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PERSPECTIVE

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Academic ecosystems must evolve to support a sustainable postdoc workforce

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The postdoctoral workforce comprises a growing proportion of the science, technology, engineering and mathematics (STEM) community, and plays a vital role in advancing science. Postdoc professional development, however, remains rooted in outdated realities. We propose enhancements to postdoc-centred policies and practices to better align this career stage with contemporary job markets and work life. By facilitating productivity, wellness and career advancement, the proposed changes will benefit all stakeholders in postdoc success—including research teams, institutions, professional societies and the scientific community as a whole. To catalyse reform, we outline recommendations for (1) skills-based training tailored to the current career landscape, and (2) supportive policies and tools outlined in postdoc handbooks. We also invite the ecology and evolution community to lead further progressive reform.

Postdoctoral researchers ('postdocs'; Fig. 1) contribute extensive research, teaching and service to their supervising faculty, home institutions and broader scientific communities[1–4]. In principle, these contributions are rewarded with opportunities to specialize and develop independence. In practice, however, postdocs' progress and well-being are constrained by social, mental and financial challenges[1,5–7]. Further, the skills and credentials that are prioritized in postdoc positions are misaligned with contemporary job markets (for example, refs. [8–11]; Fig. 1b). These issues highlight an urgent need for policies and practices that better support a growing postdoctoral workforce. Ultimately, this will benefit all stakeholders in postdoc success—providing ethical and far-reaching returns on time and resource investments[1–5,12].

Below, we describe five goals for enhancing postdoc professional development. We also highlight innovative examples of policies and practices from around the globe. Our recommendations are applicable to many STEM disciplines, but especially relevant to ecology and evolution. Alternative careers in these fields commonly require additional training[13–15], and non-academic paths are often unknown to both postdocs and their mentors. This causes anxiety and reticence for postdocs who, by choice or by necessity, are considering non-traditional careers[1,16,17]. Fortunately, the ecology and evolution community is also poised to lead adaptive reform. Our research targets complex interactions spanning many levels of biological organization. Consequently, our community possesses the tools and perspectives needed for strategic, evidence-based engineering of workplace ecosystems[9].

Goal 1: Align career development with job markets

Research-focused postdoc positions were conceived as stepping-stones to faculty jobs, and postdoc professional development remains narrowly focused on the corresponding credentials and skills[18,19]. Job markets, in contrast, have changed. While most postdocs still desire faculty positions[17], they increasingly disperse into a wide variety of careers in government, non-profit and private sectors (Fig. 1b). This changing landscape, seen in both the United States[20] and Europe[21–23], is especially evident within ecology, where 73% of US PhD recipients did not become research faculty over a ten-year period[14].

How can STEM postdocs better prepare for diverse job markets?. One approach involves provisioning skills-based training, such as workshops on teaching, project management or communication[24,25]. These can complement traditional academic training to prepare postdocs for diverse careers (Fig. 1b), but must be carefully integrated with other workplace aims and expectations[11,15,18,26,27]. While many universities now offer 'alternative' career development activities, these resources fall short if poorly advertised, infrequently offered or systematically deprioritized.

One innovative career development tool is the United Kingdom's Researcher Development Concordat[28,29], a dynamic agreement between funding agencies and research institutions—including many of the United Kingdom's top-ranked universities. The concordat outlines projections for researcher career development that were developed by representatives from all levels of the hierarchy, including a minimum of 10 days annually for employees to pursue professional development.

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Goal 2: Sustain wellness and work–life balance

Mental health is linked to physical health and is foundational to motivation and productivity[30,31]. Among graduate students, low morale and depression are often attributed to financial insecurity, social isolation and lack of sufficient mentorship[32,33], and these factors can also impact postdocs[29]. For example, postdocs face high risks of social isolation due to short-term contracts, staggered arrivals and frequent relocations[1,5,27,34]. Importantly, social isolation can be amplified for underrepresented minorities, LGBTQ+ individuals, foreign researchers and other marginalized groups[32,35,36]. Burnout, a related concern, is more likely when professional development and job searching are crammed into evenings and weekends. We recommend that individuals and institutions work to cultivate thriving peer communities, implement evidence-based initiatives supporting diversity, equity and inclusion, and provide strategic tools (for example, healthcare programs) that offset mental, logistical and financial strain. Supervisors can further promote wellness by clarifying expectations and values, modelling healthy work habits, discussing wellness in research planning and performance evaluation, and celebrating diverse axes of achievement[1,5,37]. Importantly, these mentoring efforts must be rewarded to flourish (see Goal 3).

Financial solvency, another dimension of work–life balance, is an important consideration in seeking postdoctoral work. The economic impact of a postdoc is difficult to assess given the job's uncertain duration and outcome, variation in costs of living, and a common requirement of self-financed serial relocation[8,27]. Postdoc salaries vary greatly among nations, both relative to national medians and compared to those of non-postdoc residents with comparable credentials (Supplementary Table 1). For example, current postdoc stipends funded by the US National Institutes of Health (NIH) start at €44,600 (US$50,000) yr^{-1}, falling short of the National Academy of Sciences' minimum recommendations from 2014 (an inflation-adjusted minimum of €48,600 yr^{-1})[8]. Indeed, while typical postdoc salaries correspond to 1–1.5× the median salary in most countries surveyed, 36–60% of individuals with similar educational backgrounds out-earn postdocs in these countries (Supplementary Fig. 1, Supplementary Table 1). Many postdocs will also fail to recuperate delayed earnings. In France, for example, the salaries of postdocs transitioning into the private sector are not influenced by postdoctoral experience[38]. These findings are particularly bleak given that most STEM postdocs have already deferred saving through several years of graduate training.

Disparities in other job benefits are also common among institutions, countries and funding sources. For example, less than 35% of US institutions offer (for example, parental) leave benefits for postdocs[12]. Within institutions, individuals supported by external fellowships can also be denied benefits afforded to local colleagues, such as health insurance and retirement plans. In summary, to maintain the attractiveness of the postdoc career path to diverse and high-performing researchers, we must correct the insufficiency and inequity of current compensation standards.

Goal 3: Enhance mentoring

Postdoctoral work represents a challenging metamorphosis from apprenticeship to independence, providing advisors the opportunity to play positive, formative roles. Because postdoc roles vary greatly across institutions, here we define 'advisors' in a very broad sense—including all senior colleagues who are tasked with, or benefit from, the oversight of postdoc progress. Unfortunately, most advisors receive little or no mentorship training, and mentoring excellence is poorly rewarded in academia[37]. Consequently, advisors often deploy ad hoc mentoring that can cause personal and professional harm to mentees. This also harms group leaders and academic programs by reducing retention and productivity (for example, publication rate[1,3,39,40]). More effective mentorship can be facilitated through

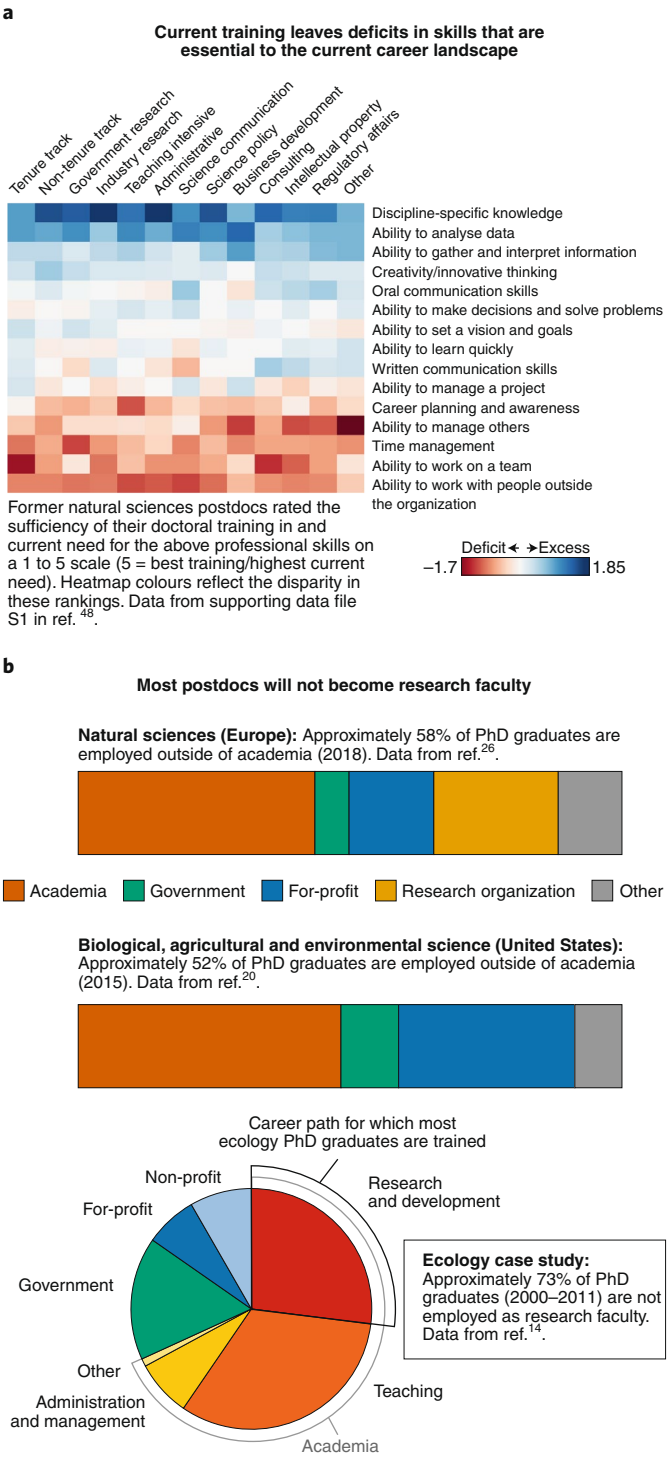

Fig. 1 | The training of a growing postdoc workforce is poorly aligned with the current career landscape. A postdoc is defined as "an individual holding a doctoral degree who is engaged in a temporary period of mentored research and/or scholarly training for the purpose of acquiring the professional skills needed to pursue a career path of his or her choosing…" (https://www.nationalpostdoc.org/page/What_is_a_postdoc). The number of US postdocs in science has doubled since 1990 to 38,241 (2017 data from ref. [47]). **a**,**b**, Statistics (**a**) and necessary skills (**b**) to align postdoc professional development to the current job market. Data in **a** are from supporting data file S1 in ref. [48] and data in **b** are from refs. [14,20,26].

Table 1 | Recommended content for postdoc handbooks

	Minimum essentials	Better-case scenario	Best-case scenario
Advocacy	External resources (National Postdoc Association and so on)	University postdoc association (run by postdocs)	Campus postdoctoral office (with permanent employees)
Policy	Official institutional mission	Postdocs explicitly integrated into campus and department missions	Participatory representation (department meetings, faculty council and so on)
Equity and inclusivity	Official protective policies	Diversity and inclusivity initiatives	Active campus support resources
Mentoring and oversight	Grievance protocol. Job description and review protocols	Personalized work plan encompassing research activity and career development	Oversight of, and incentives for, faculty excellence in mentoring. Work plan encompassing wellness
Healthcare and benefits	Human resources information	Medical and mental health coverage details. Vested retirement plan	Workplace wellness programs
Networking tools	Overview of home department	Dedicated e-resources for postdocs (listserv, website and directories)	Physical space for professional activities. Program-specific postdoc communities
Career development	Work hours permitting career search activities	Active support in job searching from mentor and institution	Skills training and professional development built into work plans and evaluations
Leave policy	Statement regarding leave policies	Progressive leave policies for parents and others in need. Information about external support while on leave (for example, National Science Foundation supplemental funding)	Temp replacements for individuals on leave
Research funding	Office of sponsored projects information	Overview of external funding opportunities (European Research Council, National Science Foundation and so on)	Seed funding opportunities. Administrative support for postdoc-led proposals
Travel policy	Travel policy and travel office information	Institutional protocols for work-related travel	Opportunities for travel support. Interest-free loans for work-related travel
Family policy	Legally mandated protections and policies	Elective childcare. Family resources and inclusive work culture	Subsidized childcare. Backup dependent care
Alumni and colleagues	Visible directories of current postdocs	Data on postdoc alumni (for example, years at institution, home lab(s) and job placement)	Active network of alumni employed in diverse sectors
Housing resources	Housing office information	Off-campus housing resources	Affordable housing options that accommodate families and indefinite employment
Relocation resources	General information about area	Current information (Motor vehicles office, state and city tax policies and so on)	Relocation assistance
International postdocs	International student/staff policy	International office information	Legal and tax resources for postdocs
Home lab resources	Contact for the department of Environment, Health and Safety and training information	Collegial and supportive lab culture	Written policies for home lab and/or research project(s)
IT resources	E-mail access and tech support information	Cloud access	Software licenses. Dedicated computer for work

The 'Minimum essentials' version consolidates relevant information that typically exists at home institutions. The 'Better-case scenario' appends resources that many institutions or programs do not yet provide. The 'Best-case scenario' outlines active and comprehensive efforts to support postdoctoral productivity.

training[37], and should be incentivized during hiring, evaluation and merit-based promotion[41].

Great mentors provide postdocs with a running start followed by light-touch guidance, helping them identify misalignments between existing credentials, skill sets and career goals, while recommending corrective steps. For research or teaching faculty, some of this work can be informed by personal experience. However, since most postdocs ultimately settle into different careers from their mentors (Fig. 1b), advisors should also encourage connections with colleagues, resources or training that bridge gaps in experiential knowledge[5].

Well-structured communication is an essential component of mentoring dynamics. To facilitate this, postdocs and advisors should meet within the first three months of an appointment to discuss goals and expectations, produce a formal mentoring agreement, and generate individual development plans[37]. Other meeting outcomes might include written research plans, which can increase grant proposals and manuscript submissions by 25%[3]. Advisors should continue regular one-on-one meetings to revisit established goals and expectations, examining progress and setbacks through constructive bidirectional performance review. These procedures are standard practice in the private sector but remain rare within STEM institutions.

Lastly, postdocs can benefit profoundly from becoming mentors themselves[37]. Fulfilling in its own right, mentoring others helps individuals better manage relationships with advisors, ultimately

benefiting all members of a research team[12]. Because authentic mentoring requires considerable time and reflection, it should also be explicitly factored into a postdoc's career development plan and performance assessments.

Goal 4: Develop administrative support

Postdocs with administrative support are better positioned to stay motivated and productive, boosting the prestige of their group and institution[1–3,16,40]. This support can also remove long-standing barriers to faculty positions for underrepresented groups in STEM[8,35,42]. Administrative support can take several forms including international offices supporting foreign postdocs, and Offices for Postdoctoral Affairs (OPAs) that provide advocacy and coordinate resources across entities[1,12]. Self-organized Postdoctoral Associations (PDAs) are another valuable resource that promotes interdisciplinarity, peer networking and postdoc-centred advocacy[12,43] (Table 1, Supplementary Table 2).

Currently, administrative support for postdocs varies widely among institutions. To demonstrate this, we surveyed 50 top-ranked universities' websites for any mention of an OPA, PDA or other (for example, department-specific) postdoc resource (for methods and full results, see Supplementary Table 2). A majority of the websites outlined at least one resource—either at the departmental level (typically within a STEM discipline), or else within the graduate school. However, only 35% indicated a dedicated OPA or PDA at the university level); this included 58% of surveyed US institutions, whereas only 16% of surveyed European institutions mentioned an OPA and 32% mentioned a university-wide PDA. Transnational dialogues, ideally including policymakers, institutional administrators and postdocs, could illuminate how this structural variation impacts various indices of success.

Local (for example, departmental) initiatives can play key roles in recruiting and empowering postdocs. For example, institutional support was found to enhance job seeking strategies and efficacy among biomedical postdocs[16]. One mechanism for increasing local support involves granting postdocs representation in organizational decisions (for example, faculty meetings). Small resource investments (such as access to a physical meeting space for video conferencing/interviews and interaction with students and colleagues) can further promote dynamic local peer communities, collaboration and career development.

Data on postdoc career trajectories are valuable to many groups including jobseekers, funding agencies and policymakers, yet are rarely gathered and shared by research institutions[44]. Public disclosure of this readily obtained information (for example, alumni research activities, service outputs and job placements at the lab, department and/or college levels) could considerably aid the development of best practices for postdoc training (Table 1).

Recent syntheses offer further recommendations for administrative change (for example, refs. [1,8,12,44]). At best, however, these carefully prepared guidelines are implemented sporadically among institutions. Our chief recommendation is therefore to explicitly include postdoc-related concerns in administrative mission statements, strategic plans and other official policies at departmental and institutional levels (Table 1). This will ensure postdocs have a protected place and voice within local workplaces.

Goal 5: Increase broader support

Scientific societies and funding agencies already play vital roles in postdoc career development. For example, conferences help disseminate research and build networks that can lead to permanent jobs. Although many societies work to cultivate student participation, postdoc inclusion initiatives are much less common. To illustrate this, we surveyed costs and supporting resources for 34 conferences in ecology and evolutionary biology that occurred between 2018 and 2020 (Supplementary Table 3). All events offered student rates (an average 44% reduction from full rate), but only 17 provided discounts for postdocs (at a smaller 13% reduction). For context, full professor salaries are often nearly double those of postdocs[12,45], making postdocs' income-adjusted conference costs disproportionately high. Conference costs are also amplified for individuals with special needs and/or more limited resources (for example, scientists in developing countries and parents needing childcare); this can restrict career progression[1,15,34,46]. Although some conferences offer support to broaden participation, only 40% of those we surveyed advertised such opportunities for postdocs. At a minimum, reduced postdoc registration fees would increase equity and invigorate scientific discourse at conferences. An even better approach might use sliding scales (for example, based on self-reported income brackets) to determine registration costs.

Throughout this Perspective, we have discussed several important postdoc support mechanisms. Many of these require resource investment and will consequently encounter inertia or resistance during planning and implementation. We end by appealing to funding agencies and reviewers to encourage change by carefully assessing postdoc development plans and budgeting during proposal reviews. By co-prioritizing training plans and resources, funding agencies can prevent unsustainable over-exploitation of one of science's most important assets: the postdoctoral workforce.

Conclusions

In summary, better support for postdocs will generate far-reaching returns. Postdocs are a vital part of the international research community and are integral to teaching and service activities at institutions around the world. Because career prospects for postdocs have changed over time, so too must the nature of their preparation for the next career stage.

We have shown here that many factors impact the quality of postdocs' personal and professional lives. Coordinated discussion and reform surrounding these factors is increasingly possible, in part due to the growing size and connectivity of the postdoc population. To leverage this emerging opportunity, we strongly encourage discourse among postdocs, home institutions, organizations and initiatives such as the National Postdoc Association and the NIH-funded Postdoc Academy. These initiatives offer free resources for postdocs' professional development and are stimulating important dialogues.

We have proposed structuring postdoc-centred policies and practices around five core goals: (1) aligning career development with job prospects; (2) sustaining wellness and work–life balance; (3) enhancing mentoring; (4) developing administrative support; and (5) increasing broader support. Achieving these goals requires coordinated effort from individuals, departments, institutions and scientific societies, and will ultimately benefit everyone involved. To facilitate and document progress, we encourage future studies of how progressive changes impact the well-being and productivity of both individual postdocs and academia at large.

We believe evolutionary biologists and ecologists should lead essential reforms to postdoc professional development, implementing data-driven practices that appropriately value and capacitate postdocs' extensive contributions to STEM. Our disciplines are collaborative and diverse, and our rigorous investigation of complex interactions among genes, individuals, species and whole ecosystems has surely prepared us well to develop optimal, postdoc-centred policies and practices within our own workplace communities.

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability

All data generated or analysed during this study are included in the published Perspective (and its Supplementary Information files).

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References

1. Jaeger, A. J. & Dinin, A. J. *The Postdoc Landscape: the Invisible Scholars* (Academic Press, 2017).
2. Rybarczyk, B., Lerea, L., Lund, P. K., Whittington, D. & Dykstra, L. Postdoctoral training aligned with the academic professoriate. *BioScience* **61**, 699–705 (2011).
3. Davis, G. in *Science and Engineering Careers in the United States: An Analysis of Markets and Employment* (eds Freeman, R. & Goroff, D. L.) 99–127 (Univ. Chicago Press, 2009).
4. Feldon, D. F. et al. Postdocs' lab engagement predicts trajectories of PhD students' skill development. *Proc. Natl. Acad. Sci. USA* **116**, 20910–20916 (2019).
5. Holzinger, F., Schiffbänker, H., Reidl, S., Hafellner, S. & Streiche, J. in *Gender and Precarious Research Careers, a Comparative Analysis* (eds Murgia, A. & Poggio, B.) 209–235 (Routledge, 2018).
6. Andalib, M. A., Ghaffarzadegan, N. & Larson, R. C. The postdoc queue: a labour force in waiting. *Syst. Res. Behav. Sci.* **35**, 675–686 (2018).
7. Grinstein, A. & Treister, R. The unhappy postdoc: a survey based study. *F1000Res.* **6**, 1642 (2018).
8. National Academy of Sciences, National Academy of Engineering, Institute of Medicine *The Postdoctoral Experience Revisited* (The National Academies Press, 2014).
9. Lancaster, A. K., Thessen, A. E. & Virapongse, A. A new paradigm for the scientific enterprise: nurturing the ecosystem. *F1000Res.* **7**, 803 (2018).
10. Dietz, J. S. & Bozeman, B. Academic careers, patents, and productivity: industry experience as scientific and technical human capital. *Res. Policy* **34**, 349–367 (2005).
11. Åkerlind, G. S. Postdoctoral researchers: roles, functions and career prospects. *High. Educ. Res. Dev.* **24**, 21–40 (2005).
12. Ferguson, K., Huang, B., Beckman, L. & Sinche, M. *National Postdoctoral Association Institutional Policy Report 2014: Supporting and Developing Postdoctoral Scholars* (National Postdoctoral Association, 2014).
13. Shaw, A. K. et al. Ecology postdocs in academia: primary concerns and possible solutions. *Bull. Ecol. Soc. Am.* **96**, 140–152 (2015).
14. Hampton, S. E. & Labou, S. G. Careers in ecology: a fine-scale investigation of national data from the U.S. Survey of Doctorate Recipients. *Ecosphere* **8**, e02031 (2017).
15. Blickley, J. L. et al. Graduate student's guide to necessary skills for nonacademic conservation careers. *Conserv. Biol.* **27**, 24–34 (2013).
16. St. Clair, R. et al. The "new normal": adapting doctoral trainee career preparation for broad career paths in science. *PLoS ONE* **12**, e0177035 (2017).
17. van der Weijden, I., Teelken, C., de Boer, M. & Drost, M. Career satisfaction of postdoctoral researchers in relation to their expectations for the future. *High. Educ.* **72**, 25–40 (2016).
18. Foote, K. E. Creating a community of support for graduate students and early career academics. *J. Geogr. High. Educ.* **34**, 7–19 (2010).
19. Agarwal, R. & Ohyama, A. Industry or academia, basic or applied? Career choices and earnings trajectories of scientists. *Manage. Sci.* **59**, 950–970 (2013).
20. National Academies of Sciences, Engineering and Medicine *Graduate STEM Education for the 21st Century* (National Academies Press, 2018).
21. Konsortium Bundesbericht Wissenschaftlicher Nachwuchs *Bundesbericht Wissenschaftlicher Nachwuchs 2017: Statistische Daten und Forschungsbefunde zu Promovierenden und Promovierten in Deutschland* (W. Bertelsmann Verlag, 2017).
22. Canal Domínguez, J. F. & Rodríguez Gutiérrez, C. Wage differences among Ph.D.s by area of knowledge: are science areas better paid than humanities and social ones? The Spanish case. *J. Educ. Work* **26**, 187–218 (2013).
23. Bloch, C., Graversen, E. K. & Pedersen, H. S. Researcher mobility and sector career choices among doctorate holders. *Res. Eval.* **24**, 171–180 (2015).
24. Derting, T. L. et al. Assessing faculty professional development in STEM higher education: sustainability of outcomes. *Sci. Adv.* **2**, e1501422 (2016).
25. Smith, B. et al. COMPASS: navigating the rules of scientific engagement. *PLoS Biol.* **11**, e1001552 (2013).
26. *2017 Career Tracking Survey of Doctorate Holders: Project Report* (European Science Foundation, 2017).
27. *Postdoctoral Funding Schemes in Europe: Survey Report* (Science Europe, 2016).
28. *The Concordat to Support the Career Development of Researchers* (The Concordat Strategy Group, 2019).
29. Roberts, G. G. *SET for Success: The Supply of People with Science, Technology, Engineering and Mathematics Skills: The Report of Sir Gareth Roberts' Review* (HM Treasury, 2002).
30. Bubonya, M., Cobb-Clark, D. A. & Wooden, M. Mental health and productivity at work: does what you do matter? *Labour Econ.* **46**, 150–165 (2017).
31. Evans, T. M., Bira, L., Gastelum, J. B., Weiss, L. T. & Vanderford, N. L. Evidence for a mental health crisis in graduate education. *Nat. Biotechnol.* **36**, 282–284 (2018).
32. Panger, G., Tryon, J. & Smith, A. *The Graduate Assembly Graduate Student Happiness & Well-Being Report 2014* (The Graduate Assembly UC Berkeley, 2014).
33. Auriol, L., Misu, M. & Freeman, R. A. *Careers of Doctorate Holders: Analysis of Labour Market and Mobility Indicators* OECD Science, Technology and Industry Working Papers (OECD, 2013).
34. McInroy, G., Lichten, C., Ioppolo, B., Parks, S. & Guthrie, S. *International Movement and Science: A Survey of Researchers by the Together Science Can Campaign* (RAND Corporation, 2018).
35. Yadav, A. & Seals, C. Taking the next step: supporting postdocs to develop an independent path in academia. *Int. J. STEM Educ.* **6**, 15 (2019).
36. Hunt, J. & Eisenberg, D. Mental health problems and help-seeking behavior among college students. *J. Adol. Heath* **46**, 3–10 (2010).
37. Hund, A. K. et al. Transforming mentorship in STEM by training scientists to be better leaders. *Ecol. Evol.* **8**, 9962–9974 (2018).
38. Recotillet, I. PhD graduates with post-doctoral qualification in the private sector: does it pay off? *Labour* **21**, 473–502 (2007).
39. Burk, H. G. & Eby, L. T. What keeps people in mentoring relationships when bad things happen? A field study from the protégé's perspective. *J. Vocat. Behav.* **77**, 437–446 (2010).
40. Lunsford, L. Doctoral advising or mentoring? effects on student outcomes. *Mentor. Tutoring Partnersh. Learn.* **20**, 251–270 (2012).
41. Morrison, J. et al. *Recognizing and Valuing the Mentoring of Undergraduate Research, Scholarship and Creative Activity (URSCA) by Faculty Members: Workload, Tenure, Promotion, and Award Systems* Council on Undergraduate Research White Paper no. 2 (Council on Undergraduate Research, 2019).
42. Grogan, K. E. How the entire scientific community can confront gender bias in the workplace. *Nat. Ecol. Evol.* **3**, 3–6 (2019).
43. Bruckmann, C. & Sebestyén, E. Ten simple rules to initiate and run a postdoctoral association. *PLoS Comput. Biol.* **13**, e1005664 (2017).
44. Polka, J. K., Krukenberg, K. A. & McDowell, G. S. A call for transparency in tracking student and postdoc career outcomes. *Mol. Biol. Cell* **26**, 1413–1415 (2015).
45. *Visualizing Change: The Annual Report on the Economic Status of the Profession, 2016-17* (American Association of University Professors, 2017).
46. Feeney, M. K., Bernal, M. & Bowman, L. Enabling work? Family-friendly policies and academic productivity for men and women scientists. *Sci. Public Policy* **41**, 750–764 (2014).
47. National Science Foundation, National Center for Science and Engineering Statistics *NCSES Survey of Graduate Students and Postdoctorates in Science and Engineering, 1972-2017: Fall 2017* (US National Science Foundation, accessed 30th January 2020); https://go.nature.com/3da5uTP
48. Sinche, M. et al. An evidence-based evaluation of transferrable skills and job satisfaction for science PhDs. *PLoS ONE* **12**, e0185023 (2017).

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Author contributions

All authors contributed to the writing of this piece (M.Å., N.E., B.J.M.J., K.J.M., H.F.M., N.M., J.G.P., J.S., A.W.T., A.R.W., K.M.Y., E.R.Z. and E.G.). The project was designed by E.G. and led by E.G., M.Å. and N.E. M.Å. and N.E. contributed equally to this work, E.G. is the senior author and all other authors are listed in alphabetical order.

Competing interests

The authors declare no competing interests.

Additional information

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Data analysis	No software was used for analyses presented in this manuscript

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All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

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Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

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Ecological, evolutionary & environmental sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	Our comment outlines recommendations for enhancing postdoc training and professional development
Research sample	We sampled data from online sources as described in the supplementary materials section
Sampling strategy	We sampled data from online sources as described in the supplementary materials section
Data collection	We collected data from the internet to characterize the current salaries, career paths, and resources available to postdocs in a variety of countries. The methods and data are clarified in the manuscript and supplementary materials.
Timing and spatial scale	We sampled data from online sources as described in the supplementary materials section and provide information about the scope and timing of available data within the manuscript.
Data exclusions	no data were excluded
Reproducibility	The data we present in our figures and text are included in the supplementary tables, along with links to their original sources.
Randomization	The manuscript does not call for randomization.
Blinding	The manuscript does not call for blinding

Did the study involve field work? ☐ Yes ☒ No

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☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology
☒	☐ Animals and other organisms
☒	☐ Human research participants
☒	☐ Clinical data

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging