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A trainee-informed model for undergraduate neuroscience research programs serving marginalized students

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Undergraduate research programs improve career outcomes for historically marginalized students in the US, but low retention rates in postgraduate research persist. As graduate students and postdocs, we present a combination of trainee-informed approaches for tailoring summer research programs to these students' needs and share key materials to facilitate adoption of these approaches at other institutions.

Despite shifts in US demographics, the systematic under-representation of women, people of color, and individuals with disabilities in the research workforce continues to threaten prospects for equal opportunity, scientific innovation, and societal impact[1–3]. Initiatives designed to address this problem have included government-funded undergraduate research programs, national professional networking conferences, and grassroots organizations serving marginalized researchers[4,5]. Despite some success, retention of marginalized researchers in the scientific workforce remains low owing to misaligned values, societal biases, and tokenization within the research setting[6–8]. Therefore, there is room for improvement in ensuring the retention of marginalized researchers at multiple stages of their postgraduate careers[9]. Undergraduate research experiences can be transformative for marginalized students and provide a critical window of opportunity to innovate on improving their research career outcomes[10,11]. Here, we provide trainee-informed recommendations for undergraduate summer research programs to help create a more equitable and fruitful research experience for marginalized students in neuroscience research.

Colors of the Brain (CoB) was founded in 2016 at UC San Diego to help undergraduate students struggling to secure research opportunities owing to academic challenges or limited institutional knowledge. In 2020, with funding from the Kavli Institute for Brain and Mind (KIBM), we launched the CoB-KIBM Scholars Program (Fig. 1). This summer research initiative targets students who are passionate about neuroscience but lack research experience from groups identified by the NIH's Interest in Diversity. We further invite LGBTQIA+ individuals and those with intersecting identities to apply. To date, we've funded and mentored 25 scholars.

The CoB-KIBM Scholars Program is designed and led by graduate students and postdocs with backgrounds like those of the scholars, fostering mentorship based on shared experiences of marginalization in academia. Drawing from our own experiences, we recommend a comprehensive plan integrating multiple retention strategies, as outlined below. Our approach, while focused on neuroscience at UC San Diego, can be applied across scientific fields and regions globally, where marginalized groups may differ owing to local historical inequities. We use 'marginalized' instead of 'underrepresented minorities' to acknowledge systemic inequities.

Removing barriers to access for prospective applicants

Proactive efforts are needed to remove academic barriers to research opportunities and ensure the inclusion of marginalized individuals in scientific research (see Box 1). These barriers can diminish self-confidence and decrease the likelihood that marginalized students will submit applications. Marginalized students often struggle to meet traditional academic success criteria such as strong recommendation letters, high GPAs, and prior research experience. These requirements can reflect systemic biases and socioeconomic constraints on a student's long-term potential for a career in research. To address this, we removed recommendation letters and prior research experience as eligibility requirements. This approach encouraged more marginalized students to apply, as reported by ~75% of our program alumni.

Prospective applicants may be hesitant to contextualize potential shortcomings in their application for fear of being judged on the basis of negative group stereotypes. Therefore, our application includes prompts that invite contextualization of career goals and academic progress, and specifically how these were shaped by past life experiences inside and outside academia. Our aim is to bring awareness to applicants of any perceived shortcomings that are products of extrinsic barriers. We provide example answers in our portal to guide applicants. We select more finalists than needed to create a waitlist and to offer all finalists academic year mentorship.

Our admissions process de-emphasizes traditional academic indicators, which often reflect socioeconomic background more than research career potential. Instead, through our delineated criteria and adapted rubric, we evaluate: 1) need for professional development support; 2) initiative and research drive; and 3) commitment and progress toward career goals. We strive for diversity among application evaluators to mitigate potential biases. We use a rank-choice voting system and open deliberation amongst reviewers to select finalists, thereby democratizing the process.

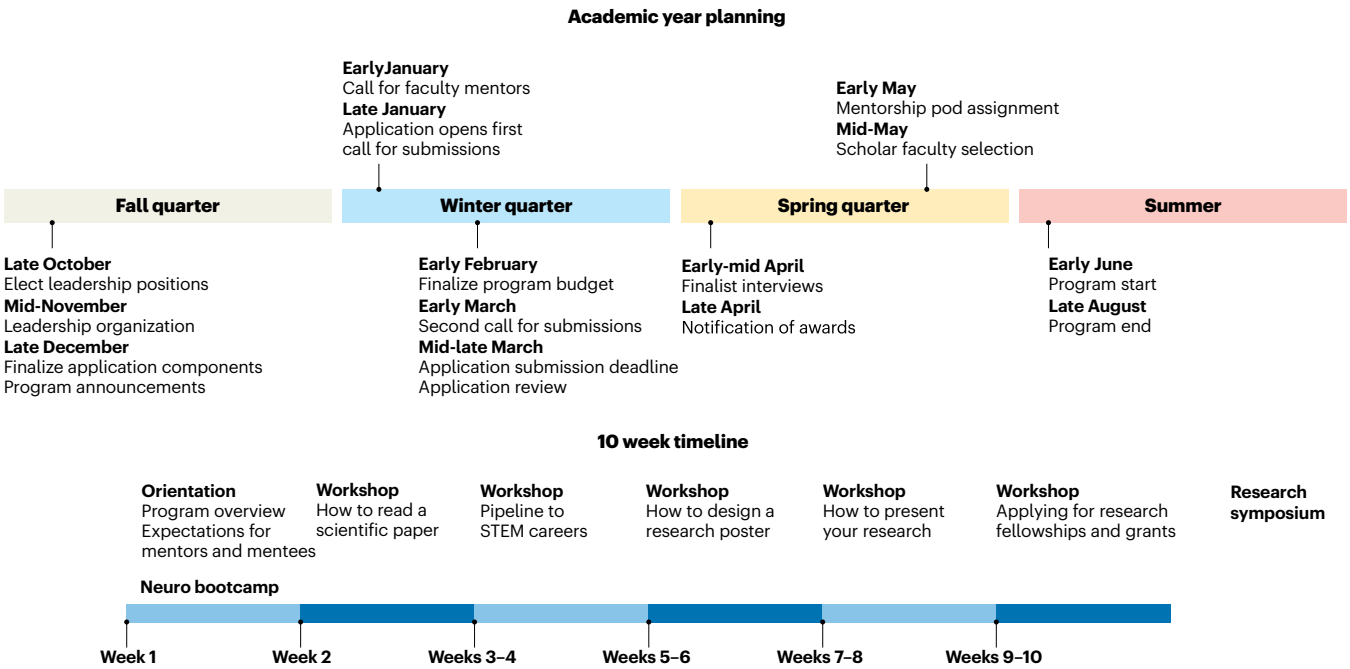

Fig. 1 | CoB-KIBM Scholars Program timeline. Academic year planning begins in the Fall quarter, when we elect leadership positions, plan and organize quarterly leadership responsibilities, and finalize application components on the basis of student feedback. Our Winter quarter focuses on logistics such as budgeting, call for submissions, and application review by our mentors. We host our interviews and notify awarded scholars by the Spring quarter. Last, the Summer quarter consists of our 10-week summer research program, which begins with an orientation to review scholar and mentor expectations and responsibilities. We added a neuroscience bootcamp to introduce scholars to varying neuroscience methods at different host labs. Weeks 2–4 focus on developing research proposals, conducting literature reviews, and initiating preliminary research. Weeks 5–6 concentrate on data collection and analysis. Weeks 7–8 involve finalizing research and drafting, with workshops to guide academic writing and science communication. Week 9 focuses on presentation preparation and honing public speaking skills. In the final week, participants present their findings at a research symposium. Throughout the program, participants have regular mentor check-ins, track progress, and engage in social events to foster a supportive and collaborative research community.

Brief (10–15 min) oral interviews with finalists provide deeper insights into their experiences and goals, which helps us to optimize our program's curriculum for that cohort. These interviews serve to assess specific interests in neuroscience research, aid in matching scholars with suitable mentors, and offer a more nuanced perspective on an applicant's written responses. We recommend virtual interviews conducted by at least two reviewers, recorded for panel evaluation using the same criteria as written applications.

Providing students with invested mentors

Fostering a sense of belonging substantially improves the retention of students unfamiliar with academic research in STEM careers[12,13]. Academic sponsorship, as exemplified by mentors who leverage their own networks to aid the professional development of their mentees, has been reported by marginalized researchers to be key for their retention in research careers[7]. Therefore, we provide scholars with a community of postgraduate mentors who may share similar lived experiences with researchers from marginalized backgrounds (for example, first-generation college students). We assign a smaller 'mentorship pod' of 3–6 mentors from various academic stages (graduate, postdoctoral) that is tailored to the research and career needs of each scholar. We also encourage the use of upperclassmen with research experience as mentors. Our multi-mentor approach prioritizes well-being for both mentors and students. It prevents overworking of marginalized postgraduates and ensures consistent mentor availability[14]. Mentors outside the student's lab provide space for reflection, career guidance, and discussions on community and cultural capital. Program leadership must be proactive in ensuring that postgraduate mentors are fulfilling their duties and intervene if any become unreasonably unavailable to the student.

A faculty mentor's acknowledgment of systemic barriers that marginalized mentees face in academic research can serve as a critical step toward active allyship[7]. Our postgraduate mentors annually curate our program's faculty mentors. Our unique selection process begins with trainee nominations followed by unanimous approval from our postgraduate mentors. Nominated faculty are evaluated on their prior success in mentoring marginalized students, ability to foster inclusive training environments (assessed by lab feedback), and prior support for trainee-led initiatives. Approved mentors are then invited to sign an agreement detailing program expectations, responsibilities, and guidelines for providing a safe, supportive environment for marginalized students.

To develop students' science identities, we invite researchers from marginalized groups to share obstacles and lessons learned in their career journey. We ask that speakers highlight any instances where integrating their culture or background into their research propelled scientific progress. These speakers lead our workshops, with faculty invited to our capstone symposium. Our goal is to inspire confidence in mentees that their authentic selves belong in research by demonstrating how cultural capital contributes to scientific progress.

BOX 1

Barriers to accessing undergraduate research for students from historically excluded and marginalized backgrounds

Financial constraints
Undergraduate students from marginalized groups are more likely to experience financial hardship during the course of their studies. Low income has been identified as a key barrier to participation in undergraduate research, often stemming from lack of financial compensation or inadequate stipends. For example, marginalized students may be forced to prioritize paid non-research part-time jobs over unpaid research positions to support themselves over the summer.

CoB-KIBM Program action: The 2024 CoB-KIBM Scholars Program stipend was set at $7,000 for its 10-week period and fully disbursed before the first week of the program.

Lack of prior research experience
Marginalized undergraduate students typically do not have access to social capital that includes career knowledge passed down through communities and professional networks. Such students may not attempt to pursue a research career until much later, as they have limited awareness of research opportunities in the early stages of their undergraduate journey. This limitation is especially pertinent to those who are the first in their family to attend college. Consequently, these students may not have the prerequisite research experience often sought for competitive research positions and fellowships, even those that aim to serve students from marginalized backgrounds.

CoB-KIBM Program action: The CoB-KIBM Scholars Program explicitly states in our calls for applications that preference is given to students with no research experience.

Letters of recommendation
Networking barriers, limited faculty diversity, and financial constraints can substantially hinder the ability of marginalized students to obtain letters of recommendation (LoR). Marginalized students report a diminished sense of belonging within STEM environments, which can affect their confidence in requesting a LoR. Additionally, part-time jobs may limit opportunities to attend office hours and cultivate relationships with professors, further complicating the process of securing a LoR. Furthermore, research has found that letter writers are susceptible to implicit biases. For example, letters for men and non-marginalized applicants are more likely to contain competency superlative descriptors, whereas women and marginalized applicants tend to receive minimal assurance, rather than strong endorsement.

CoB-KIBM Program action: CoB-KIBM replaced LoR with short essay prompts used to contextualize personal career goals and academic progress to ensure a holistic review process.

Stereotype threat
Stereotype threat denotes the stress and anxiety triggered by environmental indications that an individual may be judged on negative group stereotypes. Notably, as marginalized students accumulate stereotype threat experiences throughout their undergraduate education, they become more likely to disengage from STEM opportunities, increasingly distance themselves from forming a robust science identity, or leave STEM fields altogether.

CoB-KIBM Program action: The CoB-KIBM program incorporates specific phrasing in its essay questions (see 'Conclusions') to encourage students to discuss any self-perceived short-comings that may have affected their ability to do research in the past.

Hostile research environment
Research environments that are rife with a culture of microaggressions, a noticeable absence of diverse representation in research leadership, and a history of explicit racism are likely to be perceived as hostile by members of marginalized groups. Exclusionary research culture dissuades students from marginalized groups, as they may experience reduced feelings of belonging and discouragement from participating in research programs.

CoB-KIBM Program action: The CoB-KIBM program advertises on the call for applications that scholars will be placed in mentorship pods composed of postgraduates that share a similar background. Additionally, we annually curate a list of potential faculty mentors with a proven ability to create a positive research environment.

Ensuring student well-being

Although accepting as many students as possible to maximize a program's impact may be desirable, caution must be taken, as larger cohorts risk insufficient mentorship tailored to the needs of each student. We have found that cohorts of four to six students allow personalized support, better mentor oversight, and improved evaluation of their sense of belonging within their chosen research lab (see Box 2). This is especially recommended if prior cohorts have expressed a lack of attentive mentorship from postgraduate mentors and program leadership.

Unpaid summer research opportunities present a substantial challenge to students from low socioeconomic backgrounds and those with disabilities associated with increased healthcare costs. Without financial aid, students may be faced with the dilemma of participating in a full-time summer research program at the expense of lost income earned at other jobs. We prioritize stipends that account for local cost-of-living increases over large cohort sizes to ensure financial inclusivity and active participation. We disburse the full stipend at least two weeks before the program's official start date to assist students in covering off-campus housing costs and other living necessities.

BOX 2

Lessons Learned

A sense of community
Social events helped students to achieve a greater sense of belonging with their cohort and mentors. This provided solidarity with peers in a similar position and increased the incentive to ask their mentors for advice. Students requested that we plan more social events to foster this positive atmosphere.

A liveable stipend
Although we previously offered a competitive summer stipend ($5,000), students still faced financial challenges due to San Diego's high off-campus housing costs and the fact that we do not allow part-time work during the program. On the basis of feedback from the 2022 cohort, we increased the stipend for 2023 to $7,000 to better accommodate rising housing and living expenses.

Guaranteed mentor support for all students
In our second year, we expanded the cohort, expecting mentorship quality to stay consistent by offering financial incentives to graduate students. However, despite the mentor stipend, the larger group stretched our mentors' availability, leading to reduced support for students compared to the previous cohort. We have since prioritized quality over quantity, limiting the number of undergraduates and assigning each mentee multiple mentors to ensure consistent support throughout the program.

Professional development workshops
Our program offered workshops on professional skills, such as 'How to read a scientific paper'. In response to student feedback, we refined the workshop topics and reduced their frequency, as students preferred more time for program-sponsored social activities. They also suggested new topics, such as 'How to manage your time as a researcher'. Current workshop topics and presentation slides can be found at https://github.com/colorsofthebrain/mentors-like-us-paper.

Independence from the university
Most undergraduate research programs on our campus exist under the 'Summer Research Program' (SRP) umbrella, which brings together the programs for weekly workshops and a final presentation. While we initially participated in this program, we later chose to operate independently in order to offer workshops more tailored to our students' needs and to foster a more intimate sense of community. We retained the SRP Summer Research Conference as a final milestone, complemented by our own symposium.

Representation matters
Inviting keynote speakers from marginalized backgrounds to the capstone symposium promotes diversity and representation, helping students to connect with successful researchers who share similar experiences. This has a positive impact on students' confidence and encourages them to pursue their own aspirations in neuroscience.

Neuroscience 'bootcamp' for interdisciplinary understanding
We introduced a bootcamp during orientation week to strengthen students' understanding of neuroscience research methods, techniques, and tools. This early exposure builds their confidence, enabling them to effectively communicate their research interests to mentors.

Data-driven decision making
Qualitative and quantitative feedback guide program enhancements, resource allocation, and future planning. Pre-surveys help to gauge scholars' expectations and tailor the program accordingly, and post-surveys measure the program's effectiveness in meeting learning outcomes. Comparing pre- and post-surveys enables organizers to assess the program's impact on scholars' skills and knowledge. To avoid overburdening students, surveys also offer space for both open and guided suggestions for future professional development activities.

Alumnus engagement to demonstrate program impact
Monitoring alumnus success helps us to assess the program's long-term effect on participants' career trajectories. These data motivate both organizers and participants and highlight the program's value. Comparing outcomes across cohorts can reveal trends and emerging interests, enabling the program to adapt. Additionally, showcasing alumnus achievements serves as a powerful recruitment tool, demonstrating the program's role in advancing students' academic and professional growth.

Perceived feelings of isolation within the academic setting can impede the career success of marginalized researchers. Therefore, we organize a program orientation and a series of neuroscience workshops ('Neuro Bootcamp') within the first week, in addition to other formal opportunities such as professional development sessions, mentor meetings, and research symposia. Informal opportunities include our biweekly social events, such as picnics at local parks and outdoor team-building exercises. Importantly, we recommend organizing these social events and research symposia with other programs to expand peer networks, as we have done with the UCSD STARTneuro program.

Nurturing students' professional development

Research careers require professional development in both technical and non-technical skills that aid scientific discovery and critical thinking. While technical skill development in the lab can be tangibly evaluated, marginalized students may be at a disadvantage when navigating the more intangible aspects of academic research culture; therefore, programs should invest in the growth of students' non-technical skills as part of their curriculum.

Professional development activities can serve as effective tools to instill self-confidence and prepare marginalized students for future research careers. Our workshops cover training in science reading and

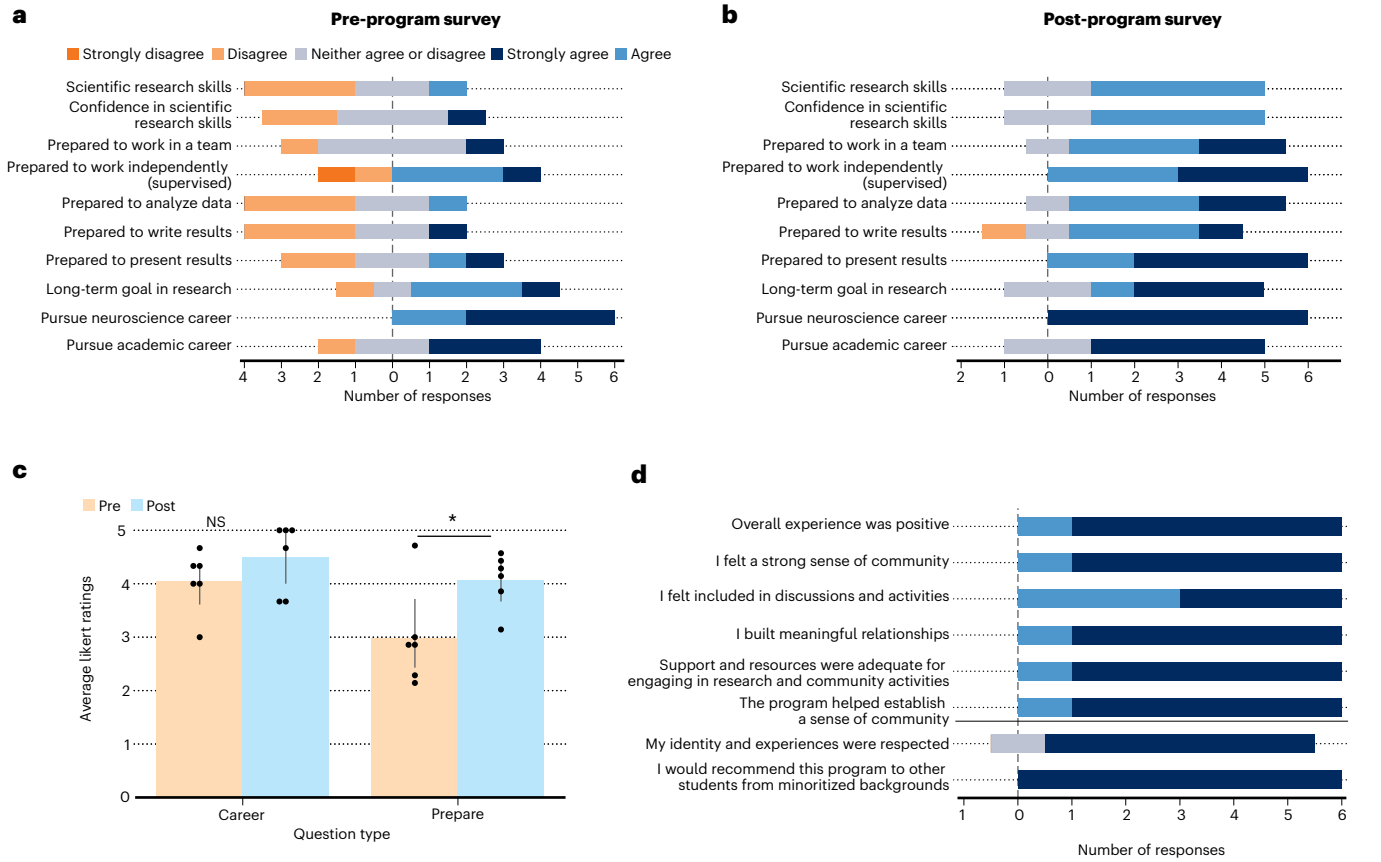

Fig. 2 | Program outcome measurements. a, Pre-program survey responses from all six scholars of the 2023 cohort. The first seven questions are categorized as preparation-type questions and the last three are categorized as career-type questions. **b**, Post-program survey responses from all six scholars of the 2023 cohort. **c**, Average Likert ratings for career-type questions and preparation-type question. Error bars represent 95% confidence intervals. *$P < 0.05$. **d**, Community survey responses from all six scholars of the 2023 cohort.

communication skills, discussions on scientific funding and publishing, instructions on how to create a curriculum vitae, and information on how to find and apply to paid research opportunities. We also provide training that enhances students' ability to network effectively in the research setting. This includes instructing students on how to appropriately email professors when seeking research opportunities and providing students with a glossary of terms and concepts commonly used in higher education (for example, candidacy exam) at the beginning of the program.

Effective communication is an essential skill for citizen-scientists. We provide training in the various formats in which students may be asked to summarize their work, ranging from research seminars to poster sessions and elevator pitches. Our program ends with a capstone symposium where students must avoid jargon, provide broad contextualization of findings, and invite discussion questions from a diverse scientific audience of faculty and students following a 10–15 min presentation. We recommend awarding outstanding presentations to help students begin a record of research achievements.

Establishing expanded networks

Intra- and inter-institutional collaborations between undergraduate research programs and organizations focused on promoting diversity, equity, and inclusion in STEM can broaden a program's reach and impact. Program leadership can share best practices to improve curricula and organizational structure. Peer and mentorship networks among programs can be leveraged to continue into the academic year. Organization of professional development events can be distributed to avoid unnecessary overlap and burden on mentors. Partnerships can provide opportunities for students to present their research at different research symposia that accommodate various presentation formats (such as posters or seminars). Our partnership with UC San Diego STARTneuro exemplifies these advantages.

Extramural programs and their postgraduate mentors should familiarize themselves with resources for students' success in continuing research at their home institutions. These can include campus groups that promote the well-being of marginalized students, such as campus community resource centers and student chapters of national research societies that focus on increased representation (for example, Society for the Advancement of Chicanos and Native Americans in Science (SACNAS)). Our program ensures that students are informed about online networks (for example, Black in Neuro and The Cientifico Latino Project) and national conferences focused on mentoring marginalized scholars (for example, the National Diversity in STEM Conference (NDiSTEM) and the Annual Biomedical Research Conference for Minoritized Scientists (ABRCMS)). These connections provide additional career mentorship, peer networks, and potential

fee waivers for graduate applications. Furthermore, we recommend that the program builds a robust social media presence to broaden program outreach and scout postgraduate research opportunities for the scholars.

Conclusions

Organizational resources discussed in this manuscript are freely available online at https://github.com/colorsofthebrain/mentors-like-us-paper, including a full list of recommended reading used during the writing of this commentary. We provide these materials to aid in the practical application of our trainee-informed recommendations for fostering a positive research experience for marginalized students. We acknowledge that systemic barriers to entry into neuroscience research may persist despite the best efforts of programs such as ours, and that these barriers may vary internationally. However, we hope that these recommendations will inspire change and that our admissions process will serve as a model for accepting students who might otherwise not be given the opportunity to explore a research career. Despite our program's infancy, our qualitative data suggest these strategies have positive effects on sense of belonging and preparedness for research careers among our students (see Fig. 2). We welcome further feedback from other neuroscientists who are passionate about diversity, equity, and inclusion in higher education and research careers.

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References

1. AlShebli, B. K., Rahwan, T. & Woon, W. L. *Nat. Commun.* **9**, 5163 (2018).
2. Hofstra, B. et al. *Proc. Natl. Acad. Sci. USA* **117**, 9284–9291 (2020).
3. Ricard, J. A. et al. *Nat. Neurosci.* **26**, 4–11 (2023).
4. Murray, D.-S. et al. *J. Neurosci.* **41**, 2314–2317 (2021).
5. Cadena, M. A. et al. *Cell* **186**, 3529–3547 (2023).
6. Werner Washburne, M. et al. *Cell* **186**, 4985–4991 (2023).
7. Hill-Jarrett, T. G. et al. *Front. Integr. Neurosci.* **17**, 1052418 (2023).
8. Ramos, R. A. *eLife* **11**, e85166 (2022).
9. Asai, D. J. *Cell* **181**, 754–757 (2020).
10. Ayoob, J. C. & Ramírez-Lugo, J. S. *PLOS Comput. Biol.* **18**, e1010588 (2022).
11. Folorunso, O. O. et al. *Neuropsychopharmacology* **47**, 2189–2193 (2022).
12. Singleton, K. S., Tesfaye, R., Dominguez, E. N. & Dukes, A. J. *Nat. Rev. Neurosci.* **22**, 71–72 (2021).
13. Mogessie, B. *Cell Stem Cell* **28**, 793–795 (2021).
14. Gewin, V. *Nature* **583**, 479–481 (2020).

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Competing interests

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