



U.S. Presidents and Astronomical Discovery

**by Robert A. Brown
and Jeanette C. Ishee**

**“Towering genius disdains a beaten path.
It seeks regions hitherto unexplored.”**

Abraham Lincoln (1838)

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This essay examines the intersection of three spheres of American thought: scientific exploration, "frontier" concepts, and public policy. It is a story of ideas, not a history of science. Here, presidents voice policy and speak for America. Astronomy is the focus because it is today both the least applied and most exploratory science. Also, astronomy is ancient, and both the nature of astronomical inquiry and the public policy challenge it poses have remained remarkably unchanged from the founding of the Republic to the present day. Finally, the object of this study is insight—in the same realm of ideas—that may be useful in conducting the federal science program, astronomy in particular.

From its earliest history, America has placed supreme value on exploration and discovery as the embodiment, the purest expression, and the due consequence of freedom. This concept has been fundamental in defining the individual and collective personalities of Americans. The U.S. presidents, in turn, have been the important national caretakers of the idea. From George Washington to George Bush, the presidents have sought federal support to open various wildernesses for American pioneers in pursuit of expanding geographical, technological, and intellectual frontiers. By variously asserting and promoting the diverse benefits of freedom manifested in exploration, they have inspired and supported voyages into the unknown, beginning with the American exploration of the West. Today, space and the realm of science are the most prominent objects of exploration being pursued with public funds.

Each frontier has distinctive challenges and rewards, and every president has interpreted the exploratory needs of America in terms of his perception of those opportunities. The frontier of astronomy in particular has held the imagination of presidents from the youngest days of the Republic. Early presidents connected the importance of astronomical exploration and discovery variously with teleological speculation, national prestige, and the centrality of learning to a successful democracy. (And, of course, astronomy has had practical applications for geography and determining civil time, which we will not consider here.) In the most recent four decades, the presidents have viewed astronomy as a distinctive discipline entwined with federal science as a whole.

Government sponsorship of astronomy as an open research discipline is a recent experiment in public policy, covering a period somewhat less than one-fifth of our Republic's age. As a policy experiment, it bears evaluation. This essay tracks the course of presidential ideas about astronomical exploration and federal support for it from the American Revolution to the present day. It shows how presidential support has helped to frame today's billion dollar per year national astronomy program through an oft-asserted historical analogy between our current conduct of science research and America's 19th century expansion west—an analogy based primarily on the idea of exploration. We will argue that, to ensure American society's return from the metaphorical frontier of astronomy, and to re-validate the analogy that sustains its special place in the American experience, new programs for education are needed within the existing federal astronomy program.

Early Presidential Interest in Astronomy

The American fascination with astronomical exploration and the U.S. presidents' role in promoting it can be traced to the origins of the American attitude toward government itself. This attitude originated in the ideas of the Enlightenment, which themselves had been greatly influenced by earlier developments in astronomy. The Copernican Revolution, Kepler's laws, and Newton's law of gravity had resolved an ancient debate on planetary motion and replaced the view of a hierarchical universe with one explained by free particles equal under the laws of nature moving according to a balance of forces. In the 18th century, this scientific triumph resonated with an analogous view of human nature and the role of government and civil law. The Founding Fathers saw a link between an understanding of the natural world and the moral improvement of mankind through new and more rational forms of government.

The Founding Fathers were knowledgeable of, took a personal interest in, and, in some cases, practiced astronomy. As a surveyor, George Washington was competent in making accurate astronomical readings and understood the practical benefits of the science both personally and for the fledgling democracy. While in England, John Adams visited Herschel at the Royal Observatory at Windsor Castle. His journals reveal intense curiosity about the possibility of life on other planets and wonder at the harmony of the solar system and what he termed its "stupendous plan of operation."¹ Thomas Jefferson once confessed in a personal letter that he felt Nature had intended him "for the tranquil pursuits of science, by rendering them my supreme delight. [It is] the enormities of the times in which I have lived," he wrote, that "have forced me to take a part in resisting them, and to commit myself on the boisterous ocean of political passions."² Nonetheless, he still managed to make frequent astronomical observations, and insisted that Lewis and Clark do so as well on their expedition to the Pacific. Later in his life, Jefferson planned an observatory for his beloved Central College (soon the University of Virginia), and designed the dome room of the Rotunda there as a teaching planetarium, complete with movable stars and a carefully-engineered elevated chair from which an astronomy professor could lecture while manipulating the planets. Presidents James Monroe, James Madison, and John Quincy Adams all argued forcefully in Congress and elsewhere for the establishment of a national observatory.

Indeed, no one has allied astronomy with American ideas more than John Quincy Adams. "The express purpose of an observatory," he wrote, "is the increase of knowledge by new discovery."³ Such new knowledge, he felt, spurred "progress in the march of the human mind."⁴ His first annual address to the nation as president was a manifesto for federal investment to improve and stimulate America. The concept of a national observatory—a "lighthouse of the skies"—was prominent among his proposals:

It is with no feeling of pride, as an American, that the remark may be made that, on the comparatively small territorial surface of Europe, there are existing upward of one hundred and thirty of these light-houses of the skies; while throughout the whole American hemisphere there is not one. If we reflect a moment upon the discoveries which, in the last four centuries, have been made in the physical constitution of the universe by the means of these buildings, and of observers stationed in them, shall we doubt of their usefulness to every nation? And while scarcely a year passes over our heads without bringing some new astronomical discovery to light, which we must fain receive at second-hand from Europe, are we not cutting ourselves off from the means of returning light for light, while we have neither observatory nor observer upon our half of the globe, and the earth revolves in perpetual darkness to our unsearching eyes?⁵

As U.S. president, as overseer and benefactor of Harvard University, as "The Old Man Eloquent" in the Congress, and as a tireless public speaker, John Quincy Adams sought to turn "the science of astronomy...into a permanent and persevering national pursuit, which may extend the bounds of human knowledge and make my country instrumental in elevating the character and improving the conditions of man on earth."⁶

Early Presidential Valuation of New Knowledge

The interest in astronomy evinced by early American leaders indicates their appreciation for the vast importance of learning to the welfare and dynamism of the nation. This belief in the value of learning, exemplified by the acquisition and diffusion of new astronomical knowledge, was reflected in the efforts of each of the first six presidents to promote knowledge and understanding as the very basis of democratic decisionmaking. "Knowledge," said Washington, "is in every country the surest basis of public happiness. In one in which the measures of Government receive their impression so immediately from the sense of the Community as in ours it is proportionably essential."⁷ John Adams claimed it was "the duty of legislators and magistrates, in all future periods of this Commonwealth, to cherish the interests of literature and the sciences, and all seminaries of them."⁸ Jefferson declared that "knowledge is power...knowledge is safety, and...knowledge is happiness,"⁹ and Madison believed that "a diffusion of knowledge is the only guardian of true liberty."¹⁰ Monroe was a proponent of formal education and, while Governor of Virginia, argued that "in a government founded on the sovereignty of the people...knowledge should be diffused throughout the whole society, and for that purpose the means of acquiring it made not only practicable, but easy to every citizen."¹¹ Later, he joined Jefferson and Madison in planning the University of Virginia, and served as a member of its first Board of Visitors. In a report to Congress in which he lobbied for Congressional acceptance of the Smithson bequest, John Quincy Adams wrote:

The attainment of knowledge...is the high and exclusive attribute of man, among the numberless myriads of animated beings, inhabitants of the terrestrial globe...It is by this attribute that man discovers his own nature as the link between earth and heaven; as the partaker of an immortal spirit; as created for a higher and more durable end...To furnish the means of acquiring knowledge is therefore the greatest benefit that can be conferred upon mankind.¹²

Clearly, the early presidents saw learning and new knowledge as keys to the future.

Early Public Policy Context of Astronomical Exploration

The first presidents' unanimity of outlook on learning was countered, though, by their differing philosophies on the federal government's role in supporting it. Early efforts to promote "internal improvements," *i.e.*, the establishment of a national university, a national observatory, and a national transportation infrastructure, proceeded only fitfully in early administrations, and were finally extinguished in the administration of the seventh president, Andrew Jackson. Resentment of the growing political and economic disparity between the diverse regions of the young nation surfaced repeatedly in the debate over the issue of internal improvements. The disagreement centered on the correctness of the federal government's use of public funds to finance improvements that might result in economic benefit to one state over another or increase the authority of the national government over the states.

Since the earliest days of the nation, the Federalists, led by Alexander Hamilton, had argued for a strong central government, and sought broad authority to finance large federal programs of inter-

nal improvement. Such improvements, they believed, would play an important role in preserving the union of the states and in promoting commerce and trade. For example, they proposed, but failed to enact, a broad federal system of roads and canals.

The Republicans, led by Thomas Jefferson, supported many of the philosophical goals of those who sought funding for internal improvements, but staunchly rejected the additional implied authority of the federal government over the states. They therefore insisted that internal improvements by the federal government first be mandated by a Constitutional amendment—despite the general agreement that such an amendment was not likely to garner the necessary approval of the states.

Andrew Jackson's campaign against federal involvement in internal improvements included denying funding for a national road and dissolving the Second National Bank of the United States. His opposition to such involvements was firm. In his first year in office he told Congress: "This was intended to be a government of limited and specific, and not general, powers...and it is our duty to preserve for it the character intended by its framers."¹³ The next year, he reminded them "the successful operation of the federal system can only be preserved by confining it to the few and simple, but yet important, objects for which it was designed."¹⁴ By the end of his second term in office, the issue of internal improvements was settled in favor of the so-called states' rights viewpoint, largely through the diligence and aggressive political maneuverings of Jackson. Although specific conflicts and pressures still arose, the broad issue itself ceased to dominate ensuing Congressional debates.¹⁵

After Jackson, federal funding of scientific research as pure exploration was in eclipse for more than a century. Although various succeeding presidents showed interest in astronomy—including Lincoln, Garfield, and Taft—none sought to promote pure astronomical research with federal funds with anything matching the verve of the pre-Jackson presidents. This is not to say that appropriated funds were not used to support astronomical observations directed at practical purposes. The U.S. Naval Observatory, for example, was built in 1844 to aid the coastal survey and improve the distribution of civil time. An observatory was built at West Point, which trained officers of the Corps of Topographical Engineers for land surveys of the West. But, until the 1950s, only private, state, or local funds were used to build astronomical observatories for pure scientific research and exploration akin to the vision of John Quincy Adams.

The President as "Voice of the People"

A second direct effect of the power struggle that took place during the Jackson administration was the transformation that occurred in the public view of the presidency. During the administrations of the first six presidents, the Executive Branch had been viewed primarily as the agent of Congress: it was to execute the laws that the Congress enacted. Jackson sought a stronger and more proactive role for the presidency and found the means in the issue of internal improvements. Jackson appealed to a sense of fairness among the masses when he vowed to represent the rights of all states in contrast to partisan political efforts in Congress seeking favor for certain individual states or regions. He came to be viewed as spokesman for all citizens and thus to be, in effect, the "voice of the people." He inspired a popular emotional reaction, which historian Leonard White describes as follows:

Masses of people believed he was their friend—the "monstrous crowd of people" that Webster observed at the inauguration ceremonies on March 4, 1829, seemed really to think that the country had been rescued from dreadful danger. When, eight years later, Jackson stood on the rear platform of the railroad car on his way again to the Hermitage, no sound came from the multitude that bade him farewell. Emotions were too deep for expression.¹⁸

The Jacksonian mystique deeply affected American attitudes towards the U.S. presidency. The American public came to expect the president to be the representative of *all* the people and not merely of a region or party. Abraham Lincoln thus remarked that “as the President in the administration of the government, I hope to be man enough not to know one citizen of the United States from another, nor one section from another.”¹⁷ Theodore Roosevelt declared that “no man is fit to hold the position of President of the United States at all unless as President he feels that he represents no party but the people as a whole.”¹⁸ And, as Harry Truman explained, “it is only the President who is responsible to all the people. He alone has no sectional, no occupational, no economic ties. If anyone is to speak for the people, it has to be the President.”¹⁹ The newly strengthened ties of the president to the people aided Jackson and later presidents in their ability to influence and often to command federal policy by voicing American ideas.

Science as an American Frontier

In the 1920s, Herbert Hoover reconnected the American ideas of exploration and discovery with pure scientific research. In an essay on American individualism, he named science an eternal frontier for American pioneers. “Our American individualism,” he wrote,

has received much of its character from our contacts with the forces of nature on a new continent...[but] the days of the pioneer are not over. The great continent of science is as yet explored only on its borders, and it is only the pioneer who will penetrate the frontier in the quest for new worlds to conquer. The very genius of our institutions has been given to them by the pioneer spirit.²⁰

Hoover thus affirmed a revolution in American historical research precipitated in 1893 by Frederick Jackson Turner, who postulated a central role for the American frontier in the development of the American character. “To the frontier the American intellect owes its striking characteristics,” Turner wrote, arguing that the American character is largely made up of “traits of the frontier, *or traits called out elsewhere because of the existence of the frontier*.”²¹ According to Turner, the will to venture forth lies at the very heart of what it is to be American. “He would be a rash prophet,” Turner maintained, “who should assert that the expansive character of American life has now entirely ceased. Movement has been its dominant fact, and, unless this training has no effect upon a people, the American energy will continually demand a wider field for its exercise.”²² Turner concluded that Americanism had long flourished on the frontier and would continue to thrive best there—if and where a new frontier might be found after the West was won. Hoover’s assertion was that science is just such a frontier. He did not suggest, however, that the frontier of science be explored with public funds.

Franklin Roosevelt, on the other hand, supported federal financing of pure science research, and forged a transition in public policy using Hoover’s theme of science as a frontier in combination with a revised “frontier policy.” Wishing to know the “lessons learned” from science’s role in winning World War II, he established a panel toward the end of the war to study and recommend a possible role for the federal government in the support of basic scientific research in peacetime. In his letter charging the panel’s chairman, Dr. Vannevar Bush (who had headed the wartime science effort), Roosevelt made reference to “new frontiers of the mind” and wondered how they might be “pioneered with the same vision, boldness, and drive with which we [had] waged [the] war.”²³ Vannevar Bush’s response was a report entitled *Science, The Endless Frontier*. The report

cited prior policy with respect to geographical frontiers as precedent for an expanded role of the federal government as patron of the sciences:

It has been basic United States policy that Government should foster the opening of new frontiers. It opened the seas to clipper ships and furnished land for pioneers. Although these frontiers have more or less disappeared, the frontier of science remains. It is in keeping with the American tradition—one which has made the United States great—that new frontiers shall be made accessible for development by all American citizens.²⁴

The report promoted the idea that science is a frontier that, if energetically explored with federal funds, will produce social benefits.

The linkage of these ideas—science with frontiers, exploration, and discovery—has been invoked by all succeeding presidents. Eisenhower, for instance, declared in 1954 that the United States had become “strong through its diligence in expanding the frontiers of scientific knowledge.”²⁵ Gerald Ford, in an inspirational speech during the U.S. Bicentennial, claimed that

The hallmark of the American adventure has been a willingness—even an eagerness—to reach for the unknown. For three and a half centuries, Americans and their ancestors have been explorers and inventors, pilgrims and pioneers, always searching for something new—across the oceans, across the continent, across the solar system, across the frontiers of science, beyond the boundaries of the human mind... Our country must never cease to be a place where men and women try the untried, test the impossible, and take uncertain paths into the unknown.²⁶

In more recent years, Ronald Reagan asserted that: “The conquest of new frontiers for the betterment of our homes and families is a crucial part of our national character... The pioneer spirit still flourishes in America. In the future, as in the past, our freedom, independence, and national well-being will be tied to new achievements, new discoveries, and pushing back new frontiers...”²⁷ Calling the Hubble Space Telescope a “metaphor for a renewed spirit of basic exploration,”²⁸ the current administration has linked pure astronomical research with the American exploration idea.

The American people have thus far been willing to support this approach with tax dollars, believing in the implied promise that basic scientific exploration will bring about social benefits. They have supported the formation of such governmental “exploration” agencies as the National Aeronautics and Space Administration and the National Science Foundation. Federal funding for pure science research has grown to more than \$12 billion per year.²⁹ Federal support for astronomy research has increased to about \$1 billion per year, including all costs. In consequence, the federal government is now the principal patron of basic scientific research, including astronomical research, in the United States.

The Issue for Astronomical Exploration Today

The value of exploration for its own sake, then, has been a prominent theme in the rhetoric of U.S. presidents from the earliest days of the Republic, and since World War II, it has been used to rationalize—in part—increased funding of basic scientific research. This motive has been particularly significant for astronomical research, the least applied of all scientific endeavors. However, while the exploration metaphor still strikes a vibrant chord in the American imagination, its effectiveness in the current implementation of federal science programs is questionable. This is because those programs have not obviously led to the social and economic results expected of a “frontier,” as is indicated by America’s crisis in education, the declining technical skills of her workforce, and the dearth of new products and processes she brings to the international marketplace.

The authors believe the social benefits of exploration have so far failed to materialize because of two related factors. First, scientists and program administrators do not appreciate the latent power of federally-funded science exploration *as exploration*. A specific example is the potential of research astronomy to respond to the national education problem. Second, there exists little programmatic coupling between federally-funded science exploration and the public interest it is meant to serve. Consequently, the social benefits of astronomical exploration, for example, are largely serendipitous.

We assert that astronomical research can provide qualitatively increased social benefits if these factors are addressed analytically and the consequences pursued. We see astronomy's untapped "frontier" potential in its dynamic ideas, not in its established facts. If it were not so, then the value of old knowledge would dwarf that of new knowledge, and the teaching of astronomy—rather than astronomy research—would have paramount importance. Relatively few Americans know what Copernicus, Kepler, and Newton knew about the cosmos, which is elementary knowledge, and far fewer know enough to understand the astronomical questions the Hubble Space Telescope was launched to answer. Yet, the Hubble mission has captured the public imagination. Find the American who does not want to know if there are planets like Earth around other stars, or that a brown dwarf or black hole exists! And find one who does not wish to make it an American discovery rather than "fain receive at second hand."

This distinction between facts and ideas is critical to exploration's contribution to "the American energy." A fact is merely data; an idea is a mental process that, once planted in the mind, creates new opportunity. Withal, it can spark a sense of progress and optimism far beyond its immediate reference. Turner's great insight was that America's frontier experience could be generalized *on the basis of ideas* from the literal to a metaphorical plane after the geographical frontiers were gone. It is at this point that America's western horizon and science "horizons of the mind" coincide.

We see that the historical analogy and thematic resonances between science and the West break down precisely when the role of the federal government is examined. In opening the West, the government's role was to create opportunity for private activity that would benefit all the citizens. It acquired the land, surveyed it, built roads through it, and assured civil order. By contrast, federally-funded science exploration now affects the intellectual experience of an elite few. The fact that there is little programmatic effort to bring the stimulus of scientific exploration and discovery to bear beneficially on the spirit of America is a failure to follow through with a great idea. What effort there is lacks focus, coherence, and coordination, and is trivial compared with expenditure on the activity itself. Without extending and enhancing the ramifications of scientific exploration, it will be as if the government commissioned Lewis and Clark to explore new territories, but then never surveyed the land for settlement, never built roads, and never allowed the pioneering families to move in.

Fulfilling the Social Promise of Astronomical Exploration

The bounty waiting on "the endless frontier" is the magic of ideas. The federal astronomy program must open opportunities for citizens to extract, utilize, and profit from that magic on much wider and deeper levels than is currently attempted. This is a revolutionary suggestion—indeed shocking to astronomers inured to a sense of academic isolation and entitlement—yet it could be accomplished at little or no risk to the research itself. It is a matter of cleverly assuring everyone access to the magic of ideas and the excitement of exploration and discovery.

The best way for this to happen is for the federal astronomy program to address the nation's most significant need today: education. (Perhaps "learning" is a better word because it extends, as does the problem, far beyond the classroom.) Recognizing this opportunity, a group of educators and astronomers have recently proposed "an education initiative in astronomy".³⁰ This new program would exploit the glory of astronomical exploration to inspire learning widely in America. Today, no program with that purpose exists.

The primary objective of the proposed education initiative is to utilize astronomy—its lore, methods, history, and discoveries—to acquaint elementary and high school students with the basic concepts of science. Attitudes toward science are formed in the early school years, and astronomy's accessibility and attractiveness can enhance a child's first impressions. Other objectives of the initiative include increasing the science literacy of the public and the involvement in science of minorities and women. Astronomy has a proven potential to achieve all these objectives.

The broad resources of a federal research program can be engaged only through the program structure itself. Thus, the existing astronomy research offices would be responsible for the proposed education initiative, but would coordinate closely with outside educational, commercial, government, and private interests. Because of the vast scale of educational activity, and because education is not primarily a responsibility of the federal government, the initiative would seek to engage the spirit of free enterprise by encouraging entrepreneurship. Also, national astronomical facilities, the storefronts of federally-funded astronomy research, would be adapted to provide high-impact learning contacts, especially for science teachers, museum and planetarium professionals, and the media.

The towering genius of America, as Abraham Lincoln maintained, is that it has ever disdained the beaten path and sought regions hitherto unexplored. Our task today is to create, through federal support, opportunities for all Americans to share in these new horizons of the mind. The proposed education initiative in astronomy exemplifies how the federal government can open a frontier of science in the way it opened the West to the American people over a century ago.

Notes

- 1 Page Smith, *John Adams*, Vol. 1, 1735-1784 (New York: Doubleday & Company, Inc., 1962) 30.
- 2 Dumas Malone, *Jefferson and His Time*, Vol. 5 (Boston: Little, Brown & Co., 1974) 668.
- 3 *Report of the Select Committee on the Smithsonian Request*, John Quincy Adams Chairman, House of Representatives, March 5, 1840, in *The Smithsonian Institution: Documents Relative to Its Origin and History*, William J. Rhees, ed. (Washington, D.C.: The Smithsonian Institution, 1879) 202-36.
- 4 Ibid.
- 5 Fred L. Israel, ed., *The State of the Union Messages of the Presidents of the United States*, Vol. 1 (New York: Chelsea House, 1966) 246.
- 6 Charles Francis Adams, *Memoirs of John Quincy Adams, Comprising Portions of His Diary from 1795-1848*, Vol. XI (Philadelphia: J.P. Lippincott and Co., 1874-7), 409.
- 7 Israel, 3.
- 8 Smith, 443.
- 9 Caroline T. Harnsberger, ed., *Treasury of Presidential Quotations* (Chicago: Follett Publishing Company, 1964) 150.
- 10 Saul K. Padover, ed., *The Complete Madison—His Basic Writings* (New York: Harper & Bros, 1953) 337.
- 11 Harry Ammon, *James Monroe: The Quest for National Identity* (New York: McGraw Hill, 1971) 177.
- 12 Samuel Flagg Bemis, *John Quincy Adams and the Union* (New York: Alfred A. Knopf, 1956) 505.
- 13 Israel, 303.
- 14 Israel, 323-4.
- 15 An ironic inverse consequence was the Philadelphia High School Observatory—one of the first few observatories in the country—started in 1836 with funds that devolved to the municipality after the Second National Bank of the United States was dissolved.
- 16 Leonard D. White, *The Jacksonians* (New York: The MacMillan Co., 1963) 5.
- 17 Arthur Bemon Tourtellot, *The Presidents on the Presidency* (New York: Doubleday & Company, Inc., 1964) 42.
- 18 Tourtellot, 54.
- 19 Tourtellot, 67.
- 20 Herbert Hoover, "American Individualism" in *Essays on Current Themes*, C. Alphonso Smith, ed. (Boston: Ginn & Company, 1923) 393.
- 21 Emphasis added. See Frederick Jackson Turner, "The Significance of the Frontier in American History" in *The Frontier in American History* (New York: Holt, Rinehart and Winston, New York, 1962) 37-38.
- 22 Ibid.
- 23 Letter from Franklin D. Roosevelt to Vannevar Bush, in Vannevar Bush, *Science, The Endless Frontier: Report to the President on a Program for Postwar Scientific Research* (Washington, D.C.: U.S. Government Printing Office, 1945) viii.
- 24 Bush, 6.
- 25 *Department of State Bulletin*, Vol. 31, July 5, 1954 (Washington, D.C.: U.S. Government Printing Office, 1954) 20.
- 26 *Weekly Compilation of Presidential Documents: Gerald Ford, 1976*, Vol. 12, No. 27 (Washington, D.C.: U.S. Government Printing Office, 1977) 1105-06.
- 27 *Public Papers of the Presidents of the United States: Ronald Reagan, 1982*, Bk II (Washington, D.C.: U.S. Government Printing Office, 1983) 892.
- 28 Richard Darman, "Keeping America First: American Romanticism and the Global Economy." Text of remarks delivered at Harvard University on May 1, 1990, Cambridge, MA.
- 29 Intersociety Working Group, *AAS Report XV: Research and Development FY 1991* (Washington, D.C.: American Association for the Advancement of Science, 1990) 55.
- 30 Robert A. Brown, ed., *An Education Initiative in Astronomy* (Baltimore: Space Telescope Science Institute, 1990).

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