for Science and Technology Policy at the Academy*

On June 21, 2018, meteorologist Jeff Berardelli printed an image representing global temperature change onto a tie and wore it on a CBS broadcast.[1] Other meteorologists followed his lead, and on the first day of summer every year since, broadcasters have used these ties and similar pins and necklaces to spark conversations about climate, policy solutions, and local environmental changes.

This example of climate communication is just one that was shared in the sounding sessions held by the Academy's Commission on Accelerating Climate Action. Formally launched in September 2021, the Commission – chaired by **Mustafa Santiago Ali** (National Wildlife Federation; Revitalization Strategies), **Christopher Field** (Stanford University), **Catherine Coleman Flowers** (The Center for Rural Enterprise and Environmental Justice; Center for Earth Ethics), **David G. Victor** (University of California, San Diego), and **Patricia Vincent-Collawn** (PNM Resources) – has three working groups: one on

communication, a second on the private sector, and a third on human and military security. As the Commission gathers information about barriers to effective and timely action on climate, each working group is organizing interviews and sounding sessions with leaders on climate who have a wide range of expertise.

This information gathering comes amidst constant news about a changing climate. Discussions about rising gas prices and energy independence have been part of the daily public discourse since Russia invaded Ukraine at the end of February 2022. Simultaneously, another installment of the Intergovernmental Panel on Climate Change (IPCC) Report warned that countries are already seeing the effects of climate change, that chances to avert larger disasters and adapt to the world's most likely climates are rapidly approaching and passing us by, and that the poorest and most marginalized groups will be the ones most affected.

Faced with the impacts of climate change, approximately 97 percent of climate scientists think global temperature changes are caused by human activity.[2] Only 57 percent of American adults agree.[3] To address this incongruence, over the last few months the Commission's communication working group – chaired by **Bob Inglis** (republicEn.org), **Kathleen Hall Jamieson** (University of Pennsylvania), and **J. Marshall Shepherd** (University of Georgia) – spoke to twenty-five individuals who work in and around broadcast media, in youth and conservative climate organizations, and in entertainment. Each person shared their success stories, recounted lessons on communication ventures that went awry, discussed what prevents them from affecting more change, and shared instances of exemplary climate communication.

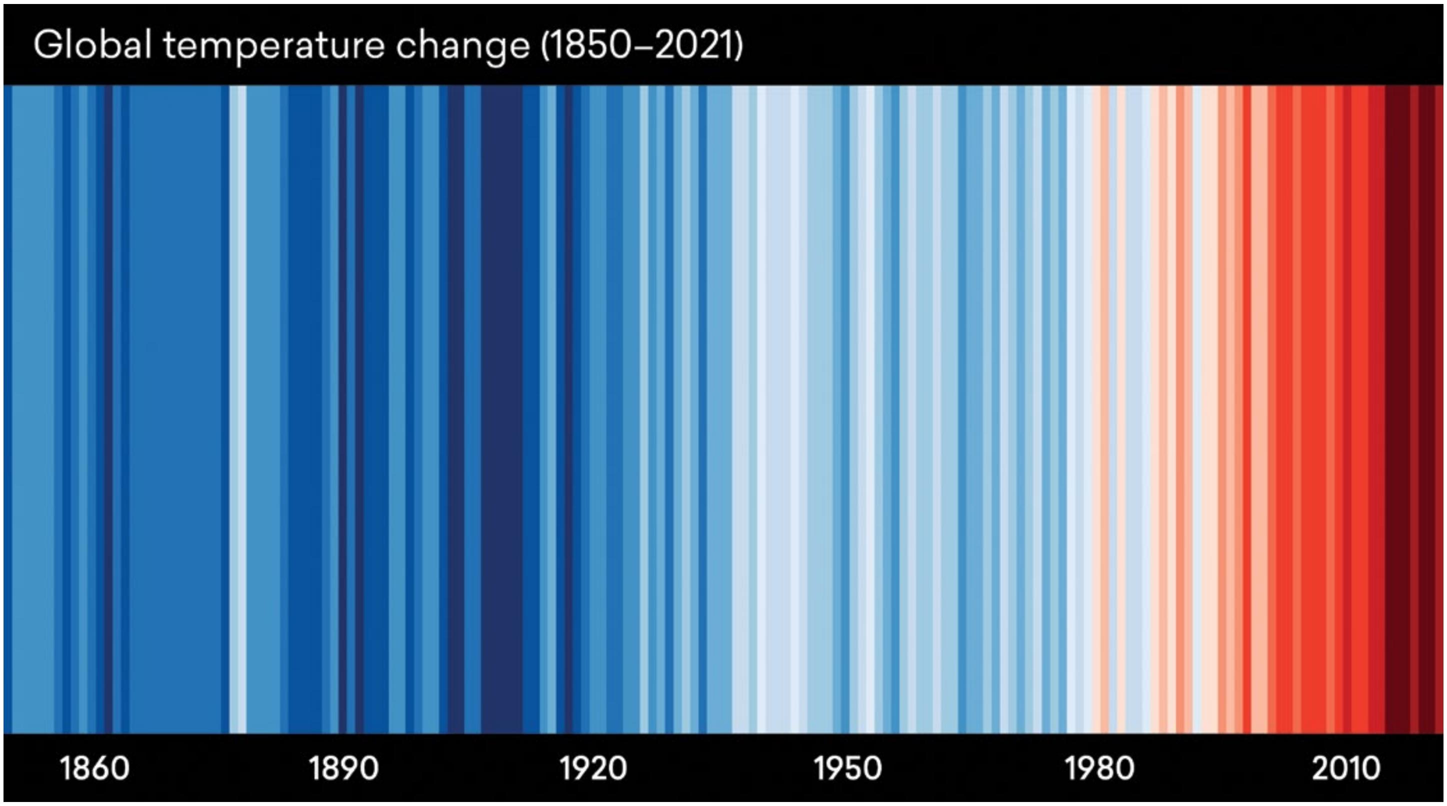
They talked about the increased toxicity of poison ivy, the effect of sea-level rise on the Maldives, the recent film *Don't Look Up*, examples of popular media infused with climate-friendly material, the power of speaking from personal experience, the engagement of youth and their moral clarity, generational and political divides, and the effects of different climate communication strategies.

Some interviewees shared examples of effective communication that centered on emotional and personal stories; others used beautiful visuals; and some exhibited zany geekiness. Several who work in the arts spoke about a need to convey urgency; others in broadcast media talked about the slow process of bringing the public along with the message.

While sounding session participants approached the question of what is exemplary communication from different perspectives, the communication working group heard repeatedly that the messenger matters, especially for audiences that may be more skeptical of climate-friendly messages. No one can argue with personal experience. For most communicators, this meant that their messages most effectively reached people with overlapping identities or who considered them a member of their community. In some cases, however, it was how the communicator was perceived by a particular audience. For example, a communicator who does not identify as center right learned from the social scientists who were analyzing her messages that she effectively and consistently reached that demographic.

Communicators from various backgrounds spoke about the need to increase the scale and quantity of good climate change communication. Only about one-third of American adults discuss global warming at least occasionally or hear about it in the media at least once a week.[4] Many of the communicators told the Commission that, for the United States to take prompter and more decisive action, Americans need to hear about climate change more often.

Many climate communicators shared that the public is hungry for more information and can understand the truth. Though America is divided in its opinions on climate change, only 9 percent of adults reject that climate change is real.[5] Yet many communicators struggle to obtain funding for research into making their messages more effective, for continuing programs that are proven to work, and for reaching more people with the messages they



A visual representation of global temperature change over the past one hundred plus years. The stripes turn from mainly blue to mainly red in more recent years, illustrating the rise in average temperatures. **Source:** Ed Hawkins, University of Reading, https://showyourstripes.info/, CC-BY 4.0 license.

do have. Funders may view climate-centered communication as too depressing to be viable or simply not as urgent as other issues.

The communication working group learned that, while communicators are becoming more comfortable with conveying the facts of global and regional climate change, many have turned their attention to educating the public about climate solutions. In the entertainment industry, this could include adding solar panels to a scene's background. For conservative groups, solutions might include a warning: "Let's get this right before big government gets it wrong." And for meteorologists, it might be a tool that shows the public how much energy wind power will generate on a specific day in their region.

All participants emphasized the importance of communicating about climate well and often. Many expressed the conviction that, with enough effective communication, people and their governments will take prompt and decisive climate actions.

ENDNOTES

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2. John Cook, Naomi Oreskes, Peter T. Doran, et al., "Consensus on Consensus: A Synthesis of Consensus Estimates on Human-Caused Global Warming," *Environmental Research Letters* 11 (4) (April 2016), https://iopscience.iop.org/article/10.1088/1748-9326/11/4/048002.

3. Jennifer Marlon, Liz Neyens, Martial Jefferson, et al., "Estimated % of Adults Who Think Global Warming Is Happening (nat'l avg. 72%), 2021," Yale Program on Climate Change Communication, Yale Climate Opinion Maps 2021, https://climatecommunication.yale.edu/visualizations-data/ycom-us/.

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5. Anthony Leiserowitz, Edward Maibach, Seth Rosenthal, et al., "Global Warming's Six Americas, September 2021" (New Haven, Conn.: Yale University and George Mason University, Yale Program on Climate Change Communication, 2022), https://climatecommunication.yale.edu/publications/global-warmings-six-americas-september-2021/.

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To learn more about the Commission on Accelerating Climate Action, visit https://www.amacad.org/project/accelerating-climate-action.

Workers handle boxes of Oxford/AstraZeneca COVID-19 vaccines, part of the COVAX program that aims to ensure equitable access to COVID-19 vaccinations, after they arrived by plane at the Ivato International Airport in Antananarivo, Madagascar, on May 8, 2021.

Strengthening International Cooperative **Reponses to Pandemics**

By **Kathryn Moffat**, *Senior Program Officer for Global Security and International Affairs at the Academy*

Wars and conflicts in the twenty-first century are putting tremendous strain on the strategies traditionally used by humanitarian responders to help those in need, particularly strategies that deliver effective health responses. Recent civil wars not only account for a larger proportion of ongoing conflicts, but they have become more protracted with more actors with fragmented affiliations. Some of the world's deadliest places are not formally war zones but areas of extreme political and criminal violence, such as in Venezuela, Mexico, Guatemala, and El Salvador. Providing humanitarian aid amid urban warfare calls for strategies that are different from the ones used in rural settings, where humanitarians have commonly operated in the past. Ruthless deliberate attacks on hospitals, schools, and civilians, as well as sexual and gender-based violence, form part of many of these twenty-first-century conflicts. Humanitarian health workers and health facilities are at growing risk of attack as the normative and legal framework that has traditionally regulated war has become less protective. Geopolitical rivalry and perceptions of a weakening commitment to humanitarian norms are further undermining traditional humanitarian approaches. At the same time, the risk of infectious diseases of pandemic potential intersects with conflict-related health and humanitarian needs, presenting additional challenges for humanitarians.

Against this backdrop, the COVID-19 pandemic has threatened the health, economic, and social well-being of the world. The pandemic exposed and amplified the lack of political solidarity and

cooperative mechanisms needed to address common threats, thereby generating a global health and security environment that presents further obstacles to the delivery of humanitarian aid.

The Academy's project on *Rethinking the Humanitarian Health Response to Violent Conflict*, led by **Jennifer M. Welsh** (McGill University), **Paul H. Wise** (Stanford University), and **Jaime Sepulveda** (University of California, San Francisco), was designed in response to these challenges. Launched in 2019, the project is helping to define new strategies for the effective provision of humanitarian health responses. Its work to date has been organized around three core principles: 1) integrating scholarship that has tended to occur within discipline-specific silos, 2) convening ongoing and substantive dialogue with victimized communities and humanitarian practitioners in the field, and 3) engaging with disciplines that help shape local and global norms, such as poetry, fiction, and the visual arts. The project has carried out a number of activities, including fieldwork to explore the humanitarian implications of the response to COVID-19 amid unprecedented migration along the U.S.-Mexico border (these results will be published in the coming months) and work focused on global cooperation and pandemic control. Two new research papers from the project (forthcoming this spring) build on this last area of focus.

The first research paper, *International Cooperation Failures in the Face of the COVID-19 Pandemic: Learning from Past Efforts to Address Common Threats*, authored by **Jennifer M. Welsh**, contributes to the wider dialogue taking place internationally to enhance technical interactions among scientists and public health officials to improve global preparedness for and responses to pandemic disease. Welsh identifies the lessons that can be learned from historical or analogous efforts to strengthen state cooperation in situations of intense geopolitical rivalry and risk. Her paper builds on research in the international relations literature as well as workshops and interviews that drew on the expertise of Academy members and others working on these issues. By looking at how competing powers have created "islands of cooperation" to address threats such as climate change or chemical and nuclear weapons, Welsh's paper generates insights to help foster state cooperation to enhance humanitarian efforts, stem the tide of the COVID-19 pandemic in zones of conflict, and improve preparedness for potential future pandemics.

Welsh examines how cooperation failed during COVID-19 and describes how pandemic preparedness and response efforts that were designed prior to COVID-19 might shed light on the origins of these cooperation challenges. She illustrates the ways in which institutions for international cooperation could be designed to overcome the cooperation problems that have impeded global efforts to prepare for and respond to pandemics. In addition, Welsh assesses some proposed reforms, identifying potential pitfalls as well as areas of opportunity. Among the key findings, she notes that, even in moments of crisis, institutions that could facilitate global cooperation often fail to emerge. Policy-makers therefore must consciously seize these moments to bring about reform before momentum is lost.

Building on the analysis of responses to other common threats, Welsh recommends that policy-makers and diplomats seeking to foster successful cooperation on pandemic preparedness and response should understand and confront the incentives shaping state behavior; understand and engage with political dynamics and channel them productively; and take the long view, recognizing that cooperation takes time, and smaller "clubs" can sometimes launch new initiatives to improve cooperation even when not all states are interested in membership.

International Cooperation Failures in the Face of the COVID-19 Pandemic: Learning from Past Efforts to Address Common Threats concludes by offering recommendations to apply these lessons to current efforts to reform the global health architecture. The paper also identifies several specific priorities for policy-makers in the near term. These include addressing the economic and political barriers to compliance with existing regulations; having targeted reforms to help the World Health Organization (WHO) increase its ability to

Humanitarian health workers and health facilities are at growing risk of attack as the normative and legal framework that has traditionally regulated war has become less protective.

A United Nations peacekeeper has his shoes cleaned with a chlorine solution before leaving an Ebola treatment center in Mangina, North Kivu province, on September 1, 2019. UN Secretary-General António Guterres on September 1 vowed continued support for the Democratic Republic of the Congo, grappling with the double scourge of militia violence and an Ebola epidemic.

respond to COVID-19 and future infectious diseases of pandemic potential; filling existing gaps in cooperation by creating a stronger global surveillance network along the lines suggested by the Independent Panel for Pandemic Preparedness and Response and the G20 High Level Independent Panel; creating a new head-of-state council to mobilize political will; and establishing a permanent platform that can help ensure equitable access to diagnostics, treatments, and vaccines.

The second paper, *Peace Operations at the Intersection of Health Emergencies and Violent Conflict: Lessons from the 2018–2020 DRC Ebola Crisis*, by **Dirk Druet** (McGill University), presents recommendations for how existing UN peace operations can tailor their actions to facilitate an effective response to pandemics, learning from past cases in which efforts to deliver humanitarian aid in areas of armed conflict have overlapped with peace operations during disease outbreaks, such as the Ebola epidemic in the Democratic Republic of the Congo (DRC) in 2018. Because these missions are designed to mediate peace agreements, protect civilians from violence, and combat armed groups, their work can create tension with humanitarians who, to avoid politicizing their presence and losing access to people in need, operate based on principles of strict neutrality and independence. When an outbreak of Ebola virus disease was detected in an area of active armed conflict, the relationship between peacekeepers and humanitarians became even more complex. Taking a "no regrets" approach to stopping the spread of Ebola, the World Health Organization initiated a large-scale emergency response, which affected the conflict in ways that ultimately undermined efforts both to promote health and build peace in the DRC.

The paper examines how the health response impacted the conflict, the roles peacekeepers played during the response, and the lessons this experience can provide about security, perceptions, and trust for future international efforts to respond to multidimensional emergencies in conflict environments. The paper draws on a series of interviews Druet conducted with key individuals involved in the response. The paper was refined based on feedback from a workshop in October 2021 that included scholars, humanitarian leaders, and representatives from international organizations, such as the WHO and the UN Department of Peace Operations (UNDPO).

Druet analyzes the intersection between health and conflict in Congo to explain the response by the population and by armed actors to the health crisis in 2018–2020. He highlights how the origins of the DRC's health system in colonial strategies that exploited human labor have shaped how public health efforts are understood and perceived today. Druet also reviews the role that the United Nations Mission in Liberia (UNMIL) played in establishing large-scale emergency operations during the 2014–2016 West African Ebola crisis. He describes what the international community learned about tailoring responses to local contexts from this earlier crisis, when it provided logistical resources that facilitated the efforts of both local and international authorities to ramp up their response to the pandemic.

Druet explores the conflict dynamics and the context of the peace operation in the DRC during the 2018 Ebola crisis, examining how the decisions that the WHO made in order to operate within a complex political and security climate – including the way its actions transformed local economies in ways that gave some security and business actors an interest in prolonging the crisis – generated distrust for health responders' motives, which in turn contributed to public resistance to Ebola response measures and violence against health workers, and ultimately undermined the health response and accelerated the Ebola outbreak.

Druet offers a series of recommendations aimed at the WHO, the United Nations Department of Peace Operations and Department of Political and Peacebuilding Affairs, diplomats, and international humanitarian organizations for how future emergency health responses in active conflict situations can be better conceived, planned, and executed. Some of the recommendations include:

- Carry out a thorough diagnostic of the political, economic, and conflict context for each future health response to help international health actors better understand how their actions may affect the conflict.
- Recognize that working with national governments or UN peace operations that are parties to the conflict may undermine the public's trust in the neutrality of public health responses; and ensure that peace operations provide security without coming within close proximity to health responses.
- Balance international concerns about the potential for a pandemic and the impulse to prioritize the public health response with the risk of doing harm. If public trust is lost, prioritizing the public health response at all costs could have the opposite of the intended effect, ultimately exacerbating the conflict and thereby *slowing* the health response.
- Leverage the unique logistical capacities that peace operations can provide to jump-start emergency health supply chains and service delivery, while maintaining a clear distinction between the mission and humanitarian actors.
- Combine localized approaches with large-scale international responses, recognizing that the approaches of peace operations to protect civilians from violence and adapting to localized community protection strategies can help health responders understand and adjust to local community structures, customs, and economies.

OUTREACH AND DISTRIBUTION

The two research papers as well as policy briefs that highlight the recommendations in each will be published in spring 2022. The research findings will be shared with key audiences, including members of Congress and their staff; appropriate individuals in the Department of State, the Department of Defense, and the National Security Council; diplomats from member states in the UN and WHO; leaders of NGOs and international organizations; humanitarian practitioners; and scholars working on relevant topics.

The project has hosted one event so far to share the findings of the paper by Jennifer M. Welsh: a meeting in Geneva in November 2021 co-hosted with the Canadian Permanent Mission to the World Trade Organization, the United Nations, and the Conference on Disarmament. The participants included diplomats from fifteen countries and the European Union. The event preceded the Special Session of the World Health Assembly that considered the creation of a new international instrument for pandemic preparedness and response.

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***International Cooperation Failures in the Face of the COVID-19 Pandemic: Learning from Past Efforts to Address Common Threats* and *Peace Operations at the Intersection of Health Emergencies and Violent Conflict: Lessons from the 2018–2020 DRC Ebola Crisis* are available at amacad.org/humanitarian health. To learn more about the project on Rethinking the Humanitarian Health Response to Violent Conflict, visit amacad.org/humanitarianhealth.**

The Commission on Reimagining Our Economy

By **Jonathan D. Cohen**, *Joan and Irwin Jacobs Program Officer for American Institutions, Society, and the Public Good at the Academy*

Economic uncertainty is a disruptive force in American life. Too many families are unable to achieve the life they want despite their best efforts, too many communities have not benefited fully from national economic growth, and too many Americans believe the economy does not work for people like them. In a 2021 Pew Research Center survey, 66 percent of Americans felt that the nation's economy needs major reforms, while just 6 percent felt it should remain unchanged.[1] Coupled with the current challenges facing American democracy, these trends contribute to the growing distrust of political and economic institutions. While it often seems that the nation cannot agree on much, there is widespread agreement that changes are needed to bolster opportunity and to allow more Americans to share in the nation's prosperity.

The specific policies needed to reform the economy, and the values that should inform those policies, are subject to intense disagreement. With this challenge in mind, the Academy launched the Commission on Reimagining Our Economy (CORE) in October 2021. The goal of the Commission is to rethink the principles, metrics, narratives, and policies that shape the nation's political economy. While policy-makers and journalists often track how the economy is doing, the Commission seeks to direct a focus onto how *Americans* are doing, elevating the human stakes of our economic and political systems.

A guiding premise of the Commission's work is that questions of political economy are inextricable from conversations about democracy. Individual well-being is not simply a matter of dollars and cents. Other factors need to be accounted for, particularly the degree to which people feel that their voice is valued, that they are a respected member of a community, and that their leaders represent them. The widespread belief that the economy does not give everyone a fair chance threatens the nation's social fabric and its constitutional democracy.

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The interdisciplinary and cross-partisan Commission comprises scholars, journalists, artists, and leaders from the faith, labor, business, education, and philanthropic communities. Three Academy members chair the Commission:

- **Katherine J. Cramer**, Virginia Sapiro Professor of Political Science and Natalie C. Holton Chair of Letters & Science, University of Wisconsin-Madison
- **Ann Fudge**, former Chief Executive Officer and Chairman, Young & Rubicam Brands
- **Nicholas Lemann**, Joseph Pulitzer II and Edith Pulitzer Moore Professor of Journalism and Dean Emeritus, Columbia Journalism School.

To that end, the CORE project will build on the work of the Academy's Commission on the Practice of Democratic Citizenship. In its final report, *Our Common Purpose*, that commission acknowledged that economic conditions influence public faith in government, political participation, and civic engagement. While *Our Common Purpose* does not offer recommendations specifically targeted at economic issues, the Commission on Reimagining Our Economy will face these issues head on.

The CORE initiative will convene listening sessions with Americans all over the country. As part of its fact-finding work, the Commission has already met with a wide array of Americans, including Native American leaders from Alaska, Arizona, and South Dakota; Black leaders in Madison, Wisconsin; and community members in Athens, Tennessee. The listening sessions will gather the reflections of Americans in their own words and enable Commission members to craft bold solutions that speak directly to Americans' experiences: what they need to access opportunity, to feel heard, and to have a chance at a better future.

In April 2022, the Commission held its second meeting in Chicago at the offices of the Chicago Community Trust. The Commission is currently engaged in a year of fact finding and will be convened through 2023, followed by at least a year of outreach and implementation. The CORE project represents a major new initiative for the Academy and its American Institutions, Society, and the Public Good program area, whose portfolio of projects seeks to tackle some of the most challenging questions facing the nation in the twenty-first century.

ENDNOTE

1. Richard Wike, Janell Fetterolf, Shannon Schumacher, and J.J. Moncus, "Citizens in Advanced Economies Want Significant Changes to Their Political Systems," Pew Research Center, October 21, 2021, https://www.pewresearch.org/global/2021/10/21/citizens-in-advanced-economies-want-significant-changes-to-their-political-systems/.

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For more about the Commission on Reimagining Our Economy, visit the Academy's website at www.amacad.org/project/reimagining-american-economy

The Commission on Reimagining Our Economy

M indicates an Academy member

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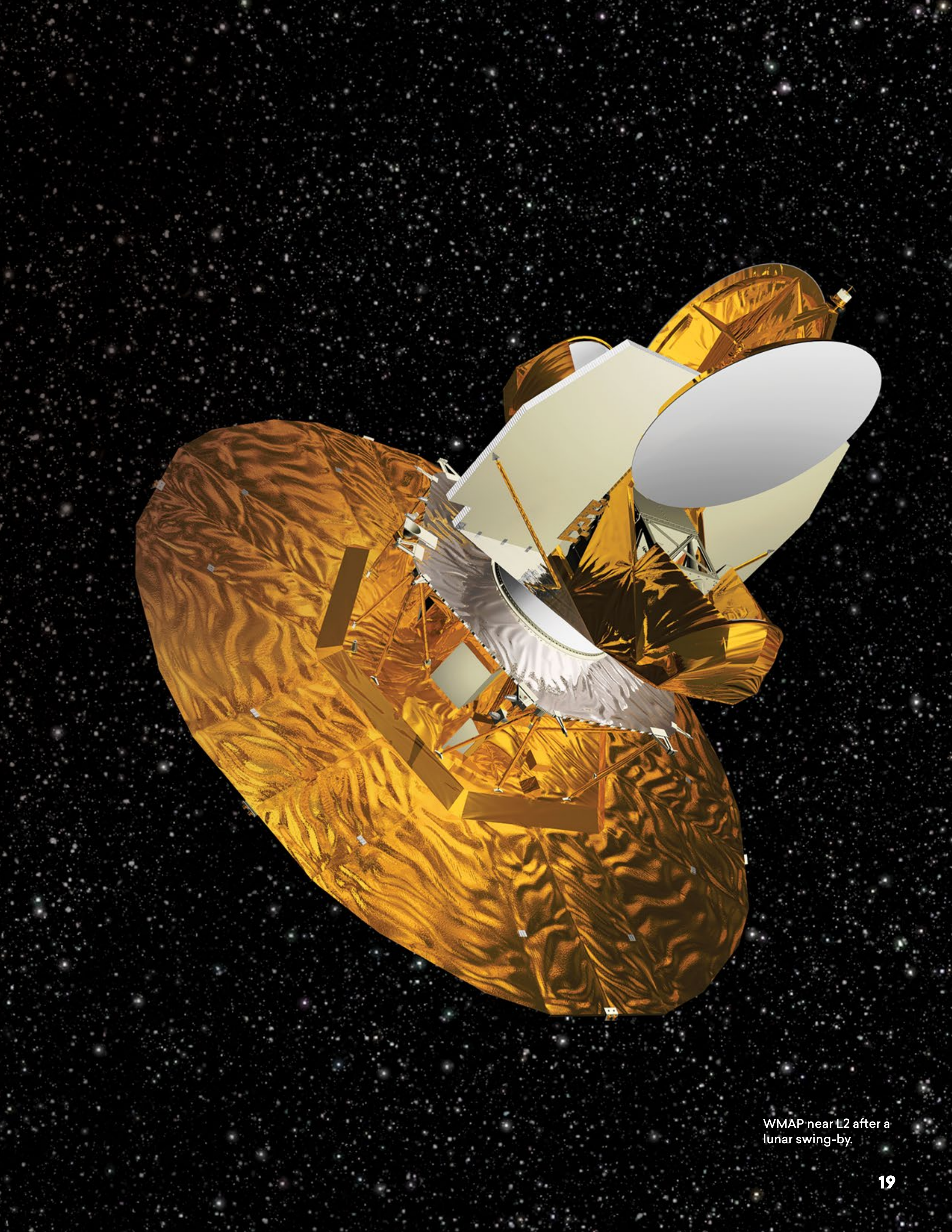
Honoring Charles L. Bennett with the Rumford Prize

2103rd Stated Meeting | February 10, 2022 | Virtual Event

The Rumford Prize, which recognizes contributions to the fields of heat and light, broadly interpreted, was first awarded in 1839 and is one of the oldest scientific prizes in the United States. Previous prize recipients include Thomas Edison in 1895, Edwin Land in 1945, and Enrico Fermi in 1953.

The American Academy awarded the 2021 Rumford Prize to astrophysicist **Charles L. Bennett** for his contributions to the field of cosmology. The virtual award ceremony included remarks by Academy President **David Oxtoby**, an introduction from theoretical physicist **Marc Kamionkowski**, a reading of the Rumford Prize citation by astronaut and scientist **Kathryn Sullivan**, and a presentation from Charles Bennett. An edited version of the speakers' remarks follows.



WMAP near L2 after a lunar swing-by.

David W. Oxtoby

David W. Oxtoby is President of the American Academy of Arts and Sciences. He was elected a Fellow of the American Academy in 2012.

Thank you for joining us to honor Dr. Charles L. Bennett with the Rumford Prize. As president of the Academy, it is my pleasure to call to order the 2103rd Stated Meeting of the American Academy of Arts and Sciences. In addition to our work as an honorary society and independent research center, the American Academy regularly awards eleven prizes for extraordinary contributions to the sciences, the humanities, public discourse, and the common good.

The Rumford Prize honors remarkable contributions to the fields of heat and light. It was first awarded in 1839, making it one of the oldest scientific prizes in the United States. The list of recipients is an illustration of the ever-expanding possibilities of scientific discovery. Early Rumford Prize awardees include inventors whose work in fields such as refracting telescopes and, in the case of Thomas Edison, electric lighting laid the scientific building blocks for later recipients' contributions to atomic spectroscopy and laser technology.

Achievements in heat and light allow us today to gather virtually on Zoom from all corners of the globe to honor Charles Bennett for his career-spanning work in experimental cosmology. Chuck's trailblazing research has elevated and transformed the field of cosmology, offering an unprecedented view of the universe, and reminding us of the joys of scientific discovery. Our program is designed to honor and celebrate Chuck's invaluable contributions and will include remarks from his colleague Marc Kamionkowski, the conferring of the award by astronaut Kathryn Sullivan, and a presentation from Chuck himself. I am delighted that so many of Chuck's family, friends, and colleagues as well as fellow Academy members could be here to celebrate his remarkable career.

It is now my pleasure to introduce Marc Kamionkowski, the William R. Kenan, Jr. Professor of Physics and Astronomy at Johns Hopkins University. Marc is a theoretical physicist, who specializes in cosmology and particle physics. His work focuses on particle dark matter, the cosmic microwave background, and cosmic acceleration. Marc was elected to this Academy in 2013. He will begin our program with remarks about his friend and colleague, Chuck Bennett.

WMAP orbits around the L2 Lagrange point, one million miles beyond Earth. The sun shield/solar panels always protect it from the radiation generated by the Sun.

Marc Kamionkowski

Marc Kamionkowski is William R. Kenan, Jr. Professor of Physics and Astronomy at Johns Hopkins University. He was elected a Fellow of the American Academy in 2013.

I am honored to introduce Charles Bennett, who has been my colleague at Johns Hopkins since I arrived at the university in 2011. Chuck was born in New Jersey, raised in Maryland, and attended the University of Maryland as an undergraduate student. An interesting story that he shared with me is that he was a family friend of Vera Rubin and was doing research with Vera at Carnegie Institution of Washington when he was an undergraduate. When Bernie Burke, a radio astronomer from MIT, was visiting, Vera introduced Chuck to Bernie and said, "This guy's pretty smart; you should take him." Chuck wound up going to graduate school at MIT and pursuing a Ph.D. in radio astronomy with Bernie Burke.

Chuck later moved to NASA's space research laboratory in Greenbelt, Maryland, and joined the team of the Cosmic Background Explorer, COBE, which was awarded the Nobel Prize a few years ago. He also joined the differential microwave radiometer (DMR) project and became deputy principal investigator (PI). Chuck was also the PI for the Wilkinson Microwave Anisotropy Probe, a NASA satellite mission that has revolutionized cosmology and is the reason why we are celebrating him today. WMAP was a remarkable achievement scientifically and managerially. The mission involved identifying, attracting, and managing a very strong team of scientists and ultimately being responsible for the scientific results. He has been awarded numerous prizes for his contributions, all of which are very well deserved. In 2005, Chuck joined the faculty at Johns Hopkins because he wanted to be involved in both education and research.

Let me briefly explain why it is that we are celebrating Chuck today. Chuck is a cosmologist. Cosmology is the study of the origin and evolution of the universe. It is not the study of certain objects in the universe. It is not the study of galaxies or planets. Rather, it is the study of the universe as one physical system. In the 1990s, before COBE, cosmology was a fringe area of physics and astronomy. There was not a lot known about the universe then. We knew that it was expanding, as Edwin Hubble discovered close to a century ago, but the rate of expansion, the velocity with which galaxies were moving away from us, was uncertain to about a factor of two.

At the time there was some evidence for some form of "dark matter," but estimates of its density varied by about a factor of two. And there were three possibilities for the geometry of the universe: flat, open, or closed. Again, we had no idea of the largest scale structure of the universe, and we had no idea of what it was that formed the seeds that later gave rise to the gravitational amplification of the astounding array of structures that we see in the universe today, things like galaxies and galaxy clusters. It was an order of magnitude game. It was an estimate game. If I told my physicist colleagues that I was a cosmologist they would sneer and say, "Oh, yeah, if you get to a factor of two, you're doing pretty well. Maybe you should get a real job."

"Cosmology is the study of the origin and evolution of the universe. It is not the study of certain objects in the universe. It is not the study of galaxies or planets. Rather, it is the study of the universe as one physical system.

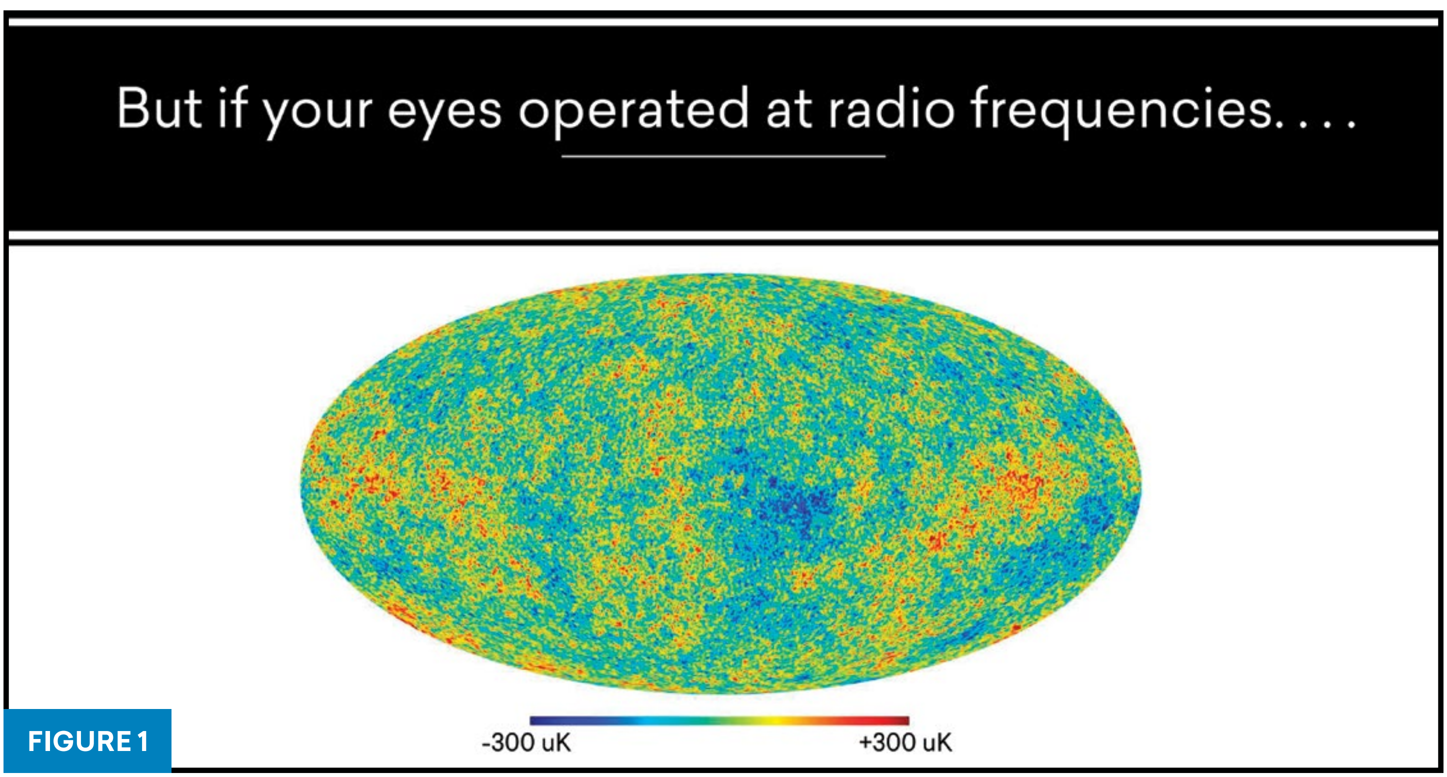


FIGURE 1

From the cosmic microwave background, we have information about the early universe. It is essential for understanding general relativity, gravity, and quantum gravity. It is an essential component of everything we do in extragalactic astronomy and cosmology, and we are even talking about it in nuclear and neutrino physics. ”

Chuck changed all of that, and this is the way he did it. If you look at the night sky, you see a bunch of stars (points of light), and if you look with a very bright telescope, you might also see galaxies. But most of the sky is the space in between stars, and that space is dark. However, if your eyes operated not at optical frequencies but at radio frequencies, the sky would look like what we see in Figure 1. This map, made by the Wilkinson Microwave Anisotropy Probe, shows the entire sky as it would look if your eyes operated at radio frequencies and if they could see intensity variations of roughly one part in 10^5. It turns out that the temperature or intensity of this cosmic microwave background everywhere in the sky is the same to roughly one part in 100,000, but if you look very carefully, which is what the Wilkinson Microwave Anisotropy Probe did, you will see that there are tiny temperature fluctuations – some regions where it is a little bit hotter and some where it is colder. We know that this is the cosmic microwave background, the afterglow of the hot Big Bang. This is literally the cooling embers of the Big Bang that we are seeing.

When we look at this cosmic microwave background, we are seeing all the way back to the time when the hot Big Bang took place. We are looking directly at the infant universe. This picture transformed everything. It may not look like a whole lot if you are not a cosmologist, if you are not a physicist, but, as Chuck will explain, we know how to interpret this map and it turns out that there is a huge amount of information in it.

A quarter of a century ago, cosmology was an order of magnitude game; now it is a paragon of precision science. From this data we now know the expansion rate, and the densities of dark and ordinary matter have been determined to a few percent. We know that the geometry of the universe is flat. We have detailed information about the primordial seeds that later gave rise to the growth of large-scale structures like galaxies and galaxy clusters. And moreover, what is perhaps most intriguing is that the characteristics of these seeds for primordial structures are in very good agreement with the predictions of an idea called *inflation*: an idea for what put the Big Bang in motion. And the idea of inflation, as it turns out, is an outgrowth of ideas in high energy physics. So, in some sense, cosmology has been merged with the study of elementary particles and fundamental physics.

I would like to close by pointing out that Richard Feynman, who all of us in physics revere as much as anybody else, apparently said that you know that a discovery is truly significant if it impacts areas of science well beyond the subfield in which it originated. The cosmic microwave background measurements that Chuck made characterize that as much as anything else that we have ever seen since the development of quantum mechanics. From the cosmic microwave background, we have information about the early universe. Our description of the late universe is founded on discoveries and measurements from the cosmic microwave background. Particle theorists now take this as one of the inputs to all of their theories. It is essential for understanding general relativity, gravity, and quantum gravity. String theorists see it as an avenue toward understanding string theory. It is an essential component of everything we do in extragalactic astronomy and cosmology, and we are even talking about it in nuclear and neutrino physics. Awarding the Rumford Prize to Chuck is extraordinarily well deserved. I would like to congratulate Chuck and say it has been a pleasure to be your colleague and to work in a field in which your research has played such a central role.

OXTOBY: Thank you, Marc. It is now my pleasure to turn things over to another Academy member, Dr. Kathryn Sullivan. Kathy is an oceanographer and astronaut and the first American woman to walk in space. In addition to her work with NASA, Kathy has served as the chief scientist and top administrator of the National Oceanographic and Atmospheric Administration as well as the Aerospace Chair of the Smithsonian's National Air and Space Museum. Kathy will read the formal citation and present the Rumford Prize to Chuck.

Kathryn Sullivan

Kathryn Sullivan, an oceanographer and astronaut, is currently a Senior Fellow at the Potomac Institute and the Ambassador-at-Large for the Smithsonian's National Air and Space Museum. She was elected a Fellow of the American Academy in 2017.

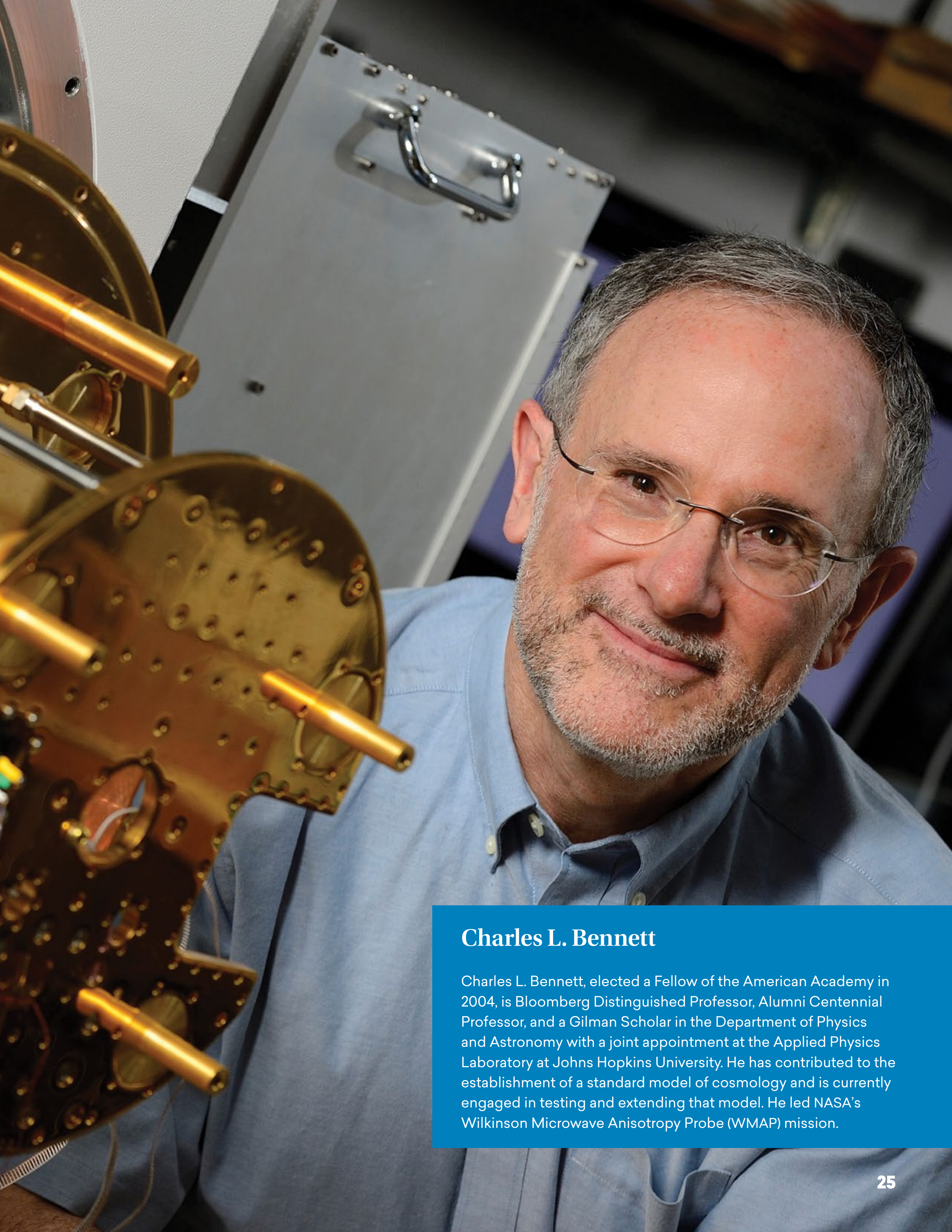
It is my honor to read the citation and present the Rumford Prize to Charles Bennett. The citation reads as follows:

Established in 1839, the American Academy's Rumford Prize recognizes contributions in the fields of heat and light. The Prize is named for physicist and inventor Benjamin Thompson, Count Rumford, whose challenges to established physical theory were part of the nineteenth-century revolution in thermodynamics. The Rumford Prize recognizes scientific discoveries that have the capability to fundamentally alter our understanding of heat and light and their potential applications. In the words of Count Rumford, the award is for work that "in the opinion of the Academy, tends most to promote the good of mankind."

For remarkable achievements in "heat and light," the American Academy of Arts and Sciences hereby recognizes *Charles L. Bennett* for his cosmos-defining work with the Wilkinson Microwave Anisotropy Probe (WMAP). Early in his career, as a member of NASA's Cosmic Background Explorer team that measured the faint electromagnetic traces of an infant universe, Dr. Bennett helped to redefine cosmology as a precision science. As chief designer and principal investigator of WMAP, he peered into the furthest corners of space, studied the oldest heat and light, and recorded the first data that describe the age, curvature, composition, and history of the cosmos – validating the theoretical work of Einstein and the early observations of Penzias, Wilson, and their successors. From a sky map of careful measurements, he extrapolated a Standard Model of Cosmology, describing the proportions of matter and energy in the breadth of space as well as the time that has elapsed since the initial expansion of the Big Bang, 13.8 billion years ago. As a result of his research, cosmology is now a central component in the pursuit of the fundamental laws of physics.

Son of a physicist and a photographer, boyhood radio enthusiast and budding astronomer, you have listened to the primordial messages of the universe, calculated their meanings, and provided us with a picture of our origins, as complex and profound as it is beautiful.

Chuck, my heartiest congratulations to you as a cosmologist and a fellow Jerseyite.



Charles L. Bennett

Charles L. Bennett, elected a Fellow of the American Academy in 2004, is Bloomberg Distinguished Professor, Alumni Centennial Professor, and a Gilman Scholar in the Department of Physics and Astronomy with a joint appointment at the Applied Physics Laboratory at Johns Hopkins University. He has contributed to the establishment of a standard model of cosmology and is currently engaged in testing and extending that model. He led NASA's Wilkinson Microwave Anisotropy Probe (WMAP) mission.

I would like to thank David Oxtoby, Marc Kamionkowski, Kathy Sullivan, and especially the American Academy of Arts and Sciences for bestowing this prize on me. I am very humbled and honored to receive it. More personally I want to thank my wife and two sons and my many teachers and mentors over the years. I have learned a great deal from them, and I'm delighted that some of them have joined us for this program. I also want to thank my highly esteemed colleagues. I have had the great fortune of working with very fine scientists over the years and learning from them as well.

I especially want to thank the WMAP science team.[1] These days a science team could have one thousand or more people on it. Our WMAP team was much smaller, and everybody made very significant contributions to the success of the mission. It really was a great team effort. Beyond the science team itself there are many people required to build the space mission, including project managers, system engineers, discipline engineers, technicians, people that operate the satellite, schedulers, and more. The mission's success depended on all of them. I am grateful to them all for their dedication and hard work on WMAP.

As Marc Kamionkowski mentioned, cosmology asks big questions: How did the universe begin? How did the universe evolve? What is the universe made of? What shape is the universe? What will happen to the universe in the future? It would seem to be impossible for us to answer these questions because Earth is a speck of dust in the vastness of the universe. But we can answer those questions because we have a time machine. We can directly observe the past, and it is an action-packed, mind-blowing, time-travel adventure.

The reason why we have a time machine is because it takes light time to travel. It may seem as if light travels instantly, but it doesn't. Light travels very quickly, one foot per nanosecond. That translates to 186,000 miles per second. That is faster than I have ever driven my car and so, again, it is very fast but it is not infinitely fast. As we look out in the distance, we are necessarily looking back in

1. The WMAP science team included C. Barnes, R. Bean, C. Bennett, O. Doré, J. Dunkley, B. Gold, M. Greason, M. Halpern, R. Hill, G. Hinshaw, N. Jarosik, A. Kogut, E. Komatsu, D. Larson, M. Limon, S. Meyer, M. Nolta, N. Odegard, L. Page, L. Peiris, K. Smith, D. Spergel, G. Tucker, L. Verde, J. Weiland, D. Wilkinson, E. Wollack, and E. Wright.

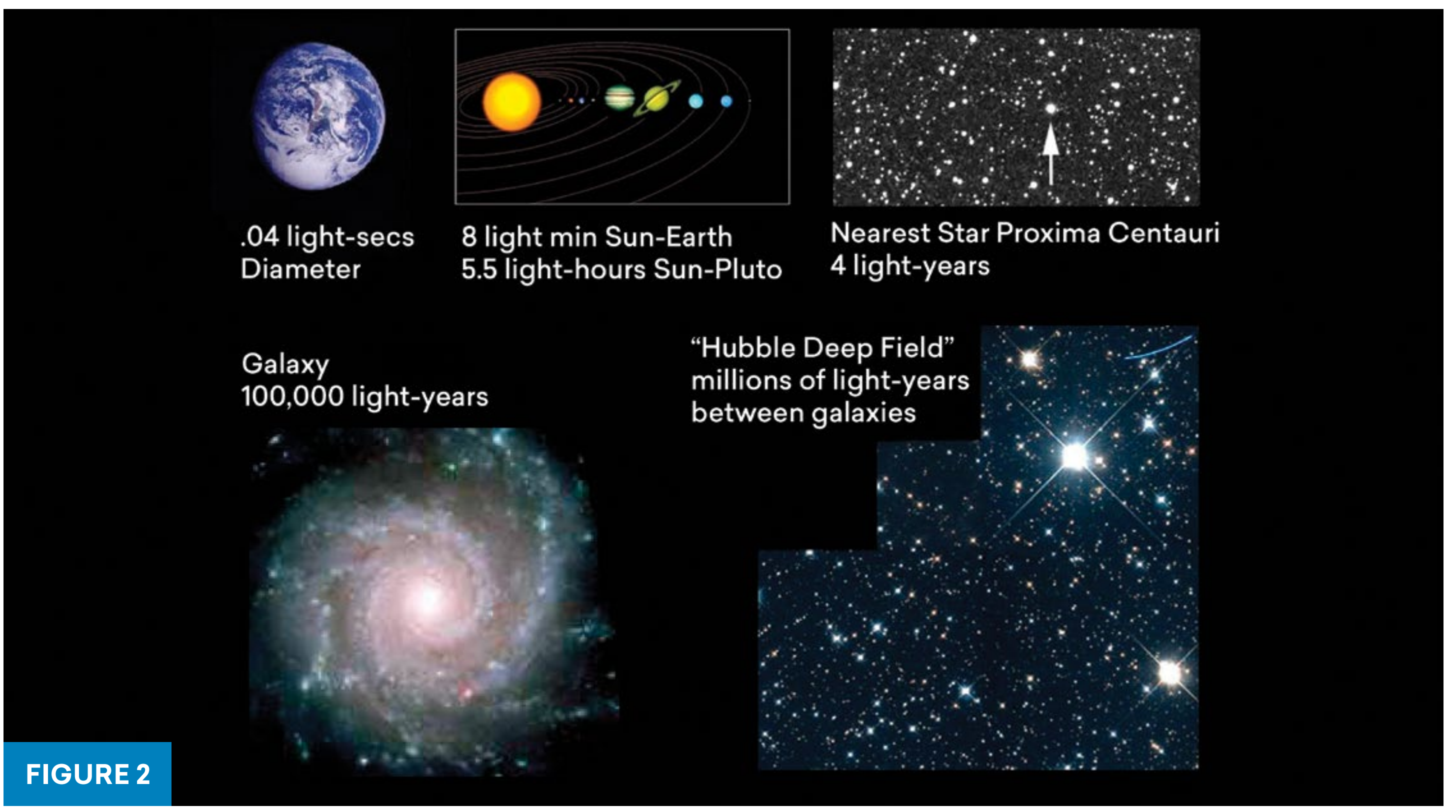


FIGURE 2

FIGURE 3

time, and we don't have a choice about that. That is the way nature works. We directly observe the past.

Let me give you some examples (see Figure 2). It takes light 0.04 seconds to go across the diameter of the Earth. It takes light eight minutes to go from the Sun to the Earth. In other words, when we look at the Sun, we are not seeing the Sun as it is that instant. We are seeing the Sun as it was eight minutes earlier. It takes five and a half hours for light to go from the Sun to Pluto. The next nearest star beyond our Sun is Proxima Centauri, and it takes four years for light to get to us from there. We live in a Milky Way galaxy. It is a swirling collection of stars, gas, and dust and it takes light 100,000 years to go across the Milky Way galaxy. So, you might think well, that's an enormous distance and it is, but it's tiny compared to the universe. As we look out further to the "Hubble Deep Field," it takes light millions of years to get between these galaxies.

To answer our big cosmological questions we use tools, like the cosmic microwave background (CMB). It is the afterglow from the hot and dense early universe, and it is our time machine to look back almost 13.8 billion years. What we see in this afterglow radiation today is what was in the universe at the beginning of its history. Another tool that helps answer our cosmological questions is that, as far as we can tell, the laws of physics that we measure here on Earth in our laboratories apply everywhere in the universe. We have never seen an example for which that is not true. Sometimes there are conditions in the universe that we can't recreate in the laboratory, but that is a different thing. Then the universe becomes our laboratory. And our last tool is something we call the "cosmological principle," which says that every part of space is like every other part. There is no special place in the universe so long as you consider sufficiently large scales. Obviously, our Earth is different from the spot next to us without an Earth there, but you have to go to much larger scales than that to see that every region of the universe is like every other region of the universe.

If you search online and ask what happened at the beginning of the universe, you will see pictures of the Big Bang like in Figure 3. They have a lot in common with each other. They seem to be showing an explosion with rocks and other things coming out. These explosions seem uneven, and this leads to a lot of misunderstandings. People often ask, "What constellation did the Big Bang happened in?" because these pictures show something like that. But this is not what we mean by the Big Bang. In fact, I would say that all these pictures are complete nonsense.

Let me say a word about the Big Bang. The Big Bang theory is the idea that the universe was hot and dense in the past and over the course of billions of years, the universe has been expanding and cooling. What supports this theory is the fact that the universe is expanding. That is what gave rise to the idea that there was an explosion. Some people said that if you play the expansion backwards eventually everything is on top of each other, so there must have been a big explosion. It is true that the universe is expanding. It is not true that you can extrapolate back like that. A few other observations are important to consider here. As you go back to the earlier universe, it was very hot and dense and, at some point, it became a nuclear fusion reactor and it made chemical elements. We see those elements today. The cosmic microwave background itself and its properties as measured by the Cosmic Background Explorer (COBE) satellite are consistent and support the idea that the universe has been expanding and cooling.

If these are not good pictures of what the Big Bang looks like, then what does the hot, dense, early universe look like? A picture of the early universe would be glowing (i.e., hot) and have a highly uniform density, so the picture would be extremely uniform from spot to spot. The idea of the expanding universe is that if you have galaxies in the universe and you wait, you see other galaxies moving apart from each other. We see galaxies moving away from us, but it is not because we are in a special place. All observers in all galaxies see other galaxies moving away. Space itself is stretching, leaving larger and larger distances between these objects. This is what Edwin Hubble found in 1929.

So how then did the universe begin if it wasn't a Big Bang? The frank answer is we don't know, but we have an idea that is called "inflation." I note Marc Kamionkowski used the same word, *idea*, in his introduction. Basically, the idea is if you go back far enough in time to hot temperatures and small distances you must take quantum mechanics into account. And in the quantum world there are fluctuations all the time. The inflation idea is that a quantum fluctuation much smaller than the size of a proton, that is, a subatomic fluctuation, inflates to a macroscopic size in a tiny fraction of a second. I mean in a trillionth of a trillionth of a trillionth of a trillionth of a second. Not only is this remarkable, but it allows us to use quantum physics to generate a universe out of nothing. It is the ultimate free lunch! By the way, while this expansion is occurring, you pick up additional quantum fluctuations; fluctuations are generated on all different scale sizes and these quantum fluctuations get converted

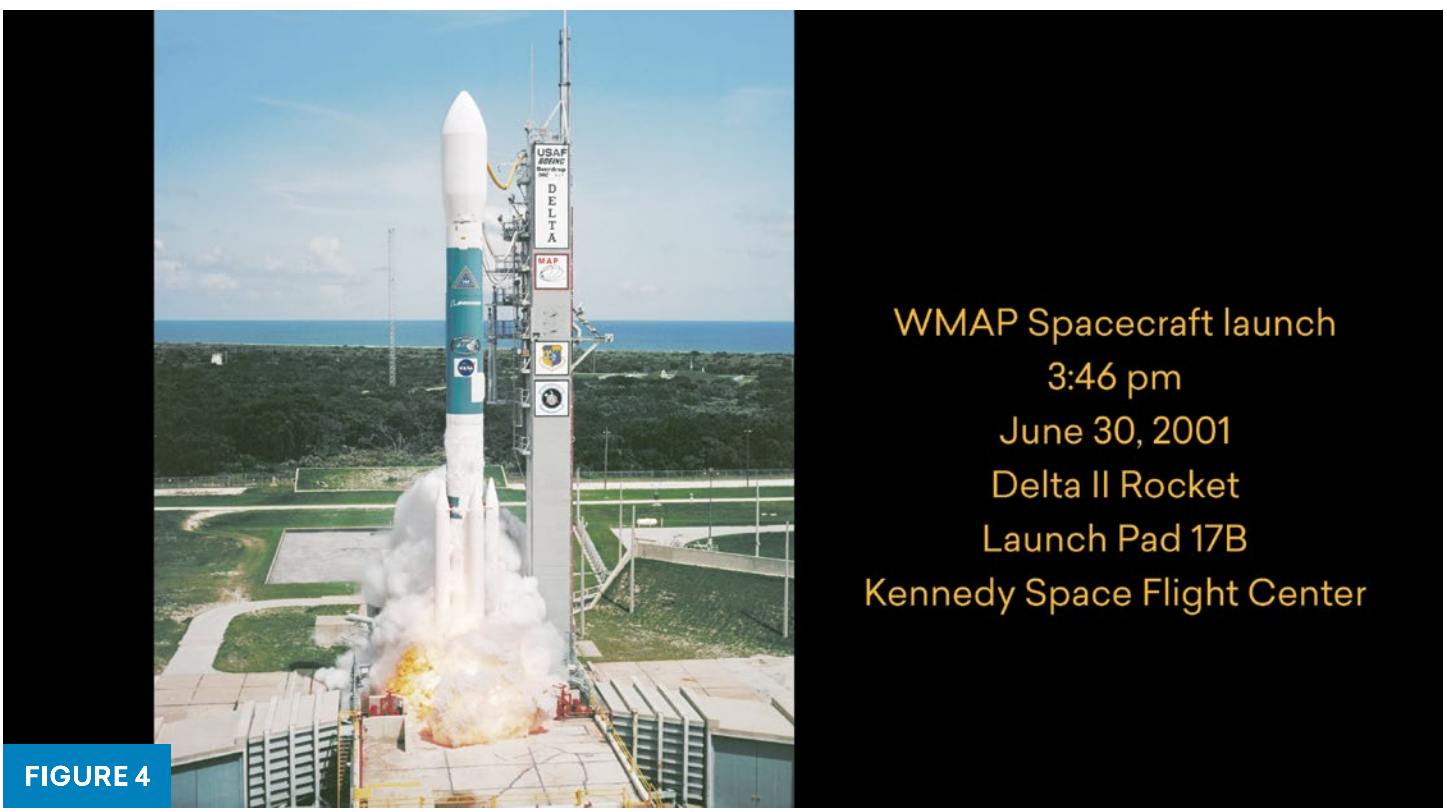


FIGURE 4

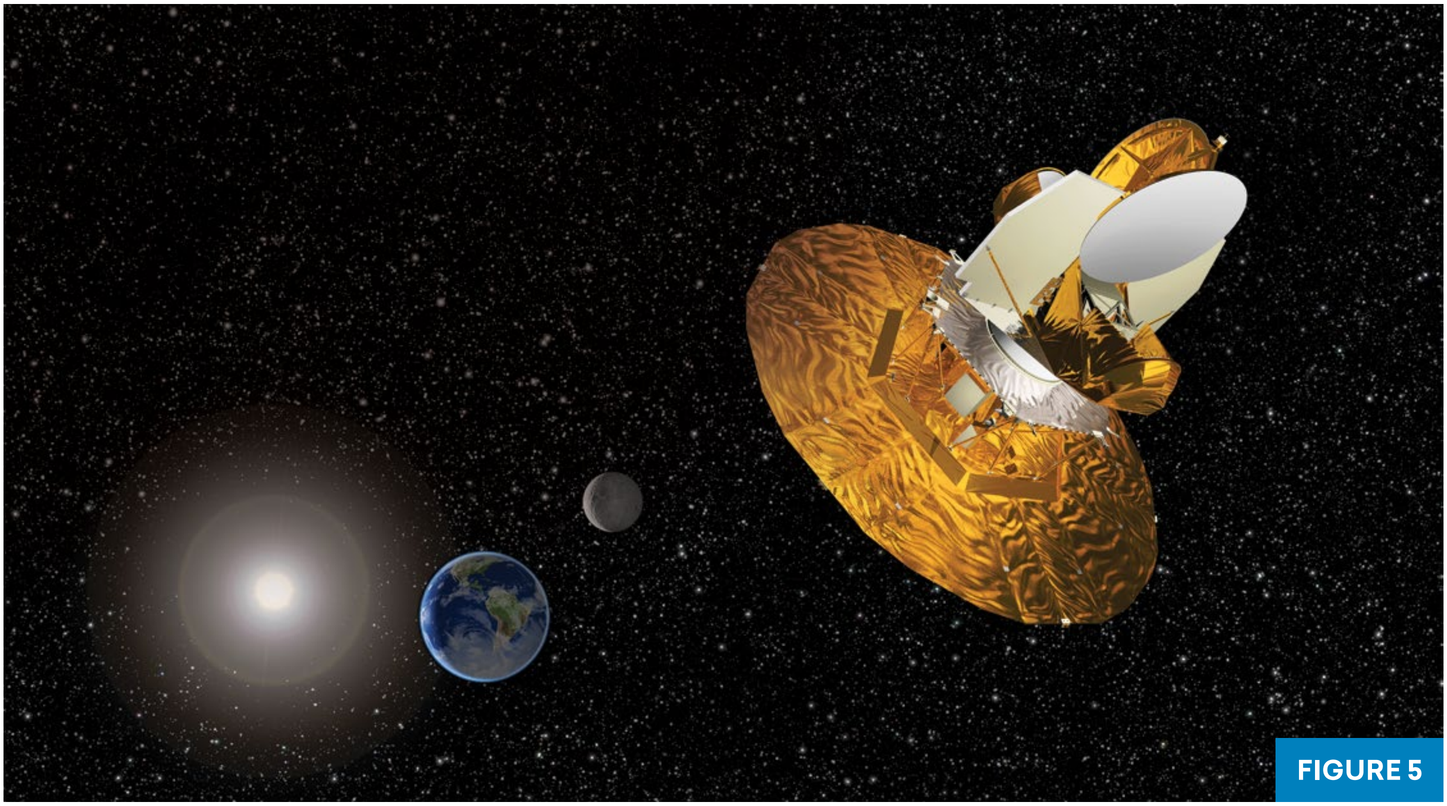


FIGURE 5

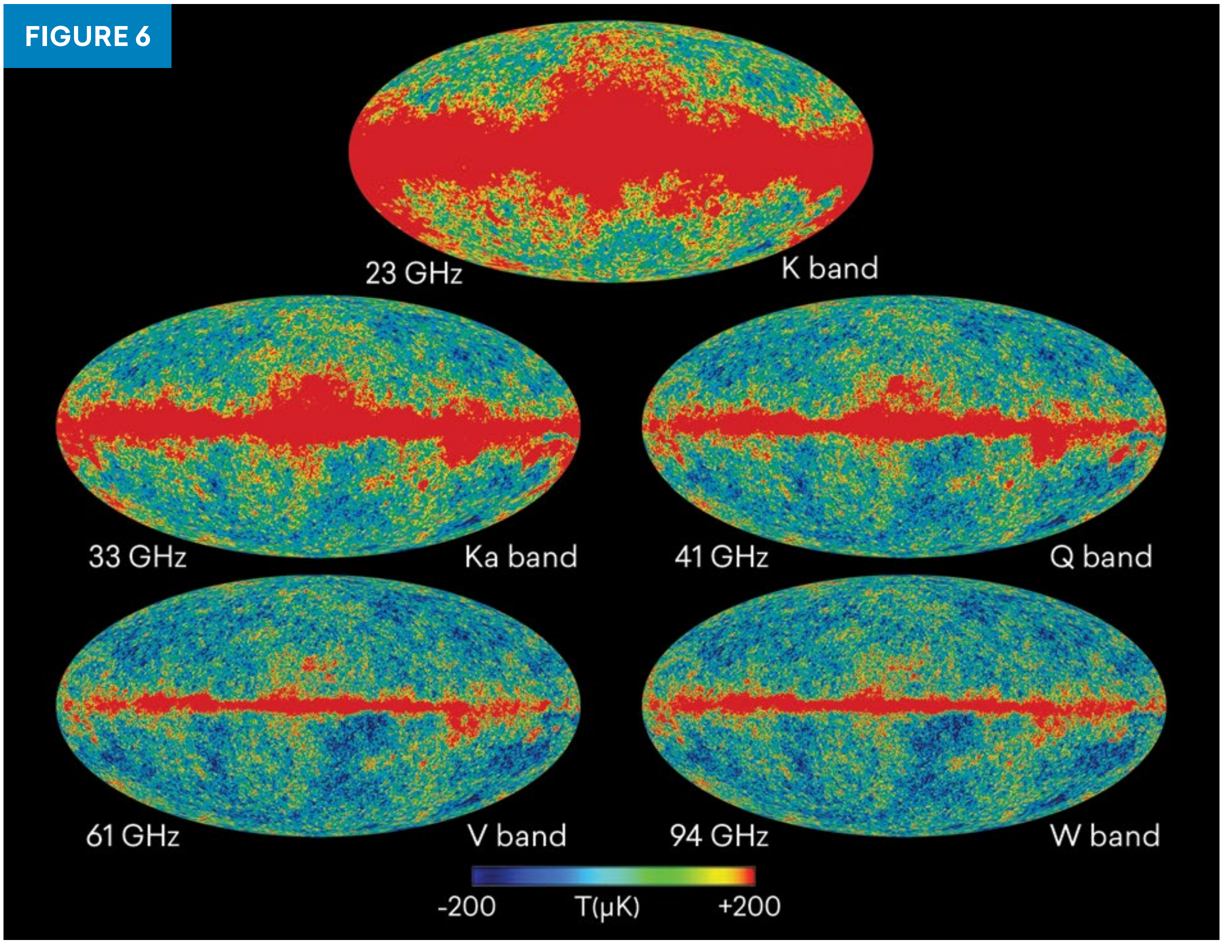
into what we call classical fluctuations. Inflation is our best idea for the beginning of the universe. We don't know for a fact that it is a correct theory or idea, and we certainly don't know which specific theory under the inflation umbrella would be the right one. Although we have ruled out many, there are many left. So where do we go from there?

In cosmology we can't experiment; we can only observe. In almost every other area of science you do experiments, which involve perturbing some system, poking at something, and seeing how it responds, whether it is an animal or a chemical. With the universe, we can't experiment. There are many people who have expressed their gratitude that I can't experiment with the universe! So we observe. We map the cosmic microwave background over the full sky and analyze the statistics of the fluctuations we observe in that map. Then we ask the question, what cosmological ingredients led to the fluctuation statistics of that map?

This is not easy to do because the fluctuations are extremely faint, and we need to avoid disturbances and interference from Earth's environment. That led us to the decision that we needed a space mission away from Earth. On June 30, 2001, at 3:46 pm WMAP launched on a Delta II rocket from the Kennedy Space Center in Florida (see Figure 4). The rocket took the mission on what we call phasing orbits around the Moon so we could steal a little of the Moon's gravity and use it as fuel to get the spacecraft out to an orbit around the second Lagrange point of L2. If you have been following the James Webb Space Telescope, the telescope is now in an orbit around L2. The reason L2 is a valuable observing position that WMAP pioneered, and now other observatories have gone there too, is because you can see that the Sun, the Earth, and the Moon are all behind the satellite (see Figure 5). The satellite has a big shield protecting the instruments from the microwave radiation from those objects, which is a billion times stronger than what we are trying to measure. There are also solar panels for power and a communications antenna, pointed back toward the Sun, the Earth, and the Moon. The telescope reflectors look out into deep cold space. The satellite spins and orbits around the Sun and that allows us to sweep out all the spots in the sky, to measure all the spots, and make the map of the full sky.

The spacecraft carried five instruments aboard that measured at five different frequencies (see Figure 6). What we see is a projection of the full sky. Every spot on the sky is somewhere on here. The most obvious thing you see is the red stripe across the center and that is because we live in the Milky Way galaxy and the red stripe represents microwaves from our own Milky Way galaxy. They're fascinating, but they are in the way of

FIGURE 6



what we are trying to measure. So we have to either model that emission and subtract it, or where it is too strong just cut out those parts of the map and not use them.

When we remove this microwave emission, the map we end up with is shown in Figure 7. This is a map of light that has been traveling across the universe for 13.8 billion years. We are seeing directly what the universe was like 13.8 billion years ago. What we need to do next is analyze the statistics of these fluctuations in the map and ask, how did this map come to be?

Upon analysis, we find the age of the universe is 13.77 ± 0.06 billion years. The contents of the universe consist of atoms, cold dark matter, and dark energy. Cold dark matter makes up 25 percent of the universe and it is either a particle or particles that we have not identified that don't interact with light. That means they don't give off light and that is why we call it dark: it doesn't block light; it doesn't scatter light. It sounds strange to have a particle that doesn't give off any light or absorb light, but we actually have candidates for what this might be: axions, axion-like particles, or neutralinos. People have been searching for some time trying to identify which particle or particles make up this cold dark matter. I'm hopeful that we will determine what this is. From a cosmological point of view, the most important thing is that we understand how it acts, which is that it gravitates but doesn't interact with light.

Dark energy makes up 70 percent of the universe. Dark energy may be the biggest problem in all of physics. Whatever it is, we don't understand it, but the fate of the universe depends on knowing what it is. Albert Einstein introduced his theory of general relativity, and very quickly applied it to the universe. I think he was both surprised and disappointed that it didn't make a universe that was stable. As far as he knew at the time, the universe was stable. So he introduced a fudge factor into his equations called the "cosmological constant." It acts like an anti-gravity. He set its value exactly equal to the gravity value of matter in the universe and with this balance attempted to make the universe stable. Once Hubble discovered the universe isn't stable, that it's expanding, Einstein realized his mistake. However, maybe realizing it was a mistake was a mistake because it appears that the universe does indeed have something like this. The cosmological constant is an example of a dark energy candidate, and we do observe an accelerated expansion of the universe today that is being driven by this dark energy, but we don't understand at all why the dark energy has the value that it has. It's a very odd value. It is not at all what we would predict. In fact, the value we predict would be much larger, and physicists have known for a long time that the high value is just not possible. So, the assumption has been that there must be some way to cancel it – to make it zero. But it appears only to cancel 121 of the 122 orders of magnitude needed to get to zero, so we end up with an unexpected small, non-zero cosmological constant.

Another possibility is that it is an environmental variable. If inflation created our universe maybe it created other universes and maybe this value just gets thrown in randomly in different universes in different ways. Most of these other universe possibilities wouldn't have the right properties to generate planets and life, thus there are no observers who could ever see them, so we have an observer's bias. This is basically an anthropic argument, and I and many physicists I know hate this argument. However, we grudgingly admit that it might be true. But believing it is true is equivalent to giving up, so we are going to try hard to see if there's some other explanation.

Without going into the details, the cosmological constant by its name is constant whereas the other possibility is that there could be a field that fills the universe that is changing with time. There are a lot of measurements trying to pin that down. Finally, Einstein could have been correct to begin with. There could be a flaw in his theory of gravity that is showing up, appearing as dark energy, and maybe we need a modified gravity model. As Yogi Berra says, "It's tough to make predictions, especially about the future." We can't predict the fate of the universe without knowing what this dark energy is.

I have left the atoms to last, which make up 5 percent of the universe. Atoms are something we know about because we are made of atoms; our houses are made of atoms; everything we come into contact with is made of atoms. In the cosmology business we call atoms "baryons." I mentioned previously that early in the history of the universe, when it was hot and dense, there were nuclear fusion reactions that made atoms in the first three minutes of the universe. Atoms are made now in nuclear fusion in stars. If we use the results of the COBE satellite mission, we get the density of photons in the universe: 411 per cubic centimeter. A region the size of a cube of sugar would hold 1,500

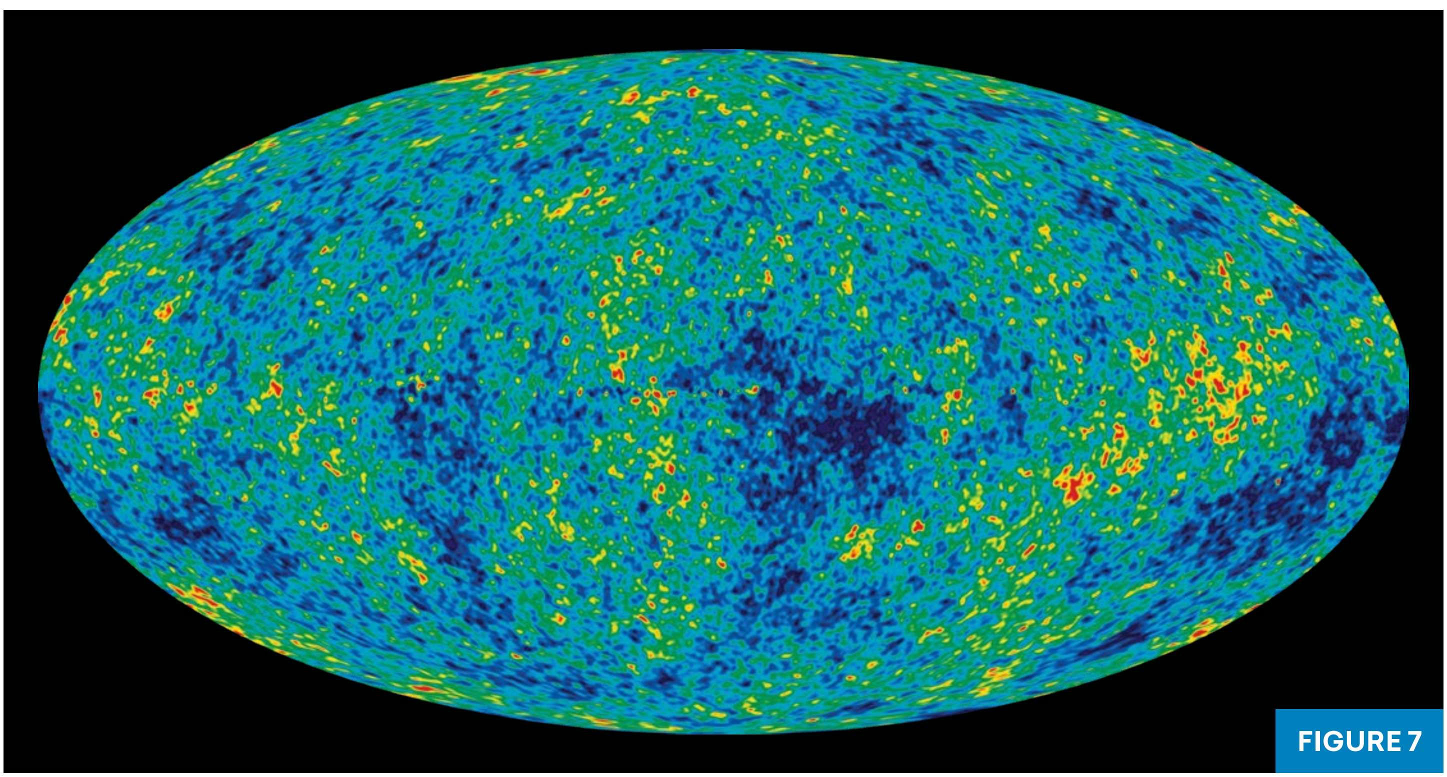


FIGURE 7

photons. If we use the WMAP data, we know the baryon density of the universe, and if we take the ratio, we learn that there are a billion photons for every baryon. This turns out to be the only free parameter in the early universe's creation of light chemical elements.

Before WMAP, when we didn't know this number very well, we would observe primordial clouds, measure the light chemical element abundances, and deduce what this ratio number was. But since WMAP, we have a very good value for this number. We can use the cosmic microwave background to predict what the abundance ratios are of ^{4}He (Helium), D (Deuterium), and ^{7}Li (Lithium). It turns out if we compare these two techniques, ^{4}He and D agree very well between the primordial clouds and what we measure in the early universe, but for some reason ^{7}Li is a little bit off. It has always been a curiosity of mine why that is. Everything I have ever read in any paper says this will be explained soon. The trouble is I have been reading such things for years, and people keep closing off avenues of explanation, so it's still a curiosity to me.

Let's turn now to the shape of space. There are three possible shapes of space (see Figure 8). The bottom one is the shape that you are most familiar with. If you draw a triangle on a piece of paper and measure the interior angles, they add up to 180 degrees. If you have a triangle that you draw on a horse saddle, the angles add up to less than 180 degrees. And if you draw a triangle on a ball, they will add up to more than 180 degrees. So if you draw a triangle in space, the angles have to be either more than, less than, or equal to 180 degrees. There is no other possibility. With the cosmic microwave background we essentially have a big triangle in space, and we have tried to assess the curvature of space. We observe the cosmic microwave background, but this light traveling across the universe is subject to the curvature of space. That allows us to determine the universe's geometry. And it turns out to be the one we are most familiar with: flat Euclidian geometry. The measurement is within 0.5 percent. This is a high-quality determination that we live in a universe with Euclidian or so-called "flat" geometry. Why is this important? Because the inflation picture that I pointed out earlier actually predicts this. It predicts it because of the enormous expansion of the universe, whatever curvature existed before, it would grow to such an extent that it would appear flat or Euclidian to us. So we can put a check mark next to that prediction. Again, inflation has many

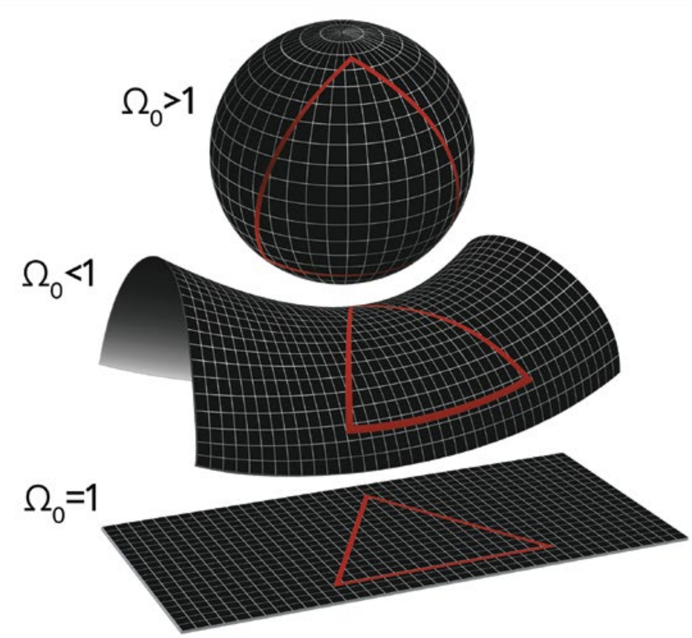


FIGURE 8

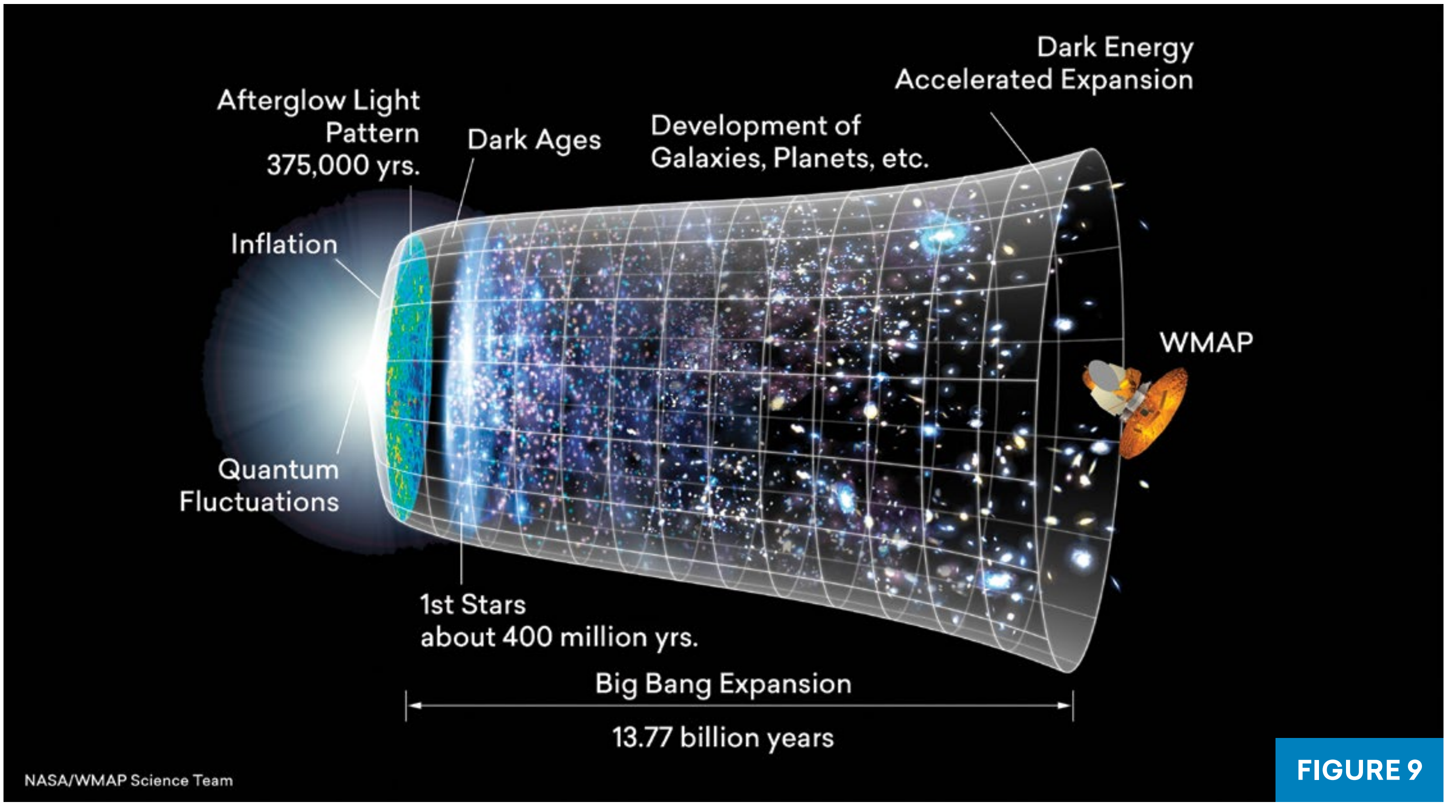


FIGURE 9

theories, but I'm referring here to generic predictions of inflation across the versions.

Another thing that we know about inflation is that if it happened, it slowed down and eventually stopped. The universe is not still inflating from the early times. While normally inflation would give you equal fluctuation power on every size scale, it had to slow and stop and that predicts a slight unevenness, a little more fluctuation on large scales than small scales. WMAP detected this for the first time. This is another check mark for inflation. There are other generic predictions of inflation, such as an equal number of hot and cold spots in the map. And so, inflation so far is making successful predictions. Again, it doesn't mean it is true. It just means that it is looking good. A statement of mine made the "quotation of the day" in *The New York Times* on March 17, 2006: "It appears that the infant universe had the kind of growth spurt that would alarm any mom or dad." It helps to have kids when you're working on these things!

Graphic artist Britt Griswold and I, with the help of Gary Hinshaw, made the graphic in Figure 9 that has become ubiquitously popular. The idea is the universe starts with quantum fluctuations that inflate to a macroscopic size. Then we have an afterglow light pattern that was put in place when the universe was 375,000 years old. I call the period after that the Dark Ages because no stars have yet formed to give off light. There is no starlight. There is still the cosmic microwave background (although it was then a much higher energy radiation), but the first stars don't form until some 400 million years later. And then what the diagram shows is the Big Bang expansion of the universe over 13.77 billion years, when the universe is expanding and gravity is doing its thing: generating galaxies and planets and the structures that we see in the sky with telescopes. Toward the end, we see this surprising accelerated expansion. Instead of the expansion slowing down, which you might expect, it is speeding up because of the dark energy component. A question then becomes, is that going to continue or is it going to reverse and collapse? We don't know the answer right now. But as Yogi Berra said, "We can observe a lot just by watching."

With WMAP we can predict what is going on in the universe at any time. We can predict what the expansion rate of the universe *should* be today, and that is the early universe number that we see in Figure 10, 68.34 km/sec/Mpc. But we can also measure what the expansion of the universe *is* today, the Hubble constant, and that is the late universe measurement, 72.61. Though these are close to each other, they are not really close enough. If we look at the number line, each of those brackets represents a 95 percent chance that the measurement is consistent within that range, but they don't overlap and that is not a good thing. Some of my colleagues think there is a mistake somewhere here, but I have to say that if there is a mistake, it is far from obvious. Data sets have been interchanged; analysis has been done by independent people. It's not unlikely that what we are seeing is some deviation from the model that may be a new piece of cosmology or a new piece of knowledge. We certainly shouldn't discount that possibility. I find this to be extremely important and exciting.

So we have several unanswered questions.

- What is the Dark Energy?
- What is the Cold Dark Matter?
- Did inflation happen, and if so which kind? This is a tall order because we need a quantum theory of gravity, and we don't have one.
- Why is there an expansion rate (Hubble constant) inconsistency?
- Why is the photon-to-baryon ratio so big?
- Why is there a gap in the early universe synthesis of ^{7}Li?

I would like to close with a thought of Einstein's that resonates with me: "The most incomprehensible thing about the universe is that it is comprehensible." We have more to learn, and we are going to keep working at it.

OXTOBY: Thank you, Chuck. We have time to take some questions and comments from the audience. I will start with the first question. In 1996, the Rumford Prize was awarded to John Mather for his contributions to understanding the cosmic microwave background. Are there connections between his work and yours?

BENNETT: That's a very good question. The Cosmic Background Explorer, COBE, was an extremely important space mission. It did breakthrough science. One experiment on COBE measured the spectrum of the cosmic microwave background, and determined it was a blackbody. That really cemented the Big Bang theory, ending the competing theories. It also gave us the photon density of the universe. People treat it now as a constant of nature, but it's a measured quantity from COBE. The other thing COBE discovered was the temperature fluctuations I showed in the WMAP map. People searched twenty-seven years for those fluctuations until COBE finally detected them. And

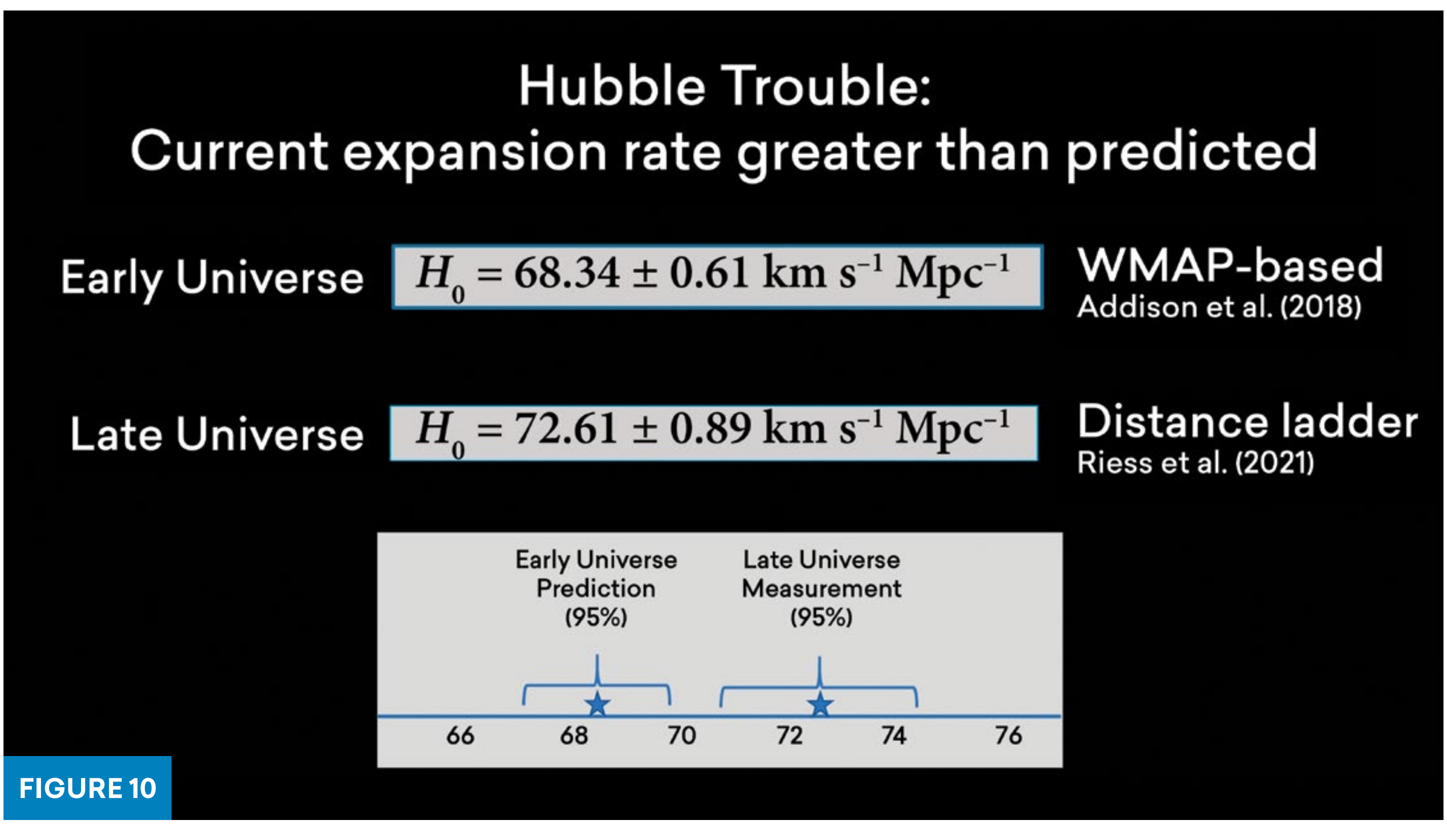


FIGURE 10

that was a motivating factor for our WMAP proposal. Now that we knew that they were there, and we knew how bright they were, we could design a mission to go study the fluctuations. So COBE was very much the mother of WMAP.

AUDIENCE MEMBER: Since we are celebrating Chuck Bennett, I want to make sure people know that Chuck participated in COBE, which was awarded the Nobel Prize for two things. One was the measurement of the blackbody spectrum, which was 2.7 Kelvin. The other was that it was the first to see the structure at a very tiny scale. A lot of people had seen other things before that. They had seen that the sky was hot in one corner and cold in another, but COBE saw it even better because of the motion of the Earth around the Sun. This was quite exceptional but had never been measured. If Chuck hadn't been part of that experiment, it would never have been measured. Chuck realized very early that the sensitivity of the device that was going to measure that anisotropy was not good enough to make the measurement. And that was a profound observation. Chuck made it so that the instrument was improved. So I hold Chuck responsible for the very first measurements of that structure, which later was measured by WMAP so exquisitely. He helped to earn that Nobel Prize.

AUDIENCE MEMBER: As a topologist I wonder about the implications for the qualitative geometry of space as a whole. Does the model that you have been describing, which involves inflationary expansion, tell us something about the cosmos as either a three-dimensional or four-dimensional manifold? Does it dictate that the geometry of the overall shape, not the curvature, is Euclidian?

BENNETT: Earth has a curved surface, but to us it looks flat because the radius of the curvature is so large. The whole idea of inflation is that you are driving the radius of the curvature to such an enormous value that locally it looks flat. What do I mean by locally? We have a concept of the observable universe. That is the part within a horizon where light has had time to come to us. When we observe the universe, we don't observe the whole universe. We only observe out to a certain distance, and beyond that light hasn't had time to get to us. We measure and quantify the Euclidian geometry within 0.5 percent. That's within our horizon. We don't know what goes on beyond our horizon because we can't observe it.

OXTOBY: Last week, the Academy's project on Challenges for International Scientific Partnerships published the final of three reports that offer recommendations for strengthening international scientific collaborations. I'm curious about your work and the extent to which it has benefited from international scientific collaboration.

BENNETT: What I did not mention is that WMAP was a very inexpensive satellite as satellites go. Its price was 1 percent or less than the cost of the James Webb Space Telescope. Most space missions have some international collaboration largely because single nations can't afford to do expensive things by themselves. And you get the benefit of expertise from around the world. Because WMAP was so small and we had such a tight budget, it was essentially a domestically funded mission with a domestic team, though we had some Canadians participating with us on the science team. I have to say that WMAP is more the exception than the rule. These days it would be hard to name a space mission that does not involve some international collaboration.

OXTOBY: A final question: How do you see the field of cosmology changing in the future?

BENNETT: I think things are about to change quite a bit. Very soon the James Webb Space Telescope is going to be collecting data. We also have the Vera C. Rubin Observatory that is going to be surveying the sky and giving us a flood of data. And then we have the Euclid space mission from the European Space Agency, which NASA is collaborating on; I am a part of that space mission too. We have the Nancy Grace Roman Space Telescope that NASA is going to be launching. There is the Subaru Prime Focus Spectrograph. There is the Simons Observatory and CMB-S4. All kinds of things are happening. And they are largely aimed at the things that I discussed: What is dark matter? What is dark energy? And what about inflation? I am amazed by the amount of data that is going to be coming in. It's a very exciting time for cosmology.

&

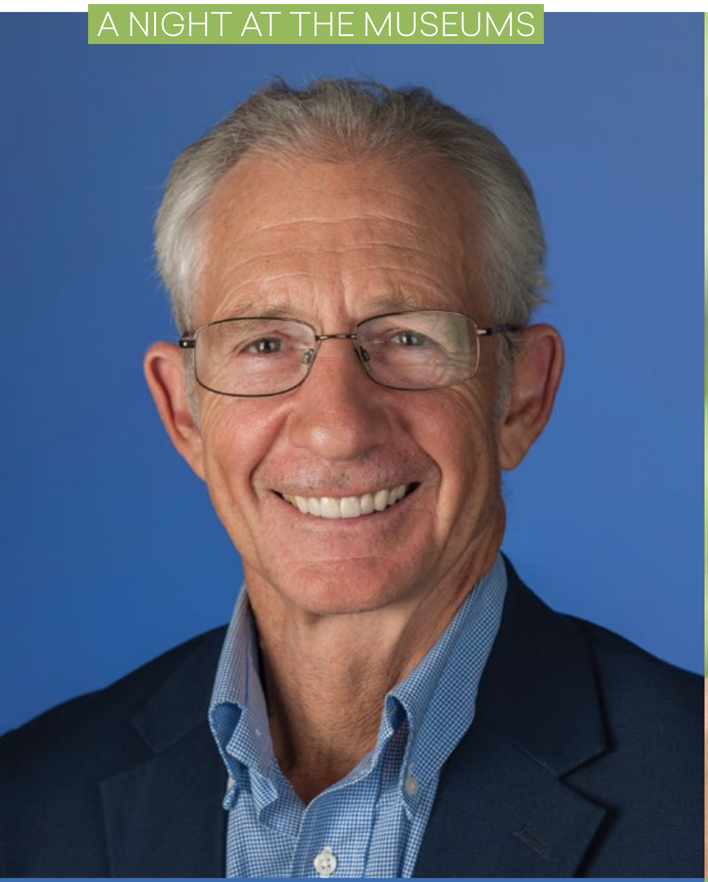
To view or listen to the presentation, visit www.amacad.org/events/charles-bennett-rumford-prize.

At the Florida Museum of Natural History, fossils, dinosaur eggs, and skeletons shed light on dinosaur family life.

A NIGHT AT THE MUSEUMS

2104th Stated Meeting | February 28, 2022 | Virtual Event
Morton L. Mandel Conversation

"A Night at the Museums" was conceived of and hosted by Academy members and Gainesville Representatives **Pamela Soltis** and **Douglas Soltis** (both, University of Florida). They wanted an event that would highlight the utility of the modern museum collection while connecting members from across the country. This program gave a behind-the-scenes look at museums in Florida, Massachusetts, Michigan, California, and Oregon – all of which are associated with universities in the Academy's network of Affiliate institutions. An edited version of select portions of the presentations and Q&A session follows.



Douglas Soltis

Douglas Soltis is a Curator at the Florida Museum of Natural History and Professor of Biology at the University of Florida. He was elected a Fellow of the American Academy in 2017.

Pamela Soltis

Pamela Soltis is a Curator at the Florida Museum of Natural History. She was elected a Fellow of the American Academy in 2017.

DOUGLAS SOLTIS: Thank you for joining us for our Night at the Museums event.

PAMELA SOLTIS: We are joining you this evening from the Denny Gallery at the Florida Museum of Natural History's Powell Hall, our exhibits and public programs building. Beyond these exhibits, the Florida Museum is home to over forty million specimens and artifacts – items that the public rarely, if ever, gets a chance to see.

DS: Perhaps many of you saw the movie *Night at the Museum*, in which the organisms, people, and museum artifacts come to life after the museum is closed at night. And so, here we are at a museum . . . at night (at least in Gainesville).

PS: Let's take a closer look at natural history museums. Natural history collections trace their history, in some cases, back several centuries, and today, natural history museums in the United States collectively house at least one billion specimens, and perhaps more! Globally, that number may be as high as three billion specimens. Natural history specimens represent science's best accounting of Earth's biodiversity, with each specimen documenting where a species occurred at a given point in time. Specimens provide documentation of species occurrences and baselines for assessing the effects of climate change and invasive species. Until recently, these vast collections were only available to specialists who could afford to travel to the physical collections. But today, our collections are being digitized, and both data and images of specimens are increasingly available online, providing free access to scientists, educators, and the public worldwide.

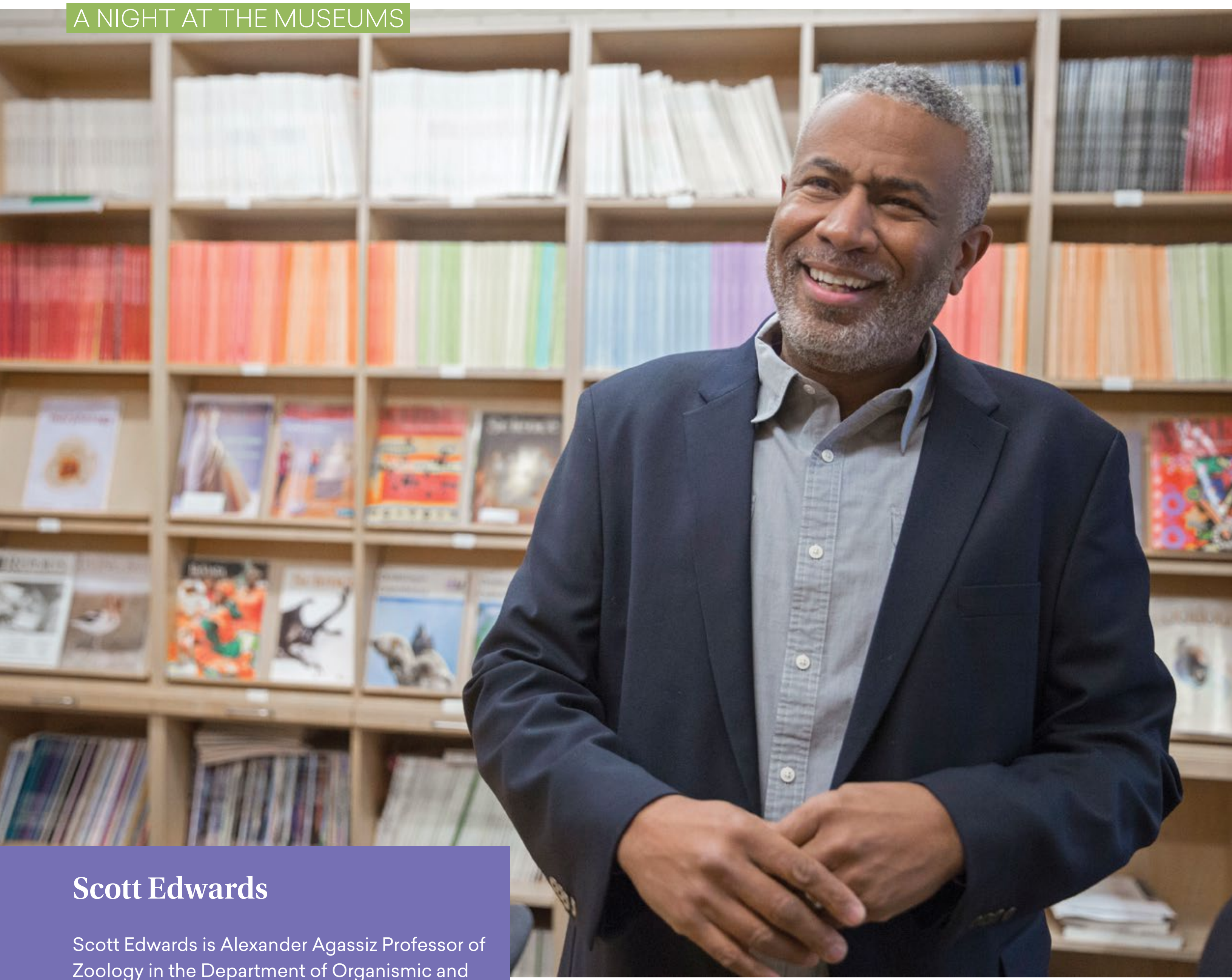
DS: You may be wondering what actually lies behind the scenes, behind the main exhibits? What treasures exist in museum cabinets and drawers?

Butterfly specimens at the Florida Museum of Natural History.

You may be envisioning a museum specimen as a stuffed bird or a pressed plant or a fossil tooth – and certainly many specimens are indeed these preserved materials. But natural history collections are increasingly also curating DNA samples and video and audio recordings – and all of these diverse specimens help tell us more about the world around us. In truth, only a tiny fraction of museum specimens is ever on display. Behind the exhibits – that is where the action occurs – is where our millions of specimens are stored and where we as researchers are privileged to examine and study them.

Today, by visiting museums across the country, we are going to go behind the scenes and share with you some of the content in those cabinets and drawers. We will turn to our American Academy colleagues at four other institutions to tell the stories of their collections. We will visit the Ornithology Collection at Harvard University's Museum of Comparative Zoology with Academy member Scott Edwards. From there, we will cross the continent to visit the living collections of UCLA's Mildred E. Mathias Botanical Garden and Herbarium, with Academy member Victoria Sork.

PS: We will then travel northward to the University of Oregon's Museum of Natural and Cultural History with Academy member Jon Erlandson. From there, we will visit the University of Michigan's Museum of Paleontology, where Academy member Philip Gingerich will introduce us to the Museum's Director, paleontologist Matt Friedman. After that, we will return to the Florida Museum, where our colleague Akito Kawahara will share the wonders of our Museum's Lepidoptera collection.



Scott Edwards

Scott Edwards is Alexander Agassiz Professor of Zoology in the Department of Organismic and Evolutionary Biology and Curator of Ornithology at the Museum of Comparative Zoology at Harvard University. He was elected a Fellow of the American Academy in 2009.

Scott Edwards led the event participants on a tour of the third floor – underground – of Harvard's Northwest Laboratory, which is home to the fifth largest bird collection in the world. In total, the museum holds approximately four hundred thousand specimens, containing as much as 95 percent of all bird species.

Professor Edwards showed several specimens, including the now extinct North American Warbler, Bachman's Warbler, the eggs of a passenger pigeon, and a collection of White-winged Crossbills. He also discussed the provenance of the collection, which was started nearly two hundred years ago, its use in genetics research, and its value as a source of ecological data.

> "Museums have a very important role to play in preserving parts of biodiversity that are no longer on our planet. . . . We get requests from all over the world. And one of my jobs is to make sure that these specimens are accessible to a wide audience.

Right: Specimens in the ornithology collection at Harvard's Museum of Comparative Zoology.

Victoria Sork

Victoria Sork is Director of the Mildred E. Mathias Botanical Garden and Herbarium at the University of California, Los Angeles, and a UCLA Distinguished Professor in the Department of Ecology and Evolutionary Biology, and in the Institute for the Environment and Sustainability. She was elected a Fellow of the American Academy in 2021.

Victoria Sork led the audience on a walking tour of the Botanical Garden, which has been part of the UCLA campus since the 1930s and home to nearly two thousand living plant species. The tour included stops at a rose gum eucalyptus (the tallest of any tree species in Southern California); their Palm Garden and Ancient Forest; and a storied and critically endangered deciduous conifer, the dawn redwood.

Mildred E. Mathias Botanical Garden

In addition to being a living collection, the Botanical Garden serves as a resource for DNA research, a venue for public engagement, and a way to honor communities native to the Los Angeles Basin. During the tour, Professor Sork discussed her collaborations with the Gabrieleno-Tongva community to plant species that could be harvested by the community for basket weaving and other traditional uses.

> “I really thought closely about the responsibility to recognize Native peoples who have lived in this land long before UCLA became part of this landscape. . . . Three key words that come to mind are: recognition, respect, and reciprocity.

10,000-year-old Fort Rock sandals recovered from cave sites in Oregon's Northern Great Basin; on exhibit at the Museum of Natural and Cultural History.

Jon Erlandson

Jon Erlandson is Executive Director of the Museum of Natural and Cultural History and Professor Emeritus of Anthropology at the University of Oregon. He was elected a Fellow of the American Academy in 2013.

Jon Erlandson's presentation highlighted the vast collection held at the Museum of Natural and Cultural History, which serves as the official repository for anthropological and paleontological collections for the State of Oregon and curates collections for the U.S. Bureau of Land Management, the National Park Service, the Forest Service, and other federal agencies.

Among the items on display at the Museum are a fossil collection that illustrates mammalian evolution and climate change, the world's oldest running shoes, and an exhibit focused on the Native Americans who lived and thrived in Oregon for more than fourteen thousand years.

"We don't shy away from controversial topics. We address evolution, climate change, and social justice issues. . . . We stress the links between the past, present, and future in all of our exhibits and programs, working to imbue a sense of constructive stewardship in our visitors.

Matt Friedman

Matt Friedman is Associate Professor and Director of the Museum of Paleontology at the University of Michigan.

Matt Friedman invited the audience into the collections' storage space at the Museum of Paleontology to see a fraction of the nearly three million fossil specimens housed at the Museum. He showed the cast of the skull of an early whale whose dentition resembles that of a human, a variety of ammonite fossils, and specimens from fifty-six million years ago. He also discussed the essential role of avocational paleontologists who make donations to the Museum's collections.

> "We tend to think about paleontology as the study of things that happened a long time ago, but, of course, paleontology has a very real bearing on our understanding of things that could happen in the future.

Akito Kawahara

Akito Kawahara is Associate Professor at the University of Florida and Curator at the Florida Museum of Natural History's McGuire Center for Lepidoptera and Biodiversity.

Akito Kawahara led participants on a walking tour of the public exhibitions and storage space that house the Florida Museum of Natural History's Lepidoptera collection. The moths and butterflies on display include both rare as well as common species found throughout the world. The collection not only captivates the public but helps scientists answer questions about evolution and biodiversity. Professor Kawahara spoke about the combination of public and private support required to build an appropriate space for such an important collection.

> "Some of the specimens in this drawer are very rare, and some of them come from places where the habitat no longer exists. . . . This information is very important for understanding how the world is changing and what organisms existed in place and time."

Following the tour of the museums, the speakers answered questions from the audience.

DAVID OXTOBY: The Academy has a new commission on Accelerating Climate Action, and one of the things that the commission has been focusing on is that many people are not convinced by scientific facts alone. Though it's important to show the science and museums are doing an excellent job at that, you also need to include moral and ethical arguments and integrate storytelling, among other things. I'm curious about how you think about that in the exhibits and programming at your museums.

VICTORIA SORK: You can tell stories in many ways. When people come to the Botanical Garden, I think it is important to use that opportunity to talk about plants from around the world but also to bring up the issue of climate change. Certainly, museums get involved in outreach activities to school groups and schoolkids, many of whom do not get the chance to really understand and study nature. I think raising consciousness about the importance of nature, the planet, climate warming, and loss of species is something that we can do in a very gentle way just by touching and connecting with people's love of nature. It is a responsibility that we can fulfill through our public outreach programs.

JON ERLANDSON: I agree with Victoria. A lot of people in Oregon, including schoolkids from all over the state, can't get to the Museum of Natural and Cultural History. So during the pandemic, we started sending programs and lessons about the important issues that threaten us as a species today to the schools and libraries across Oregon as a way to reach the schoolchildren.

PAM SOLTIS: The Florida Museum of Natural History has also been extremely active during the pandemic trying to reach the schools throughout Florida. We have a program called the Scientist in Every Florida School in which students, faculty, and staff make literally hundreds of visits to school classrooms around the state, sharing information, lessons, and just fun experiences with K-12 students. The pandemic has given us an opportunity to think about how to broaden our reach to children and older schoolkids whom we haven't been able to engage in the past.

AUDIENCE MEMBER: The presentations today really emphasized the importance of gardens and museums in a variety of ways, from research to cultural issues. At the same time, it's clear that a lot of gardens and museums are struggling. Could the speakers talk about the kinds of struggles they face and what can be done to impress upon people the importance of these institutions apart from their academic value?

ERLANDSON: The Museum of Natural and Cultural History has had some challenges during the pandemic, but even before then. After we were accredited in 2016 by the AAM (American Alliance of Museums), the University of Oregon cut our funding by 20 percent, which is a significant amount. We had to lay off some of our public program staff. What allowed us to survive and move forward has been our extensive development efforts. We've increased our endowment by more than tenfold and that allows us to sustain our programs in perpetuity.

SCOTT EDWARDS: Pam, I, and several others worked on a report through the National Academy of Sciences on the importance of biological collections, and how they can be sustainable. We recommended that museums need to have diverse sources of funding. And so private funding, as we just heard, is important. The United States is extremely unique in that we have government programs that support collections. The National Science Foundation has a collections improvement program that is, in my experience, virtually unheard of in other countries. So we are very fortunate in that way.

AUDIENCE MEMBER: This is a question for Victoria Sork. Do you ever have trouble convincing people or explaining that a botanic garden is, in some sense, a museum, and that you're trying to preserve the specimens for study?

SORK: Our Botanical Garden is a teaching and research garden. Because a very small part of our budget comes from the university, we need public support. And that's when I realized we need attractive displays within the garden to bring people in, so then you can start educating them about different species. I think herbariums have even more of a challenge in how to do this. We just renovated our herbarium, and we're going to try to involve the public, maybe amateur botanists and conservation biologists who will help to identify specimens. Our hope is to get more involvement and appreciation of why we document, preserve, and study the wonderful diversity of our world.

SORK: I have a question for my fellow panelists about the decolonization movement and recognizing where specimens have come from and how they were gathered. I'm curious what other museums, especially those that have collections from all over the world, are doing to recognize where things came from.

ERLANDSON: Certainly, for any American museum that has archaeological collections, the decolonization movement is huge. It started with the Native American Graves Protection and Repatriation Act. There are museums that have fought the return and repatriation of human remains and associated burial materials. Oregon's Museum of Natural and Cultural History has always been in full legal and philosophical compliance with NAGPRA, and it's one of the reasons our relationship with Oregon's tribes is so strong.

PAM SOLTIS: For the Florida Museum of Natural History, this is something that our archeology collections have been dealing with for a long time. Where did these collections come from? Under what circumstances were the specimens collected? Who was involved in the collections beyond the person whose name appears on the label? How do we provide attribution? How do we share data appropriately? There are many questions that have been raised in recent years and we're just starting to have some of these discussions. Over the next several years, we have a lot of responsibilities to live up to, a lot of growth, and a lot of things that need to be addressed.

EDWARDS: In addition to decolonization, there's also just the bare fact that a lot of museums in this country have a very racist origin. Harvard's Museum of Comparative Zoology (MCZ) and the Peabody Museum of Anthropology next door are a case in point. Louis Agassiz founded our museum in 1859 and he, even in his own time, was recognized to be a virulent racist. He collected distasteful objects, such as photographs of slaves. A few years ago, descendants of those slaves demanded retribution. There are also unsung heroes in museums who, for reasons of their race, creed, or gender, have not been celebrated as much as they should be in the building of those collections. A case in point is an African American in the MCZ, Robert Gilbert, who was working in the late 1800s and early 1900s for William Brewster, a much better-known ornithologist, and did a lot to ensure Brewster's success. Until now, he has not been recognized. It's a long road ahead, and I think we all have to take a less biased view of the history of museums, and not only try to address the injustices, but also celebrate all the unsung heroes who have made some of these museums great attributes of modern society.

OXTOBY: To follow up on that, is ecotourism, where you go to an underdeveloped country and see amazing living species, helping or hurting? Is bringing tourists into these places a concern?

EDWARDS: I think ecotourism is recognized as being an important source of income for local communities. The industry is in a much better position now to reward local and Indigenous people in that enterprise. On the flip side, people in Africa and in other areas of the globe want their own museums, which have a universal kind of appeal. So it's incumbent on scientists and administrators in the West to help facilitate that so folks in their local communities can celebrate their natural specimens.

DOUGLAS SOLTIS: This has been a terrific program. We hope you had as much fun traveling across the country to these collections as we have and that you gained a better understanding of what's behind the scenes at natural history museums. Many thanks to Scott, Victoria, Jon, Philip, Matt, and Akito for guiding us through the collections. Thanks also to our excellent staff, some of whom are still here at the Florida Museum, especially Dale Johnson and Alberto Lopez, for logistic support this evening. And many thanks as well to David Oxtoby, Patrick Meade, and Laurie McDonough at the American Academy for pulling this event together.

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A recording of this event is available on the Academy's website. To view or listen to the presentations, visit www.amacad.org/events/collections-museums.

NOTEWORTHY

Select Prizes and Awards to Members

Carol Anderson (Emory University) was selected as the 2022 winner of the Joseph B. and Toby Gittler Prize, given by Brandeis University.

Richard Baraniuk (Rice University) was elected a member of the National Academy of Engineering.

Bonnie L. Bassler (Princeton University) is a co-recipient of the 2022 Wolf Prize in Chemistry.

Carolyn R. Bertozzi (Stanford University) is a co-recipient of the 2022 Wolf Prize in Chemistry.

Squire J. Booker (Pennsylvania State University) received the Hans Neurath Award from the Protein Society.

Susan L. Brantley (Pennsylvania State University) was elected a foreign associate of the French Academy of Sciences.

John Clarke (University of California, Berkeley) is a co-recipient of the Micius Quantum Prize, given by the Micius Quantum Foundation.

George Crabtree (Argonne National Laboratory) received the 2022 Energy Systems Award from the American Institute of Aeronautics and Astronautics.

Benjamin F. Cravatt III (Scripps Research Institute) is a co-recipient of the 2022 Wolf Prize in Chemistry.

Elizabeth Diller (Diller Scofidio + Renfro Architects) was awarded the 2022 Wolf Prize in Architecture.

James R. Downing (St. Jude Children's Research Hospital) was elected to the 2022 Class of Fellows of the American Association for Cancer Research.

Jennifer L. Eberhardt (Stanford University) was awarded the 2022 Rockefeller University Lewis Thomas Prize for Writing about Science.

Joy Harjo (Tulsa, OK) received the 2022 Leadership Award in Poetry from the Academy of American Poets.

Stephen L. Hauser (University of California, San Francisco) is the recipient of the American Brain Foundation's Scientific Breakthrough Award.

Mellody Hobson (Ariel Investments) received the 2022 Lincoln Leadership Prize, given by the Abraham Lincoln Presidential Library Foundation.

John P. Holdren (Harvard University) was awarded the National Academy of Sciences' Public Welfare Medal.

Peter Hotez (Baylor College of Medicine) is the recipient of the 2022 Scientific Achievement Award of the American Medical Association.

Tony Hunter (Salk Institute for Biological Studies) received the 2022 AACR Award for Lifetime Achievement in Cancer Research.

Sherrilyn Ifill (NAACP Legal Defense and Education Fund) received the 2022 Radcliffe Medal from the Radcliffe Institute for Advanced Study.

Sheila Jasanoff (Harvard Kennedy School) was awarded the 2022 Holberg Prize.

Leonard Kleinrock (University of California, Los Angeles) was named a 2022 Fellow of the Computer History Museum.

William F. Lee (Wilmer Cutler Pickering Hale and Dorr, LLP) received the 2022 Harvard Medal.

Ruth Lehmann (Whitehead Institute for Biomedical Research) is the recipient of the 2022 Vanderbilt Prize in Biomedical Science.

Jianguo "Jack" Liu (Michigan State University) received the Eminent Ecologist Award from the Ecology Society of America.

Phillip Lopate (Columbia University) is the recipient of the American Academy of Arts and Letters' Christopher Lightfoot Walker Award.

Glenn Loury (Brown University) was awarded the 2022 Bradley Prize, given by the Lynde and Harry Bradley Foundation.

Kenneth M. Ludmerer (Washington University in St. Louis) received the 2022 John C. Gienapp Award for Distinguished Service to Graduate Medical Education from the Accreditation Council for Graduate Medical Education.

George Lusztig (Massachusetts Institute of Technology) was awarded the 2022 Wolf Prize in Mathematics.

Michael Lynch (Arizona State University) was awarded the 2022 Genetics Society of America (GSA) Thomas Hunt Morgan Medal.

Ira Mellman (Genentech) is the recipient of the 2022 AACR-Cancer Research Institute Lloyd J. Old Award in Cancer Immunology.

Michele Norris (*The Washington Post*) received the 2022 Goldsmith Career Award for Excellence in Journalism, given by the Shorenstein Center on Media, Politics, and Public Policy at Harvard Kennedy School.

Sharon Olds (New York University) was awarded the 2022 Frost Medal by the Poetry Society of America.

Olufunmilayo Olopade (University of Chicago Medicine) is the recipient of the William L. McGuire Award and Lecture by the San Antonio Breast Cancer Symposium.

Enrico Ramirez-Ruiz (University of California, Santa Cruz) received a Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring, given by the White House Office of Science and Technology Policy and the National Science Foundation.

John A. Rogers (Northwestern University) received the 2022 Washington Award from the Western Society of Engineers and the Washington Award Commission.

J. Marshall Shepherd (University of Georgia) received the 2022 SEC Faculty Achievement Award for the University of Georgia. He was also named 2022 SEC Professor of the Year.

Theda Skocpol (Harvard University) was named a fellow of the American Academy of Political and Social Science.

Anna Deavere Smith (New York University) was awarded the Medal for Spoken Language from the American Academy of Arts and Letters.

Dennis Parnell Sullivan (City University of New York; Stony Brook University) was awarded the 2022 Abel Prize for Mathematics.

Esther Takeuchi (Stony Brook University) received the 2022 National Academy of Sciences' Award in Chemical Sciences.

Colm Tóibín (Columbia University) was named Laureate for Irish Fiction by the Arts Council of Ireland. He was also awarded the Rathbones Folio prize for *The Magician*.

Sherry Turkle (Massachusetts Institute of Technology) received the Krauss Family Award in Memory of Simon & Shulamith (Sofi) Goldberg from the National Jewish Book Council for *The Empathy Diaries: A Memoir*.

Kara Walker (New York, NY) was awarded the Gold Medal for Graphic Art from the American Academy of Arts and Letters.

Oprah Winfrey (Harpo Productions, Inc.) was named the 2022 PEN/Faulkner Literary Champion.

New Appointments

Susan Ackerman (University of California, San Diego) was appointed to the Scientific Advisory Board of Tevard Biosciences.

Cynthia Barnhart (Massachusetts Institute of Technology) was appointed to the Board of Directors of *MIT Technology Review*.

Ian Baucom (University of Virginia) was appointed Executive Vice President and Provost of the University of Virginia.

May Berenbaum (University of Illinois at Urbana-Champaign) was appointed a member of the U.S. President's Committee on the National Medal of Science.

Nicholas Christakis (Yale University) was appointed to the Advisory Board of ProQuo AI.

Katherine E. Fleming (New York University) was named President and CEO of the J. Paul Getty Trust.

Kenneth C. Frazier (Merck) was appointed independent director of Eikon Therapeutics Inc.

Elena Fuentes-Afflick (University of California, San Francisco) was appointed Vice Dean of the UCSF School of Medicine at the Zuckerberg San Francisco General Hospital.

Helene D. Gayle (The Chicago Community Trust) was appointed President of Spelman College.

Hugh Grant (St. Louis, MO) was appointed to the Board of Directors of Invaio Sciences, Inc.

Rachel Green (Johns Hopkins University School of Medicine) was appointed Chair of the Scientific Advisory Board of Alltrna.

Amy Gutmann (University of Pennsylvania) was confirmed by the U.S. Senate to serve as U.S. Ambassador to Germany.

Lisa P. Jackson (Apple) was appointed to the President of the United States' Board of Advisors on Historically Black Colleges and Universities.

Gish Jen (Cambridge, MA) was elected to the John D. and Catherine T. MacArthur Foundation Board of Directors.

Laura Kiessling (Massachusetts Institute of Technology) was appointed to the Scientific Advisory Board of Exo Therapeutics, Inc.

George E. Lewis (Columbia University) was named Artistic Director of New York's International Contemporary Ensemble.

M. Elizabeth Magill (University of Virginia) was named President of the University of Pennsylvania.

Juan Maldacena (Institute for Advanced Study) was appointed a member of the U.S. President's Committee on the National Medal of Science.

Cora Marrett (University of Wisconsin-Madison) was appointed a member of the U.S. President's Committee on the National Medal of Science.

Diane Mathis (Harvard Medical School) was appointed Chair of the Advisory Board of Abata Therapeutics.

Martha Minow (Harvard University) was elected Chair of the Board of Directors of The John D. and Catherine T. MacArthur Foundation.

Melissa Moore (Moderna Therapeutics) was appointed to the Scientific Advisory Board of Alltrna.

Penny Pritzker (PSP Partners) was elected Senior Fellow of the Harvard Corporation.

David M. Rubenstein (The Carlyle Group) was elected Chair of the University of Chicago's Board of Trustees.

Pedro A. Sanchez (University of Florida) was appointed a member of the U.S. President's Committee on the National Medal of Science.

Paul Schimmel (Scripps Research Institute) was appointed to the Scientific Advisory Board of Tevard Biosciences. He also joined the company's Board of Directors.

J. Marshall Shepherd (University of Georgia) was appointed to the Advisory Board of the Tomorrow Companies Inc. (Tomorrow.io).

Ruth J. Simmons (Prairie View A&M University) was appointed to the President of the United States' Board of Advisors on Historically Black Colleges and Universities.

Select Publications

POETRY

Mary Jo Salter (Johns Hopkins University). *Zoom Rooms: Poems*. Knopf, March 2022

Colm Tóibín (Columbia University). *Vinegar Hill: Poems*. Beacon Press, April 2022

FICTION

Jonathan Galassi (Farrar, Straus & Giroux). *School Days: A Novel*. Other Press, April 2022

Kevin Young (National Museum of African American History and Culture, Smithsonian Institution); art by Chioma Ebinama (Athens, Greece). *Emile and the Field*. Make Me a World, March 2022

NONFICTION

Elizabeth Alexander (Andrew W. Mellon Foundation). *The Trayvon Generation*. Grand Central Publishing, April 2022

Margaret Atwood (Toronto, Canada). *Burning Questions: Essays and Occasional Pieces, 2004 to 2021*. Doubleday, March 2022

Ben S. Bernanke (Brookings Institution). *21st Century Monetary Policy: The Federal Reserve from the Great Inflation to COVID-19*. W. W. Norton & Company, May 2022

David Clary (University of Oxford). *Schrödinger in Oxford*. World Scientific Publishing, March 2022

Jeremy Denk (New York, NY). *Every Good Boy Does Fine: A Love Story, in Music Lessons*. Random House, March 2022

Frans de Waal (Emory University). *Different: Gender Through the Eyes of a Primatologist*. W. W. Norton, April 2022

Michael Dine (University of California, Santa Cruz). *This Way to the Universe: A Theoretical Physicist's Journey to the Edge of Reality*. Penguin Random House, February 2022

Geoff Dyer (Los Angeles, CA). *The Last Days of Roger Federer: And Other Endings*. Farrar, Straus & Giroux, May 2022

Lindy Elkins-Tanton (Arizona State University). *A Portrait of the Scientist as a Young Woman*. William Morrow, June 2022

Nancy Foner (City University of New York). *One Quarter of the Nation: Immigration and the Transformation of America*. Princeton University Press, February 2022

Bill Gates (Bill & Melinda Gates Foundation). *How to Prevent the Next Pandemic*. Knopf, May 2022

Brian K. Hall (Dalhousie University) and P. Eckhard Witten (Ghent University). *The Notochord: Development, Evolution, and Contributions to the Vertebral Column*. CRC Press, April 2022

Eric Holder (Covington & Burling) with Sam Koppelman (New York, NY). *Our Unfinished March: The Violent Past and Imperiled Future of the Vote – a History, a Crisis, a Plan*. One World, May 2022

Anna Quindlen (New York, NY). *Write for Your Life*. Random House, April 2022

Steve Reich (New York, NY). *Conversations*. Hanover Square Press, March 2022

John Shattuck (Harvard University; Tufts University), Sushma Raman (Harvard University), and Mathias Risse (Harvard University). *Holding Together: The Hijacking of Rights in America and How to Reclaim Them for Everyone*. The New Press, May 2022

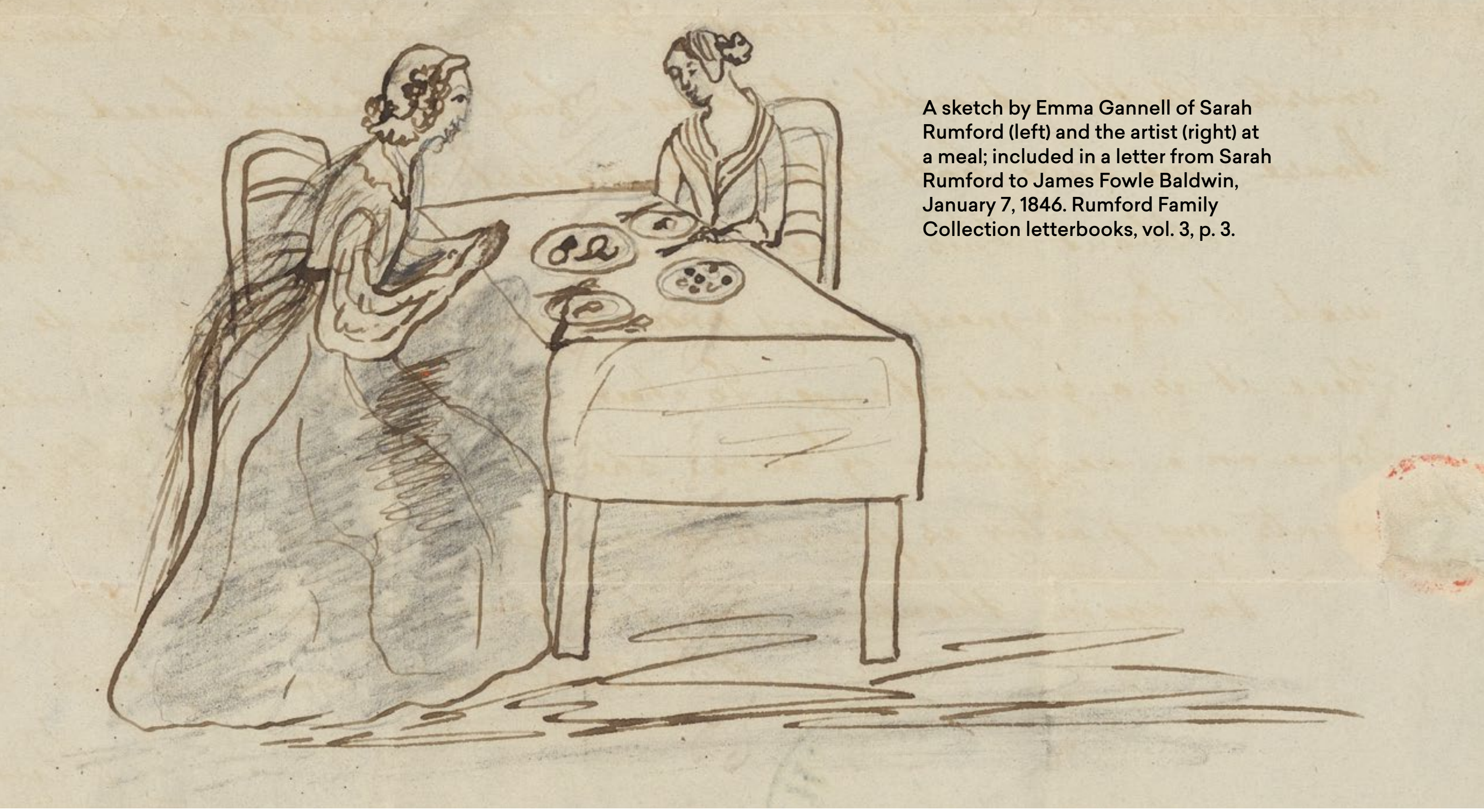
Colm Tóibín (Columbia University), ed. *One Hundred Years of James Joyce's "Ulysses."* Penn State University Press, May 2022

Exhibitions

Kay WalkingStick (Easton, PA). "Mountains/Canyons/Clouds," solo exhibition at Hales Gallery, New York, March 4–April 16, 2022; "Genesis/Violent Garden," 1981, on view at The Metropolitan Museum of Art, New York; "Salt River Canon" and "Wallowa Mountains Winter Memory" on display at the Chicago EXPO Art Fair, Chicago, IL, April 7–10, 2022; "#201 Hidden Acres," "#203," and "#204 Bear Claw" on display at the Dallas Art Fair, Dallas, TX, April 21–24, 2022.

We invite all Fellows and International Honorary Members to send notices about their recent and forthcoming publications, new appointments, exhibitions and performances, films and documentaries, and honors and prizes to bulletin@amacad.org.

FROM THE
ARCHIVES



A sketch by Emma Gannell of Sarah Rumford (left) and the artist (right) at a meal; included in a letter from Sarah Rumford to James Fowle Baldwin, January 7, 1846. Rumford Family Collection letterbooks, vol. 3, p. 3.

Rumford Family Collection Conserved and Digitized

By **Michele Lavoie**, *Director of Archives at the Academy*

Over the past eighteen months, the Academy has partnered with the Northeast Document Conservation Center to repair, clean, and digitize six bound volumes of letters and other documents related to early Academy member and donor Benjamin Thompson (Count Rumford) and his daughter, Sarah.[1]

After the materials were returned to the Academy, the Archives staff reviewed the collection and created an inventory of the documents.[2] That inventory includes links to more than 1,800 digital images of items in the collection.

Most of the letters from Sarah Rumford to James Fowle Baldwin, her friend and estate manager, relate to the management of her financial affairs. However, occasional bits of gossip or political observation appear in the correspondence as well as some of Sarah's amateur poetry. Letters containing the latter often include sketches by her ward, Emma Gannell (later Burgum), that may illustrate an item referenced within the document.

A quaint family dinner, as described to Baldwin in a letter from Sarah dated January 7, 1846, provided the subject for one such sketch. Earlier in the letter, Sarah had complained about not being able to avail herself of cooking services. In an accompanying image, Emma has depicted herself and her aunt at table, enjoying the last of a fresh ham that the young woman purchased and prepared as a surprise. Sarah included a short poem to record her reaction:

T'is very good, I do declare!
Ham delicious, potatoes cooked well
A like dish no mean fare
For you on album a thing to tell.

1. For more on the Rumford Family Collection, see the article in the Winter 2021 issue of the *Bulletin*, www.amacad.org/news/archives-rumford-family-collection.

2. The inventory list is available online at www.amacad.org/archives/sc001-rumford-family-collection.

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ONLINE

As a member of the Academy, you received the official announcement about the 261 individuals elected in 2022. Here are a few reactions on Twitter to the big news:

Cornell Chronicle @CornellNews
President of @Cornell Martha E. Pollack and Dr. Jean William Pape, M.D. '75, professor in clinical medicine at @WeillCornell, have been elected to the American Academy of Arts and Sciences (@americanacad).

Hahrie Han @hahriehan
I am extraordinarily honored--not to mention fell-out-of-my-chair shocked--to be welcomed into the Academy!

Dr. Manuel Pastor @Prof_MPastor
Been crazy-busy this week w travels but some news: I got elected to the American Academy of Arts & Sciences (@americanacad). Working class kid that I am (mom dropped out of hs, dad out of elem) at first, I thought the letter was a phishing scam. It wasn't.

Dorothy Roberts @DorothyERoberts
Thank you! I'm thrilled and honored by this recognition, especially as anti-racist and abolitionist scholarship and activism are under-appreciated and under assault.

Follow the Academy on social media to keep current with news and events.

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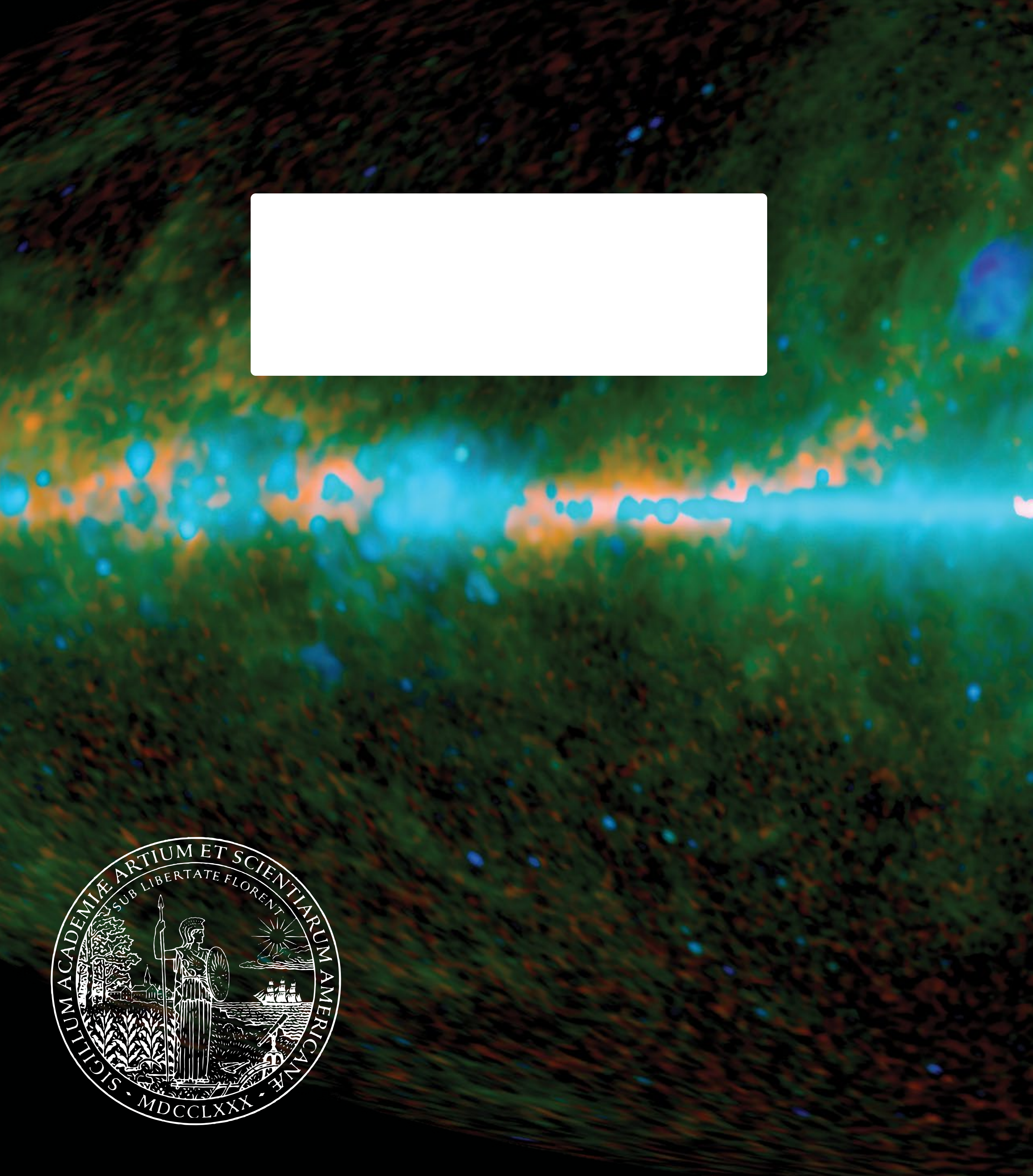

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