APPLYING THE BRAIDED RIVER STEM WORKFORCE DEVELOPMENT MODEL TO PLANETARY SCIENCE AND ASTROBIOLOGY. K. G. Gardner-Vandy[1], R. L. Batchelor[2], and D. M. Scalice[3]. [1]Aviation and Space, Oklahoma State University (kat.gardner-vandy@okstate.edu), [2]Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder, [3]NASA Ames Research Center.

Introduction: The traditional workforce model of the 20th century is becoming increasingly obsolete, as the professional environment of the 21st century grows more and more flexible. This is especially true in planetary science and astrobiology. Students enter graduate programs from a variety of STEM fields, industry professionals become integral parts of mission teams, and community members assist with data analysis via Citizen Science programs. Likewise, it is common for students to enter graduate programs after working in an unrelated field, or take time off to care for children or family members. The varied paths that individuals travel in their scientific career cultivate a diversity of experiences that benefit our field. **This framework should be celebrated, represented in our verbiage, and incorporated into the planetary science and astrobiology workforce development.**

The path many students and professionals in planetary science and astrobiology travel is not linear. Yet many continue to view the workforce in STEM, and thus planetary science and astrobiology, as a pipeline. This metaphor is grossly problematic. Pipelines are two-dimensional and consist of linear fragments that lead to one lone outlet. A welded pipeline has no room for stretching or growth. Likewise, in the metaphor, those leaving the pipeline, whether voluntarily or involuntarily, are considered "leaks" from the pipeline. This verbiage yields the false implication that exiting a STEM career makes you lost or inconsequential to the overall success of the pipeline.

A New Model: Batchelor et al. (2021) presented in AGU's *Eos* a new model to replace the pipeline model: the braided river STEM workforce development model [1]. The authors describe how the geological characteristics of a braided river, i.e. its multiple water sources, its wide, channeled morphology, and its varying flow rates into one large body of water, all make it a much more constructive metaphor that maximizes inclusivity, diversity, equity and accessibility (IDEA) principles. Figure 1 details the many characteristics of an inclusive STEM workforce along the braided river profile. Multiple entry points to the braided river system accept people from all educational experiences and disciplines, and those people can move through the system in a variety of training paths, each one traveling at its own speed. There are natural breaks in flow when sediment collects into a sand bar or an external organism impedes the flow by building a barrier. Water that leaves the river enriches and serves the communities and landscape around it. In the end, all paths converge successfully into one body of water [1].

Application to Planetary Science and Astrobiology: There are many ways in which we in planetary science and astrobiology can apply the braided river model to our community's workforce. Here are a few ways to begin this conversation:

Define your path: An integral part of applying the braided river STEM workforce development model is recognizing your path along the braided river. We can name the various components of our individual journeys (i.e. our water source, the speed of our path, the sand bars, the twists and turns, etc.) in order to examine how learning opportunities and successes along our path could be applied to mentor others.

Reimagine the non-linear components: Once you know your place on the braided river, you can reimagine the components from the pipeline model that require redefinition. Incalculable life events such as maternity and paternity leave deserve redefinition, as does the term "early career" in our programming and award structures, with a goal of including those who have taken a slower channel and moved back into the field. As stated in [1], we need to "normalize the idea of individuals changing pace and direction" for whatever reason. We also need to collectively examine what defines 'success' in our field. In the pipeline model, success is achieved when one reaches a predetermined exit or endpoint. A more inclusive definition would be in how one contributes to the whole. In other words, "Success in science should be measured not just in citations but also in broader positive impacts" [1].

Redesign programming: Internships and programs for young planetary scientists and astrobiologists play a key role in "piping" young scientists into the system in the pipeline model. In the braided river model, this is possible in a more inclusive way. Because there are many entry and exit points along the braided river, it would be beneficial to ensure teaching programming is not exclusive. While internships and REU experiences for undergraduates are important, a similar experience could benefit mid-career individuals, too.

Recognize the diverse cultural implications: The braided river STEM workforce development model, by definition, allows the braiding or interweaving of multiple systems and ways of knowing. A poignant example is how the braided river model aligns with Indigenous knowledge systems, which interweave many aspects of the natural world [2]. This is synonymous with the *He Awa Whiria*, or braided river approach, by Māori scholar Angus Macfarlane in which

research becomes "culturally relevant" by braiding Māori and Western knowledge "streams" [3]. Likewise, the braided river model allows planetary scientists and astrobiologists the space and flexibility to incorporate a relationships-first approach of co-creation and collaboration with Indigenous populations [4].

Encourage institutional changes: The braided river model is an inherently community-driven model as it allows the exchange of ideas into and out of the system freely. Administrators would do well to consider further programming with community partners, educators, elders and youth. One example within planetary sciences and astrobiology is the recognition that many colleges and universities, particularly smaller institutions, do not have courses or degrees in either subject area. Institutions with planetary science and astrobiology programs could pair with those without to offer transfer courses and workshops.

Finally, let us remember that our collective vocabulary matters to our community. If we replace the "leaky pipeline" verbiage, we commit to opening the workforce of planetary science and astrobiology to as diverse a crowd as possible. A diverse group of people will help solve the important and complex problems we face in planetary sciences and astrobiology.

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References: [1] Batchelor R. L. et al. (2021) *Eos 102(9)*. https://doi.org/10.1029/2021EO157277. [2] Curtis G. et al. (2013) *Stud. Teacher Ed., 9(2)*, 175-186. [3] Macfarlane A. and Macfarlane S. (2019) *Royal Soc. New Zealand, 49(S1)*, 48-57. [4] Gardner-Vandy K. G. et al. (2020) *Planetary 2023-2032 Decadal Survey White Papers*, #524.

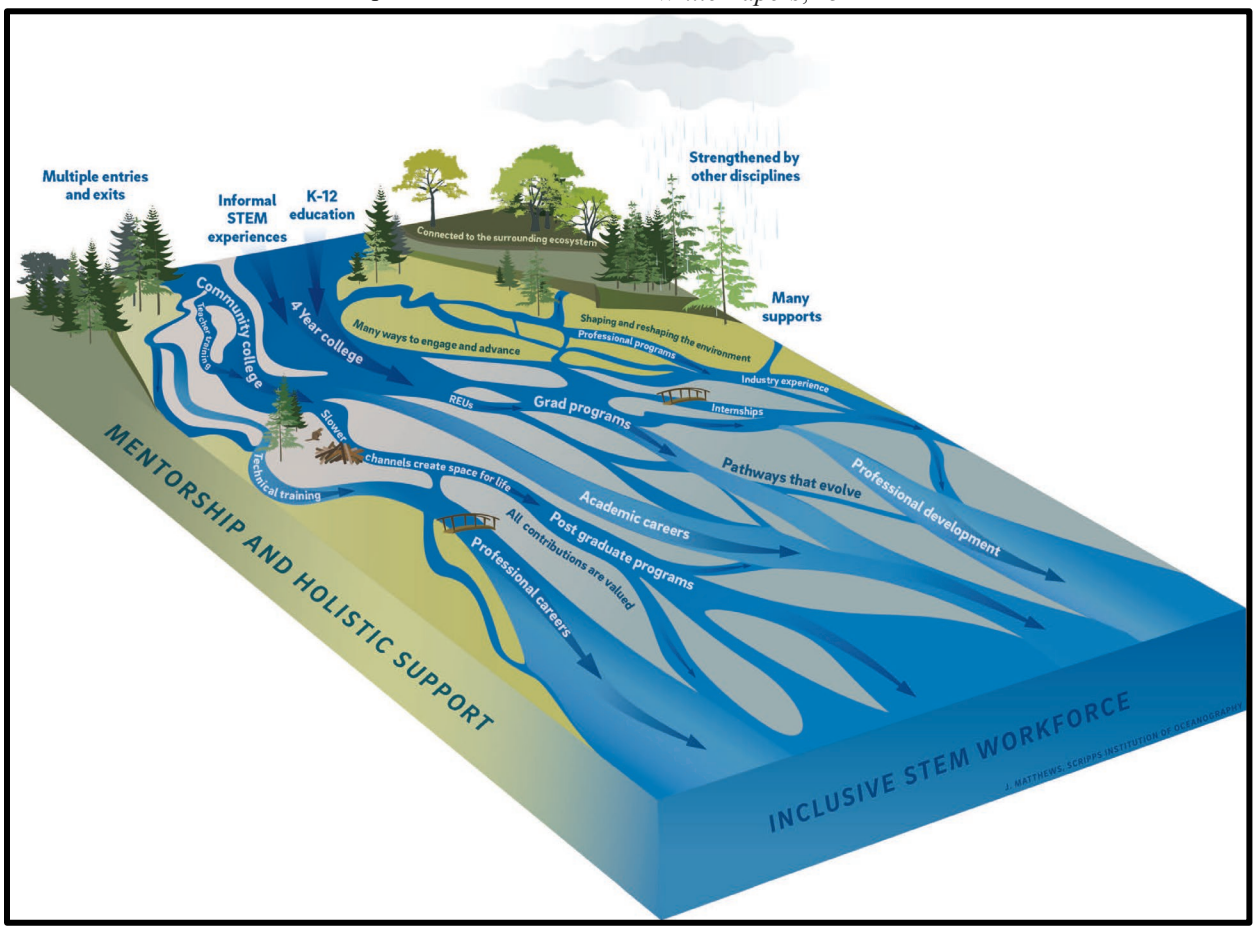

Figure 1. The braided river workforce development model [1]. The 3D figure shows a wide braided river with channels of varying sizes and depths. There are multiple entry and exit points including informal STEM experiences, K-12 education, and other disciplines. The channels include 4-year colleges, community colleges, teacher and technical training, REUs, graduate and professional programs, internships, industry experience, professional careers, post-graduate programs, academic careers, and professional development. The channels flow around land and sand bars that shape the environment and remind us that all contributions are valued. Some channels move quickly and some move slower to create space for life. All channels meet down river and pour into a large body of water, an inclusive STEM workforce. Figure by Jennifer Matthews, Scripps Institution of Oceanography, 2021 [1].