50 YEARS OF A PLANETARY SCIENCE WORKFORCE: HIDDEN FIGURES AND THE LEGACY OF APOLLO K. L. Lynch[1], S. Diniega[2], L. C. Quick[3], S. M. Hörst[4], E. G. Rivera-Valentin[5], J. A. Rathbun[6], [1]Georgia Institute of Technology (klynch31@gatech.edu),[2]Jet Propulsion Laboratory, California Institute of Technology, [3]Center for Earth and Planetary Studies, Smithsonian Institution, [4]Johns Hopkins University, [5]Lunar and Planetary Institute, [6]Planetary Science Institute (rathbun@psi.edu),.

Introduction: The dawn of the human spaceflight era and the Apollo program came during a pivotal transition time for America. In addition to the successful flights of both Yuri Gagarin and John Glenn, 1961 was a year of significant social change in America with the Freedom Rides occurring within weeks of these transformative spaceflight accomplishments [1]. As a result, President Kennedy's administration found itself on a dual battlefront between the race to the moon with Russia, and the fight for civil rights for all Americans. The US Space program become a pivotal agent of change for both battles. Prior to 1964, Kennedy and Johnson choose to use the federal jobs system to force workplace integration across the country and NASA became a key agency of focus due to the increased job opportunities that grew out of the the Apollo program and associated agency centers located in the southern US (Marshall, Kennedy, Johnson, Stennis, etc.) [1].

This focused effort by NASA facilitated historically significant events such as Rice University amending its charter to admit Black students so that it could donate the land for Johnson Space Center [2], the recruitment of the first Black astronaut candidate, Edward Dwight [3], and the creation of NASA's Cooperative Education (Co-Op) program that recruited and hired the first black NASA engineers in the south [1]. Although all of the Apollo astronauts were white males, these additional efforts on the part of NASA and the Kennedy administration created opportunities for racial and ethnic minorities to make key contributions to the Apollo program specifically, and to space science in general. Consequently, the percentage of non-white NASA engineers increased from 3% pre-1960 to 5% after 1965 [4]. These unintentional pioneers of equality also included the co-op students at NASA's Marshall Space Flight Center, and the "Hidden Figures", Black women "computers" who calculated flight trajectories for the space program [5]., and innovative Black scientists such as Dr. George R. Carruthers, who invented the first observatory placed on the Moon during Apollo 16 [2].

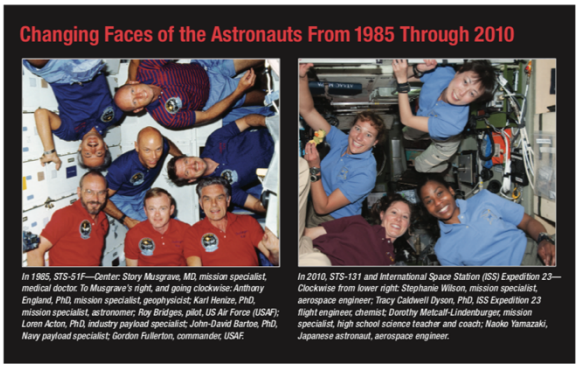
Influence of Apollo: The number of physical science and engineering PhDs rose dramatically during the Apollo program [6]. However, this did not result in a fully equitable space industry workforce. Despite successful efforts by Harriet Jenkins and Nichelle Nichols, NASA's workforce diversity in the 70s and 80s [7], and although the first Black astronauts were selected in 1978-79 [8], racial and ethnic diversity within the planetary sciences has remained relatively flat over the past 50 years since Apollo.

21st Century Space Workforce Diversity: Currently, the American planetary science workforce is not as diverse as the population from which its membership is drawn and from which the majority of our funding comes. The most recent survey of the planetary science workforce, conducted in 2011 [9], showed that only 25% of responding planetary scientists were women and, by ethnicity, 87% white, 7% Asian, and 1% each Black and Hispanic. (Compare to 64, 5, 13, and 16% in the US population in 2010 [10].) The percentage of women in planetary science has increased from ~15% in the late-1990s to >25% by the early 2010s [11]. While there have been no studies of the participation of members of racial and ethnic minority groups in planetary science over time, a study of earned geoscience doctorates in the US found no improvement in racial and ethnic diversity over the past 40 years [12]. Furthermore, the number of PhDs awarded to African-American students in physics has remained flat for the past 20 years [13]. This is despite the fact that more Black women than white women initially intended to major in a STEM field [14].

Even once they are in the field, women are still lagging behind in some measures of success, such as involvement in spacecraft mission science teams, which has been stagnant at 15% for the past 15 years [11, 15-16]. In sum, these and other recent studies have shown that women, particularly women of color [14, 17-18], frequently face systemic challenges that prevent them from entering and/or succeeding in planetary science.

If we assume that the population of planetary scientists is pulled from the US population, then given equal opportunity for all, the demographics of both groups should match. By comparing the demographics of planetary scientists [9] to the US population [10], and assuming that 100% of white men that want to be and have the ability to become planetary scientists, do so, [19] found that only 32% of white women do, while only approximately 3% of scientists from racial minority groups (excluding Asians) be-

come planetary scientists. This calculation illustrates that racial and ethnic minority groups are the most



Increase in astronaut diversity [21].

underrepresented group in planetary science, being more underrepresented than white women by a factor of 10.

Support for Space: Previous studies have suggested that members of racial and ethnic minority groups have lower support for space exploration than white Americans [20], and antipathy felt by some members of racial and ethnic minority groups to the Apollo program has been documented [7]. This antipathy may be a testament to a lack of access to space, as evidenced by the low numbers of non-white astronauts and other visible minorities in space exploration. NASA realized that this was a problem and encouraged prominent members of underrepresented groups to space shuttle launches in the early 1980s. "Hundreds of officials from the National Association for the Advancement of Colored People and the Urban League attended the launch of STS-8," the first mission with a black astronaut, Guion Bluford [7].

Suggestions for recruitment of planetary scientists of color: The data suggest that there are individual- and system-level barriers in place prior to and within planetary science which prevent equal participation from certain groups [19]. Thus, more recruitment and retention efforts are needed to focus on the groups that are the most underrepresented in planetary science: African American, Indigenous and Lantinx scientists.

We suggest: 1. More engagement with and recruitment of undergraduate students from underrepresented minority groups, including students that attend major planetary and space science institutions, and those that do not. 2. More focused recruitment of underrepresented students from minority serving institutions, such as Historically Black Colleges and Universities (HBCUs), Hispanic Serving Institutions (HSIs), and tribal colleges. 3. Developing, implementing, and maintaining mentoring programs and networks for members of racial and ethnic minority groups in planetary science. Strong mentoring relationships are proven critical components to success in STEM. 4. Deploying targeted internships, scholarships, graduate and postgraduate fellowships for members of racial and ethnic minority groups will enable these students to apply their strong knowledge from areas such as physics, math, and engineering, to planetary science.

To check for progress, the planetary science community would be well served by gathering data about our community's racial demographics and evaluating race-focused programs for their effectiveness in bringing and welcoming more diverse voices into the field.

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