



AGU Advances

Original Version of Manuscript for

Counteracting Systemic Bias in the Lab, Field, and Classroom

Emily H. G. Cooperdock¹, Christine Y. Chen², Victor E. Guevara³, and James R. Metcalf⁴

¹ Department of Earth Sciences, University of Southern California, USA

² Division of Geological and Planetary Sciences, California Institute of Technology, USA

³ Department of Geology, Amherst College, USA

⁴ Department of Geological Sciences, University of Colorado - Boulder, USA

1 **Addressing Systemic Bias in the Lab, Field, and Classroom**

2 **Emily H. G. Cooperdock¹, Christine Y. Chen², Victor E. Guevara³, and James R. Metcalf⁴**

3 ¹ Department of Earth Sciences, University of Southern California, USA

4 ² Division of Geological and Planetary Sciences, California Institute of Technology, USA

5 ³ Department of Geology, Amherst College, USA

6 ⁴ Department of Geological Sciences, University of Colorado - Boulder, USA

7
8 Corresponding author: Emily H. G. Cooperdock (cooperdo@usc.edu)

9

10 **Abstract**

11 Grappling with systemic issues of discrimination and bias in geosciences can be overwhelming
12 to the point that one may feel powerless to fix it. Despite the overwhelming nature of this
13 challenge, faculty, principal investigators, and other scientists with leadership roles have
14 unparalleled power to make positive changes in environments they oversee. Here, we highlight
15 ways that scientists in these roles can immediately address systemic bias in three common spaces
16 — the lab, field, and classroom. Although culture change requires action from all individuals,
17 scientists in leadership positions have particular responsibility and power to mitigate harm to
18 marginalized groups without delay.

19 **1 Introduction**

20 Conversations about racism within geoscience have seen renewed vigor at all levels in recent
21 months — from research groups and departments, to institutions and professional societies. Yet,
22 the sad truth is that our community has discussed diversity, equity, and inclusion for decades
23 (Gillette and Gillette 1972), with no progress in demographic diversity to show for it (Bernard
24 and Cooperdock 2018).

25 Recent discussions on this topic have focused on systemic bias — the ways in which institutional
26 culture and norms exclude people based on their social identity and/or background, in both
27 intentional and unintentional ways. Several calls have been made to dismantle structures
28 upholding systemic racism and bigotry at the institutional and federal agency level (e.g.,
29 notimeforsilence.org). At the same time, faculty, principal investigators (PIs), and other scientists
30 that manage labs, lead fieldwork, or teach students also have an important role to play. As
31 authoritative figures of environments that people navigate on a near-daily basis — research labs,
32 the field, and classrooms — these individuals have outsized influence over the spaces where the
33 adverse impacts of systemic bias are most keenly felt. While this power imbalance is often the
34 source of problems (Stemwedel 2016), it also grants them the exceptional capacity to make
35 meaningful changes quickly, unconstrained by protracted committee-driven processes that often
36 delay progress (Ovienmhada et al., 2020).

37 Here, we highlight actions for scientists supervising labs, fieldwork, and classrooms to address
38 systemic bias. While faculty and PIs are the target of this article, these ideas are relevant to any
39 individual in a position of authority (e.g., lab managers, teaching assistants, fieldwork
40 organizers). We focus on tractable actions that can have immediate positive impacts for
41 marginalized community members. We call on all scientists in leadership roles to personally
42 reflect and engage with research on anti-oppressive practices published by historians, social
43 scientists, and education scholars, and to translate this learning into sustained, life-long action.

44 **2 The Lab**

45 For many, “the lab” is both the physical space and the group of people with whom we work to
46 accomplish our scientific objectives. Lab work is central to geoscience research, education, and
47 professional development, but bias and harassment can make laboratories exceptionally hostile
48 spaces for under-represented groups. Hostile work environments are a primary driver for the lack
49 of diversity in all STEM fields (Marín-Spiotta et al., 2020).

50 Generally, no PI intends to create a toxic lab culture. However, most receive no formal training
51 on how to create spaces where people of all backgrounds and identities can succeed.
52 Consequently, most default to familiar practices, universalizing their own experiences by
53 mentoring and managing in ways that worked for themselves. For example, most white scientists
54 probably have minimal anxiety interacting with campus security; men likely never think twice
55 about working isolated in a room with a stranger or acquaintance; and able-bodied scientists
56 rarely worry about the arrangement of microscopes, work benches, or walkways. Due to power
57 imbalances, PIs can remain oblivious to problems occurring in their own labs. This vicious cycle,
58 in which labs are designed for those most similar to current leadership (i.e. “affinity bias”; Dutt

59 2020), perpetuates a lack of diversity and propagates harmful supervisory practices (Hund et al.,
60 2018).

61 To combat this cycle, PIs must create lab procedures and guidelines that are deliberately anti-
62 oppressive, following recommendations by leaders in these efforts (e.g., Chaudhary and Berhe
63 2020). Recruitment of underrepresented scholars is essential, but must be coupled with efforts to
64 improve inclusion, with the latter prioritized to avoid inflicting further harm. To effectively
65 implement inclusive principles, PIs should familiarize themselves with the barriers and dangers
66 faced by those other than themselves (Marín-Spiotta et al., 2020), and then invest time in
67 developing skills to support them, including training in bystander intervention and conflict
68 management. In mentorship, PIs must recognize that identities and sociodemographic
69 backgrounds matter, and that embracing difference promotes an environment where everyone
70 can bring their whole selves to their work (Table 1).

71 **3 The Field**

72 Field trips and fieldwork are common components of geoscience training and practice. The
73 chance to experience new geographic settings, bond with a research team, and apply knowledge
74 first hand are aspects of the field that attract many to the discipline. However, a long history of
75 exclusion tarnishes this space: the idea of “the field” as the domain of rugged straight white men
76 persists, and its endurance reflects the shameful reality that many who do not fit this archetype
77 must contend with hostile environments involving alienation, unsafe conditions, harassment, and
78 assault.

79 Certain field requirements and harmful field experiences can stifle diversity (Giles 2020). For
80 example, field gear costs disproportionately affect low-income students and sharing tents or
81 bunkhouses can be exclusionary or dangerous, especially for transgender students or those with
82 past trauma. The physical requirements associated with hiking and camping can be unsafe for
83 those without experience and infeasible for those with disabilities. The goal here is not to remove
84 field experiences, but to identify barriers to participation and adapt accordingly (Table 1).

85 Fieldwork can also be a life or death situation for some, not only due to weather or terrain, but
86 based on an individual’s sex, race, and sexuality. Over 64% of surveyed women report
87 experiencing sexual harassment and 20% experiencing sexual assault while doing fieldwork
88 (Clancy et al., 2014). In the US, Black people are faced with threats of violence and even death
89 in the outdoors and other predominantly white spaces (Lanham, 2016; Anadu et al. 2020).
90 LGBTQ+ scientists must also contend with violence and even criminalization in many countries
91 (Olcott and Downen, 2020). Although we cannot control societal biases, it is our responsibility to
92 ensure the safety of every member of our group. This starts with selecting safe destinations,
93 developing safety protocol plans based on participants’ identities before travel, and ensuring
94 safety structures are in place once there (Viglione 2020).

95 Lastly, fieldwork can become more inclusive by avoiding practices like “parachute science,” in
96 which Western scientists gather data in other countries and then leave without collaborating with
97 or investing in those communities. Researchers should meaningfully involve Indigenous and
98 other local communities and collaborators to incorporate non-Western knowledge systems and
99 avoid exacerbating inequalities (e.g., Maldonado et al., 2016; North et al., 2020).

100 **4 The Classroom**

101 Diversity in STEM decreases with every stage of professional advancement, from undergraduate
102 through graduate programs, postdocs, and faculty. Geoscience has the most room for
103 improvement, with the lowest ethnic and racial representation of all STEM fields at all levels
104 (Riggs et al., 2018). Educators must acknowledge that while classrooms can be places of positive
105 transformation, they can also be spaces of emotional toil and attrition, especially for students of
106 color (hooks 1994; Hurtado et al., 2011).

107 One way geoscience educators can promote positive experiences is through intentional anti-
108 oppressive, intersectional course design, recognizing the interrelated ways that multiple social
109 identities can impact opportunities (e.g., Núñez et al., 2020). For instance, instead of relying on
110 textbook portrayals of white male geoscientists (Bush and Mattox, 2019), teachers can highlight
111 contributions by scientists from marginalized backgrounds (Table 1). Exposing students to
112 relatable role models inspires a sense of belonging, increasing recruitment and retention of
113 underrepresented minorities (Hernandez et al., 2017). In-class community building exercises and
114 active learning techniques can combat imposter syndrome, particularly for first-generation
115 college students and those from underrepresented groups (e.g., Theobald et al., 2020). Instructors
116 should explicitly acknowledge the exclusionary history of geology as a discipline, and
117 incorporate complementary Indigenous perspectives on Earth processes in their teaching (e.g.,
118 Reano and Ridgway, 2015; Gibson and Puniwai, 2006).

119 Another way to advance equity in the classroom is to adopt principles of Universal Design. For
120 example, recorded and closed captioned lectures allow non-native English speakers and learning-
121 disabled students to review course content at their own pace. Incorporating scientific research
122 projects within class assignments provides working students with an essential experience that
123 they might not have otherwise. Developing multiple avenues to experience the field rather than
124 creating alternative assignments for those unable to participate promotes inclusion and avoids
125 further marginalization (e.g., Carabajal and Atchison, 2020).

126 Ultimately, classroom structures that empower students of all identities to engage in their own
127 learning should be adopted. In support of these efforts, institutions should provide and
128 incentivize formal pedagogical training in student-centered, inclusive teaching methods.

129 **5 Closing Thoughts**

130 History repeatedly shows us that the core values and traditions of scientific disciplines are set by
131 the individuals who practice it. We, as a community, must acknowledge the historical roots of
132 systemic bias in our field: shaped by early Western naturalists, the original practice of
133 geoscience was exclusive by design. In the 1800s, Western geoscientists dismissed knowledge
134 generated by non-white groups in violent ways, promoting ideas about the racial inferiority of
135 Black and Indigenous people (e.g., Pico 2019) while also being complicit in the transatlantic
136 slave trade, e.g., “hitch[ing] rides on slave ships” for so-called discovery (St. Onge 2018; Wynn-
137 Grant 2019). Despite social progress in the following century, the exclusion of certain groups
138 continued in the form of segregated laboratories and classrooms (e.g., Felt 2017).

139 Today, marginalization and devaluation of contributions remain, not as distant history but as the
140 continued lived experience of many scientists (e.g., Makgoba, 2020). As individuals, no action
141 we take will eradicate these long-standing issues overnight, but each of us bears responsibility to
142 help transform geoscience into a safe, diverse, and accessible discipline. Analogous to the
143 concept of anti-racism, there is no neutral position: one is either working to make spaces more
144 inclusive and less hostile, or maintaining systems that reward privilege at the expense of
145 marginalized communities.

146 Uprooting the systems that have prevented the full and broad participation of marginalized
147 groups in our field is arguably the most pressing task we must confront, now and into the future
148 (Dutt, 2020). The suggested actions highlighted here represent only a fraction of the work needed
149 to address systemic bias baked into our discipline. A safe, accessible, and diverse geosciences for
150 all will only be realized when historical injustices are reckoned with and institutional structures
151 and policies are redesigned with equity, inclusion, and justice prioritized.

152

153

154 **Table 1.** Some suggested actions that can be readily adopted to make the lab, field, and
 155 classroom more inclusive.
 156

The Lab	The Field	The Classroom
<p>Normalize the discussion of diversity, equity, and inclusion (DEI) and commit resources (time, money, and personnel) to DEI efforts</p>	<p>Adopt and enforce codes of conduct (Nelson et al. 2017)</p>	<p>Show examples of diverse geoscientists (e.g., Instagram/Twitter: @diversegeologists, @geolatinas, @blackingeoscience)</p>
<p>Create and enforce written lab guidelines that foster anti-oppressive spaces (e.g., Chaudhary & Berhe 2020)</p>	<p>Create safety plans that consider those who are non-white, LGBTQ+, disabled, women, etc.; avoid work in intolerant areas (e.g., ADVANCEGeo Partnership: https://serc.carleton.edu/advancegeo/resources/field_work.html)</p>	<p>Plan universally accessible field trips and classroom activities; provide multiple ways to experience the field, using virtual options or other technology (www.theiagd.org)</p>
<p>Combat “affinity bias” and apply inclusive mentoring practices (e.g., Science of Effective Mentorship in STEMM: https://www.nap.edu/resource/25568/interactive/)</p>	<p>Provide financial and material assistance for equipment and other expenditures</p>	<p>Apply inclusive learning techniques that empower students to engage (hooks, 1994)</p>
<p>Apply best practices in letter reference writing to avoid racial and gender bias (e.g., Dutt et al., 2016; Berhe and Kim, 2019; University of Arizona Commission on the Status of Women 2016)</p>	<p>Collaborate with and recognize as co-authors local researchers (e.g., North et al., 2020)</p>	<p>Provide opportunities and reward trainees for learning experiential and inclusive teaching techniques</p>

157

158 **Author contributions**

159 EHGC initiated the article. All authors contributed to each section.

160 **Acknowledgments**

161 The authors would like to thank Penny King, Anahi Carrera, and Ryley Collins for helpful
162 comments on an earlier version of this manuscript.

163 **References**

164 Anadu J, Ali H, Jackson C (2020) Ten Steps to Protect BIPOC Scholars in the Field. *Eos*, 101.
165 <https://doi.org/10.1029/2020EO150525>

166
167 Berhe AA, Kim S (2019) Avoiding racial bias in letter reference writing.
168 <https://tinyurl.com/y8vub7nd>

169
170 Bernard RE, Cooperdock EH (2018) No progress on diversity in 40 years. *Nature Geoscience*
171 11: 292-295

172
173 Bush P, Mattox S (2019) Decadal Review: How Gender and Race of Geoscientists Are Portrayed
174 in Physical Geology Textbooks.” *Journal of Geoscience Education* 68(1): 2–7

175
176 Carabajal IG, Atchison CL (2020) An investigation of accessible and inclusive instructional field
177 practices in US geoscience departments. *Adv. Geosci.* 53: 53–63

178
179 Chaudhary VB, Berhe AA (2020) Ten simple rules for building an antiracist lab. *PLoS Comput*
180 *Biol* 16(10): e1008210.

181
182 Clancy KBH, Nelson RG, Rutherford JN, Hinde K (2014) Survey of Academic Field
183 Experiences (SAFE): Trainees Report Harassment and Assault. *PLoS ONE* 9(7): e102172

184
185 Dutt K (2020) Race and racism in the geosciences. *Nature Geoscience* 13: 2–3

186
187 Dutt, K., Pfaff, D., Bernstein, A. *et al.* Gender differences in recommendation letters for
188 postdoctoral fellowships in geoscience. *Nature Geosci* 9, 805–808 (2016).
189 <https://doi.org/10.1038/ngeo2819>

190
191 Felt H (2017) Marie Tharp — Plate Tectonics Pioneer. *GSA Today*.
192 <https://www.geosociety.org/gsatoday/archive/27/6/pdf/i1052-5173-27-6-32.pdf>

193
194 Gibson, B.A., and Puniwai, N., 2006, Developing an archetype for integrating Native Hawaiian
195 traditional knowledge with earth system science education: *Journal of Geoscience Education*, 54
196 (3), 287–294.

197 Giles S, Jackson C, Stephen N (2020) Barriers to fieldwork in undergraduate geoscience degrees.
198 *Nat. Rev. Earth Environ.* 1: 77–78

- 199
200 Gillette R, Gillette E (eds) (1972) Report of the First National Conference on Minority
201 Participation in Earth Science and Mineral Engineering. Colorado School of Mines, Golden, 135
202 pp
203
204 Hall D (2016) Making a Mark on the Ocean Floor.
205
206 Harding S (2008) *Sciences from Below: Feminisms, Postcolonialities, and Modernities*. Duke
207 University Press, p. 283
208
209 Hernandez PR, Bloodhart B, Adams AS, Barnes RT, Burt M, Clinton SM, Du W (2018) Role
210 Modeling Is a Viable Retention Strategy for Undergraduate Women in the Geosciences.
211 *Geosphere* 14(6): 2585–93
212
213 Hurtado S, Cuellar M, Guillermo-Wann C (2011) Quantitative measures of students' sense of
214 validation: Advancing the study of diverse learning environments. *Enrollment Management*
215 *Journal*: 53-71.
216
217 hooks b (1994) *Teaching to Transgress: Education as the Practice of Freedom*. Routledge, 216 p.
218
219 Hund AK, Churchill AC, Faist AM, Havrilla CA, Love Stowell SM, McCreery HF, Ng J,
220 Pinzone CA, Sordato ESC (2018) Transforming mentorship in STEM by training scientists to be
221 better leaders. *Eco. Evo.* 8(20): 9962–9974
222
223 Lanham, JD (2016) *Birding While Black*. Lit Hub. <https://lithub.com/birding-while-black/>
224
225 Makgoba, MW (2020) Black scientists matter. *Science*. 884.
226
227 Maldonado, J., Lazarus, H., Gough, B., Bennett, S., Chief, K., Kruger, K., Morisette, J., Petrovic,
228 S., & Whyte, K. P. (2016). *The Story of Rising Voices: Facilitating Collaboration between*
229 *Indigenous and Western Ways of Knowing*. In *Understanding Vulnerability, Building*
230 *Resilience: Responses to Disasters and Climate Change*. CR Press.
231
232 Marín-Spiotta E, Barnes RT, Berhe AA, Hastings MG, Mattheis A, Schneider B, Williams BM.
233 (2020) Hostile Climates Are Barriers to Diversifying the Geosciences. *Adv. Geosci.* 53: 117–27
234
235 North MA, Hastie WW, Hoyer L (2020) Out of Africa: The underrepresentation of African
236 authors in high-impact geoscience literature. *Earth-Sci Reviews* 208: 13262
237
238 Nelson RG, Rutherford JH, Hinde K, Clancy KBH (2017) Signaling Safety: Characterizing
239 Fieldwork Experiences and Their Implications for Career Trajectories. *American Anthropologist*
240 119(4): 710–722
241
242 Núñez AM, Rivera J, Hallmark T (2020) Applying an Intersectionality Lens to Expand Equity in
243 the Geosciences. *Journal of Geoscience Education* 68(2): 97–114
244

- 245 Olcott AN, Downen MR (2020) The Challenges of Fieldwork for LGBTQ+ Geoscientists. *EOS*
246 101
247
- 248 Oviennhada U, Lepe B, Carter J-K (2020) Stop telling URM's to wait for change. *The Tech*.
249 <https://thetech.com/2020/10/08/dei-cant-wait>
250
- 251 Pico T (2019) The Darker Side of John Wesley Powell. *Scientific American*.
252 <https://blogs.scientificamerican.com/voices/the-darker-side-of-john-wesley-powell/>
253
- 254 Reano, D., and Ridgway, K.D. (2015) Connecting geology and Native American culture on the
255 reservation of Acoma Pueblo, New Mexico, USA. *GSA Today*, 25 (8) 26-28.
256
- 257 Riggs EM, Callahan C, Brey J (2018) Research on Access and Success of Under-Represented
258 Groups in the Geosciences.” In *Community Framework for Geoscience Education Research*.
259 National Association of Geoscience Teachers.
260
- 261 St. Onge T (2018) Scientist of the Seas: The Legacy of Matthew Fontaine Maury. Library of
262 Congress. [https://blogs.loc.gov/maps/2018/07/scientist-of-the-seas-the-legacy-of-matthew-](https://blogs.loc.gov/maps/2018/07/scientist-of-the-seas-the-legacy-of-matthew-fontaine-maury/)
263 [fontaine-maury/](https://blogs.loc.gov/maps/2018/07/scientist-of-the-seas-the-legacy-of-matthew-fontaine-maury/)
264
- 265 Stemwedel J (2016) Reducing Harassment In Science: Funding Follows Trainees. *Forbes*.
266 [https://www.forbes.com/sites/janetstemwedel/2016/02/29/reducing-harassment-in-science-](https://www.forbes.com/sites/janetstemwedel/2016/02/29/reducing-harassment-in-science-funding-follows-trainees/)
267 [funding-follows-trainees/](https://www.forbes.com/sites/janetstemwedel/2016/02/29/reducing-harassment-in-science-funding-follows-trainees/)
268
- 269 Theobald EJ, et al. (2020) Active learning narrows achievement gaps for underrepresented
270 students in undergraduate science, technology, engineering, and math. *PNAS* 117 (12): 6476-
271 6483
272
- 273 University of Arizona Commission on the Status of Women (2016) Avoiding gender bias in
274 reference writing.
275 [https://csw.arizona.edu/sites/default/files/avoiding_gender_bias_in_letter_of_reference_writing.p](https://csw.arizona.edu/sites/default/files/avoiding_gender_bias_in_letter_of_reference_writing.pdf)
276 [df](https://csw.arizona.edu/sites/default/files/avoiding_gender_bias_in_letter_of_reference_writing.pdf)
277
- 278 Viglione G (2020) Racism and harassment are common in field research. *Nature* 585: 15–16
279
- 280 Wynn-Grant R (2019) On reporting scientific and racial history. *Science* 365: 1256–1257
281
282