

**DIRECTORATE FOR GEOSCIENCES (GEO)**

**\$1,239,050,000**  
**+\$234,790,000 / 23.4%**

**GEO Funding**  
(Dollars in Millions)

	FY 2021		FY 2022 (TBD)	FY 2023 Request	Change over FY 2021 Actual	
	FY 2021 Actual	ARP Actual			Amount	Percent
Atmospheric and Geospace Sciences (AGS)	\$283.35	\$17.29	-	\$301.37	\$18.02	6.4%
Earth Sciences (EAR)	201.65	16.74	-	206.36	4.71	2.3%
Research, Innovation, Synergies, and Education (RISE) <sup>1</sup>	116.27	15.00	-	299.54	183.27	157.6%
Ocean Sciences (OCE)	402.99	22.01	-	431.78	28.79	7.1%
<b>Total</b>	<b>\$1,004.26</b>	<b>\$71.04</b>	<b>-</b>	<b>\$1,239.05</b>	<b>\$234.79</b>	<b>23.4%</b>

<sup>1</sup> The Division of Integrative and Collaborative Education and Research (ICER) has been renamed the Division of Research, Innovation, Synergies, and Education (RISE).

**About GEO**

GEO supports basic research that advances the frontiers of knowledge and drives technological innovation while improving our understanding of the many processes that create and sustain vital natural resources on which society depends. Home to NSF’s atmospheric and geospace, earth, and ocean research activities and providing coordination and administrative oversight to OPP, GEO investigates diverse Earth processes including the planet’s water cycle, interactions across the land-ocean interface, the behavior of ice sheets, and geologic processes responsible for hydrocarbon energy sources and strategic minerals. Lives are saved and property is preserved by better forecasting and understanding of natural phenomena and environmental hazards such as earthquakes, tornadoes, drought, and solar storms. GEO prioritizes support for interdisciplinary studies that contribute directly to national research priorities including climate change, racial equity, and recovery from the COVID pandemic.

Support for climate change research and USGCRP is a particular emphasis. Investments will focus on predictability and resilience of the Earth system, the role of the oceans in climate change, terrestrial-climate interactions, and water sustainability including drought and floods. There is special emphasis on social equity which utilizes the integrating theme of climate change as the foundation for building diverse and inclusive research ecosystems that also focus on institutional transformation towards inclusivity.

As the lead directorate, GEO is the steward of funds designated for the NSF-wide Big Idea: Navigating the New Arctic (NNA). For more information about the Big Ideas, see the narrative in the Cross Theme section of the NSF-Wide Investments chapter.

GEO provides 56 percent of the federal funding for basic research at academic institutions in the atmospheric, earth, and ocean sciences.

## Major Investments

### GEO Major Investments

(Dollars in Millions)

Area of Investment <sup>1,2</sup>	FY 2021	FY 2022	FY 2023	Change over	
	Actual	(TBD)	Request	FY 2021 Actual Amount	Percent
Artificial Intelligence	\$1.00	-	\$5.00	\$4.00	400.0%
Biotechnology	10.00	-	10.00	-	-
Climate: USGCRP <sup>3</sup>	329.00	-	515.37	186.37	56.6%
Coastlines and People <sup>4</sup>	29.59	-	23.00	-6.59	-22.3%
Navigating the New Arctic	32.82	-	30.00	-2.82	-8.6%
Postdoctoral Fellowships	5.34	-	13.34	8.00	149.8%

<sup>1</sup> Major investments may have funding overlap and thus should not be summed.

<sup>2</sup> This table reflects this directorate's support for selected areas of investment. In other directorate narratives, areas of investment displayed in this table may differ and thus should not be summed across narratives.

<sup>3</sup> Funding includes resources for agency-wide initiatives.

<sup>4</sup> FY 2021 Actual investment in the Coastlines and People program includes \$14.57 million previously planned for FY 2020.

- AI: GEO, in partnership with CISE and other NSF directorates and offices, federal agencies, and the private sector, will support AI research and development. A key focal point in GEO is support for a set of National AI Research Institutes. These center-scale projects will advance foundational research; leverage use-inspired research; build the next-generation of talent; mobilize multidisciplinary groups of scientists, engineers, and educators; and serve as a nexus point for multisector collaborative efforts.
- Biotechnology: GEO, together with other NSF directorates and offices, will invest in fundamental research, infrastructure, and education that advances foundational knowledge needed to understand and harness biological processes for societal benefit.
- Climate: USGCRP: GEO leads NSF efforts to support the goals of the USGCRP. Investments will focus on predictability and resilience of the Earth system, the role of the oceans in climate change, terrestrial-climate interactions, and water sustainability including drought and floods.
- Coastlines and People (CoPe): CoPe was established in FY 2019 and received broad community interest. Through this program, GEO supports projects to build capacity and better understand the impacts of coastal environmental variability and natural hazards on populated coastal regions. Improved Earth system prediction is a major CoPe objective.
- NNA: GEO provides stewardship of the NNA Big Idea. NNA fosters innovations in Arctic observational networks and fundamental convergence research across the social, natural, environmental, and computing and information sciences and engineering that address the intersection of natural, social, and built systems. Improved Earth system prediction is a major NNA objective
- Postdoctoral Fellowships: GEO is increasing support for programs that provide fellowships to postdoctoral researchers. These programs support fundamental research in important priority areas such as USGCRP, while also serving broader goals related to inclusivity in the science workforce.

**GEO Funding for Centers Programs and Major Facilities**

**GEO Funding for Centers Programs**

(Dollars in Millions)

	FY 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over	
				FY 2021 Actual	Actual Percent
STC: Cntr for Learning the Earth w/ AI and Physics (AGS)	\$3.50	-	\$5.00	\$1.50	42.9%
STC: Cntr for Chemical Curriencies of a Microbial Planet	-	-	5.00	5.00	N/A
<b>Total</b>	<b>\$3.50</b>	<b>-</b>	<b>\$10.00</b>	<b>\$6.50</b>	<b>185.7%</b>

For detailed information on individual centers programs, please see the Cross Theme Topics section of the NSF-Wide Investments chapter.

**GEO Funding for Major Facilities**

(Dollars in Millions)

	FY 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over	
				FY 2021 Actual	Actual Percent
Academic Research Fleet (ARF)	\$99.54	-	\$119.11	\$19.57	19.7%
Arecibo Observatory (AO)	10.04	-	3.00	-\$7.04	-70.1%
Geodetic Facility for the Advancement of Geoscience (GAGE)	13.13	-	13.25	\$0.12	0.9%
International Ocean Discovery Program (IODP)	48.00	-	50.40	\$2.40	5.0%
National Center for Atmospheric Research (NCAR)	104.10	-	116.20	\$12.10	11.6%
Ocean Observatories Initiative (OOI)	45.30	-	51.00	\$5.70	12.6%
Seismological Facility for the Advancement of Geoscience	21.36	-	22.50	\$1.14	5.3%
<b>Total</b>	<b>\$341.47</b>	<b>-</b>	<b>\$375.46</b>	<b>\$33.99</b>	<b>10.0%</b>

For detailed information on individual facilities, please see the Research Infrastructure section of the NSF-Wide Investments chapter.

## Funding Profile

<b>GEO Funding Profile</b>			
	FY 2021		
	Actual	FY 2022	FY 2023
	Estimate	(TBD)	Estimate
<b>Statistics for Competitive Awards:</b>			
Number of Proposals	3,293	-	4,100
Number of New Awards	1,441	-	1,500
Regular Appropriation	1,229		1,500
ARP	212		
Funding Rate	44%	-	37%
<b>Statistics for Research Grants:</b>			
Number of Research Grant Proposals	2,944	-	3,700
Number of Research Grants	1,216	-	1,300
Regular Appropriation	1,055		1,300
ARP	161		
Funding Rate	41%	-	35%
Median Annualized Award Size	\$166,665	-	\$175,000
Average Annualized Award Size	\$219,659	-	\$240,000
Average Award Duration, in years	3.0	-	3.2

The number of research grant proposals is expected to increase by about 750 compared to the FY 2021 Actual, and GEO expects to award about 100 more research grants as grant competitions related to climate change are anticipated to increase. Average annual award size and duration are expected to increase.

## People Involved in GEO Activities

<b>Number of People Involved in GEO Activities</b>				
	FY 2021	FY 2021		
	Actual	ARP Actual	FY 2022	FY 2023
	Estimate	Estimate	(TBD)	Estimate
Senior Researchers	5,265	818	-	6,500
Other Professionals	3,238	116	-	4,000
Postdoctoral Associates	709	64	-	900
Graduate Students	2,570	315	-	3,200
Undergraduate Students	2,423	349	-	3,000
<b>Total Number of People</b>	<b>14,205</b>	<b>1,662</b>	<b>-</b>	<b>17,600</b>

**DIVISION OF ATMOSPHERIC AND GEOSPACE SCIENCES (AGS)**

**\$301,370,000**  
**+\$18,020,000 / 6.4%**

**AGS Funding**  
(Dollars in Millions)

	FY 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over	
				FY 2021 Actual Amount	Actual Percent
<b>Total</b>	<b>\$283.35</b>	<b>-</b>	<b>\$301.37</b>	<b>\$18.02</b>	<b>6.4%</b>
<b>Research</b>	<b>119.21</b>	<b>-</b>	<b>144.25</b>	<b>25.04</b>	<b>21.0%</b>
CAREER	9.73	-	10.00	0.27	2.8%
Centers Funding (total)	0.50	-	5.00	4.50	900.0%
STC: Cntr for Learning the Earth w/ AI and	0.50	-	5.00	4.50	900.0%
<b>Education</b>	<b>2.43</b>	<b>-</b>	<b>4.68</b>	<b>2.25</b>	<b>92.6%</b>
<b>Infrastructure</b>	<b>161.71</b>	<b>-</b>	<b>152.44</b>	<b>-9.27</b>	<b>-5.7%</b>
Arecibo Observatory (AO)	10.04	-	3.00	-7.04	-70.1%
National Center for Atmospheric Research (NCAR)	104.10	-	116.20	12.10	11.6%
Research Resources	47.57	-	33.24	-14.33	-30.1%

**About AGS**

AGS supports fundamental research that leads to improved understanding of the physics, chemistry, and dynamics of the Earth’s atmosphere, weather, and climate, and how the sun interacts with the Earth's atmosphere and how the atmosphere interacts with other components of the Earth’s integrated systems. Improved understanding drives state-of-the-science model development and predictability of weather, climate, and space weather events. AGS provides support for: (1) basic science projects and (2) the infrastructure, facilities, and services that enable and support modern-day atmospheric and geospace research activities.

Research supported by AGS directly impacts and improves the lives of Americans. Advances in understanding severe weather events leads to the development and enhancement of the sophisticated computer models that simulate and predict high-impact events e.g., tornados, hurricanes, and drought, which helps protect life, property, natural resources, and contributes to the establishment of a weather-ready nation. AGS also funds related education activities, fosters the success of early career scientists, and supports the continuing development of a world-class scientific and technical workforce that contributes significantly to the Nation’s economic vitality.

AGS supports the research of individual scientists at academic institutions, groups of researchers, and research activities at the National Center for Atmospheric Research (NCAR). Often in partnership with complementary activities at other agencies, including the National Oceanic and Atmospheric Administration and the National Aeronautics and Space Administration, research is conducted using world-class facilities provided by NCAR and other groups across the U.S. AGS supports a neutron monitoring network, providing early warning should there be a large Earth-directed solar flare. AGS-supported scientists lead innovations ranging from development of research instruments, the miniaturization of sensors that fly on CubeSats, to the development of models that provide the scientific basis of forecasting a variety of severe weather hazards and understanding of our climate and space environment.

AGS activities directly support the USGCRP. Enhanced process understanding, both through observational and modeling studies, builds our knowledge base related to climate change. This knowledge is translated into predictive models of future climate scenarios to help inform national and international climate policy. This knowledge has direct applications to society in terms of decision-making and forms the underpinnings of a robust development of the national policy for adaptation and mitigation of climate change.

In general, about 39 percent of the AGS portfolio is available for new research grants. The remaining 61 percent supports research grants made in prior years and the research infrastructure that supports the capabilities, creativity, and innovation of the atmospheric and geospace science community.

**DIVISION OF EARTH SCIENCES (EAR)**

**\$206,360,000**  
**+\$4,710,000 / 2.3%**

**EAR Funding**  
(Dollars in Millions)

	FY 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over	
				FY 2021 Actual Amount	Percent
<b>Total</b>	<b>\$201.65</b>	<b>-</b>	<b>\$206.36</b>	<b>\$4.71</b>	<b>2.3%</b>
<b>Research</b>	<b>134.58</b>	<b>-</b>	<b>134.59</b>	<b>0.01</b>	<b>0.0%</b>
CAREER	14.11	-	14.11	-	-
<b>Education</b>	<b>7.92</b>	<b>-</b>	<b>9.20</b>	<b>1.28</b>	<b>16.2%</b>
<b>Infrastructure</b>	<b>59.15</b>	<b>-</b>	<b>62.57</b>	<b>3.42</b>	<b>5.8%</b>
Geodetic Facility for the Advancement of Geoscience (GAGE)	13.13	-	13.25	0.12	0.9%
National Nanoscale Coordinated Infrastructure (NNCI)	0.40	-	0.30	-0.10	-25.0%
Seismic Facility for the Advancement of Geoscience (SAGE)	21.36	-	22.50	1.14	5.3%
Research Resources	24.25	-	26.52	2.27	9.4%

**About EAR**

EAR supports fundamental research into the structure and composition of the Earth and the processes that govern it. Research spans the Earth from its surface to its center, and includes its evolution and history, and the life it has sustained over its four and a half billion years. This research, as articulated by the National Academies of Science, Engineering and Medicine decadal *Earth in Time* report, is critical for understanding Earth's environment and its impact on society, including its climate (past, present, future), the distribution of its natural resources (mineral, water, biota, and energy), and the fundamental drivers of geologic hazards. EAR research provides predictive and quantitative understanding of earthquakes, volcanic eruptions, floods, landslides, changing climate, natural resources, and the overall Earth System. EAR education and human resources engages a wide range of audiences in Earth Science research efforts and fosters a just, equitable, diverse, and inclusive culture across the geosciences.

EAR's research programs support state-of-the-art science using observational, experimental, theoretical, and computational approaches to address topics ranging in scope from the Earth's surface to its deep interior. In addition to these fundamental research programs, EAR supports large-scale community and global efforts, including seismic and geodetic facilities, geohazards centers, and cyberinfrastructure focused on Earth science applications and reducing the risk of geologic hazards. EAR also supports community-based, shared-use facilities, and the acquisition and development of instrumentation by investigators. Integrated research that crosses disciplinary boundaries is supported through division programs as well as partnership with other GEO divisions and directorates. Education and human resource development activities support postdoctoral and other early career scientists, as well as projects and programs to attract students and young investigators to the field of Earth science.

EAR supports research aligned with USCGRP priorities. Programs support multi-disciplinary, fundamental research on the impacts and feedbacks between climate change and the water cycle, the Earth's surface, and biota, as well as the impacts of climate change on geohealth and extreme events, such as droughts, wildfires, and floods. Research on paleobiology and paleoclimate further the

understanding of what the Earth's past reveals about the dynamics of climate change. Research on tectonics, geophysics, and geodesy advance understanding of how solid Earth processes impact soil moisture, landslides, subsidence, ice sheet mass balance, and sea level rise. The division also supports multidisciplinary research on the "critical zone", which extends from the top of the vegetation canopy to the base of the weathered rock zone, including woodland ecosystems. These components of the Earth's life-support system interact through connected processes that influence and are affected by climate, lithology, anthropogenic activity, and water and nutrient cycles. This research is vital to understanding the Earth System and how it has responded, and will respond, to climate change. Contributions to cross-disciplinary Earth observation efforts include continental drilling infrastructure that forms the basis of collection of records of past climate, providing critical data for predicting modern climate change; integration of atmospheric and Earth surface observations with seismic and geodetic capabilities; and cyberinfrastructure to enable analysis and modeling of terrestrial Earth responses to climate change. Through its community facilities, EAR supports collection of data critical for understanding past, present, and future climate; and the development and dissemination of integrated climate models related to Earth surface processes and the hydrologic cycle. These facilities and models serve the research community at large and further the understanding of the interactions between water, Earth, society, and changing climate.

In general, about 46 percent of the EAR portfolio is available for new research grants. The remaining 54 percent supports research grants made in prior years and the research infrastructure needed by this community.

**DIVISION OF RESEARCH, INNOVATION, SYNERGIES, AND EDUCATION (RISE)**

**\$299,540,000**  
**+\$183,270,000 / 157.6%**

**RISE<sup>1</sup> Funding**  
(Dollars in Millions)

	FY 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over	
				FY 2021 Actual Amount	Actual Percent
<b>Total</b>	<b>\$116.27</b>	<b>-</b>	<b>\$299.54</b>	<b>\$183.27</b>	<b>157.6%</b>
<b>Research</b>	<b>109.20</b>	<b>-</b>	<b>294.54</b>	<b>185.34</b>	<b>169.7%</b>
CAREER	0.54	-	-	-0.54	-100.0%
Centers Funding (total)	3.00	-	-	-3.00	-100.0%
STC: Cntr for Learning the Earth w/ AI and Physics	3.00	-	-	-3.00	-100.0%
<b>Education</b>	<b>6.16</b>	<b>-</b>	<b>5.00</b>	<b>-1.16</b>	<b>-18.8%</b>
<b>Infrastructure</b>	<b>0.91</b>	<b>-</b>	<b>-</b>	<b>-0.91</b>	<b>-100.0%</b>
Research Resources	0.91	-	-	-0.91	-100.0%

<sup>1</sup> The Division of Integrative and Collaborative Education and Research (ICER) has been renamed the Division of Research, Innovation, Synergies, and Education (RISE).

**About RISE**

RISE supports novel, complex, or partnership projects in both research and education. These investments cut across traditional boundaries within the geosciences, encouraging interdisciplinary activities and responding directly to critical needs of the entire geoscience community. RISE’s principal goals are to develop innovative means to initiate and support geoscience education, attract underrepresented groups to careers in the geosciences, foster the interchange of scientific information nationally and internationally, and join with other parts of NSF in major integrative research and education efforts. In addition, in partnership with several of the NSF directorates, RISE will advance the NNA Big Idea by investing funds to support convergent activities that transcend the traditional disciplinary boundaries of individual NSF directorates and offices. The division makes strategic investments in multidisciplinary research areas, international activities, education, diversity, and human resource development. The results of RISE investments will assist in ensuring that the United States has a well-educated and diverse workforce in the geosciences and in related technical fields such as resource exploration.

Numerous RISE activities directly support goals of the USGCRP. The NNA Big Idea focuses on the impacts of Arctic change and the NSF-wide CoPe program, which is primarily supported in RISE, examines the impacts of climate on coastal regions to improve human and community resilience to climate change. In addition, RISE supports international collaborative activities which focus on climate change.

New innovative activities are initiated in FY 2023 within RISE that will blur disciplinary boundaries to catalyze critical research efforts of strategic importance, RISE is home to several new crosscutting investments in FY 2023 in addition to increased investments in existing priority areas. Key incremental investments in new activities include:

- \$80.0 million for large-scale interdisciplinary work on climate change. Building on the strong foundation of fundamental research supported across GEO, this investment will transcend

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disciplinary boundaries and focus on topics of direct national importance at resolutions and scales needed by decisionmakers such as forecasting drought and water availability on timescales of months to years at local and regional scales.

- \$33.67 million for agency-wide initiatives in climate, with a focus on multidisciplinary research.
- \$20.0 million for computation and cyberinfrastructure development. Initial investment will focus on revolutionizing data structures and architectures used across the geosciences through an Open Science Initiative. This initiative will develop the data infrastructure necessary to address critical geosciences questions on climate and its impacts, support the AI and machine learning research that would use this open science framework, and support a scientific community and workforce trained to use these resources.
- \$17.50 million for education, equity, and workforce development, emphasizing climate equity and the inclusion of all Americans in the growing green economy and geoscience research enterprise.

In general, about 63 percent of the RISE portfolio is available for new research grants with the remaining 37 percent supporting grants made in prior years.

In FY 2023, the former Division of Integrative and Collaborative Education and Research (ICER) has been renamed the Division of Research, Innovation, Synergies, and Education to better reflect the themes of synergy and entrepreneurial investment fostered by the division. All programs formerly supported in the ICER division including CoPe and NNA continue in the renamed organization.

**DIVISION OF OCEAN SCIENCES (OCE)**

**\$431,780,000**  
**+\$28,790,000 / 7.1%**

**OCE Funding**  
(Dollars in Millions)

	FY 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over	
				FY 2021 Actual Amount	Actual Percent
<b>Total</b>	<b>\$402.99</b>	<b>-</b>	<b>\$431.78</b>	<b>\$28.79</b>	<b>7.1%</b>
<b>Research</b>	<b>188.24</b>	<b>-</b>	<b>190.01</b>	<b>1.77</b>	<b>0.9%</b>
CAREER	6.20	-	6.20	-	-
Centers Funding (total)	-	-	5.00	5.00	N/A
STC: Cntr for Chemical Curriencies of a Microbial	-	-	5.00	5.00	N/A
<b>Education</b>	<b>6.91</b>	<b>-</b>	<b>10.96</b>	<b>4.05</b>	<b>58.6%</b>
<b>Infrastructure</b>	<b>207.84</b>	<b>-</b>	<b>230.81</b>	<b>22.97</b>	<b>11.1%</b>
Academic Research Fleet (ARF)	99.54	-	119.11	19.57	19.7%
International Ocean Discovery Program (IODP)	48.00	-	50.40	2.40	5.0%
Ocean Observatories Initiative (OOI)	45.30	-	51.00	5.70	12.6%
Research Resources	13.23	-	10.30	-2.93	-22.1%

**About OCE**

OCE supports cutting-edge research, education, and infrastructure that advances the Nation’s scientific knowledge of the oceans to support the U.S. economy over the long term, provides vital information regarding national security matters such as sea-level rise, and advances U.S. leadership in ocean science and technological innovation. OCE supports basic research, including interdisciplinary scientific research and technology development to better understand the drivers of ocean circulation and other physical and chemical parameters, biodiversity and the dynamics of marine organisms and ecosystems, harmful algal blooms, and changes in the marine environment as exemplified by ocean acidification. OCE also supports research on the geology and geophysics of the ocean margins and sub-seafloor to investigate natural hazards such as earthquakes and volcanic eruptions, nearshore processes affecting the coasts, the long-term evolution of marine systems, and other fundamental ocean processes. Ocean education emphasizes the interdisciplinary nature of ocean sciences, and commonly leverages research facilities and infrastructure via telepresence to far and distant seas. Since ocean science requires access to the sea, OCE supports research vessels, deep submergence capability including submersibles and autonomous vehicles, and technologically advanced sensors and instrumentation. Examples include the Ocean Observatories Initiative (OOI) network, the Global Ocean Biogeochemistry Array (GO-BGC) Project, and the Academic Research Fleet (ARF), including the Regional Class Research Vessels (RCRV). OCE-funded research, education, and infrastructure addresses the oceans’ central role in a changing Earth and as a national strategic resource, as recognized in reviews by external bodies (e.g., the National Academies Decadal Survey Sea Change<sup>1</sup>). OCE is participating in the United Nations Decade of Ocean Science (2021-2030), through the U.S. National Committee for the Decade, to help ensure sustainable use of ocean resources and long-term ocean health.

<sup>1</sup>[www.nap.edu/catalog/21655/sea-change-2015-2025-decadal-survey-of-ocean-sciences](http://www.nap.edu/catalog/21655/sea-change-2015-2025-decadal-survey-of-ocean-sciences)

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OCE supports USGCRP with investments in science and infrastructure programs that focus on observing today's changing ocean and facilitating discoveries of past climate changes to inform future climate change. In addition to OOI, examples include the International Ocean Discovery Program (IODP), Long-Term Ecological Research (LTER), Hawaii Ocean Time-series (HOT), Bermuda Atlantic Time-series Study (BATS), Overturning in the Subpolar North Atlantic Program (O-SNAP), and the Paleo Perspectives on Climate Change (P2C2) Program. OCE has strong representation on the USGCRP Observations Interagency Working Group and the reinvigorated Coasts Focus Area.

In general, about 33 percent of the OCE portfolio is available for new research grants, with the remaining 67 percent supporting grants made in prior years and the research infrastructure needed by this community.