

Emerging network of resources for exploring paths beyond academia

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An expanding collection of resources is helping trainees acquire important knowledge about careers outside academia.

The current career landscape for scientists in biomedical research is a widespread concern for many¹⁻⁸. Much of the scrutiny from trainees and administrators alike focuses on ways in which the existing structure of US biomedical research programs no longer serves the best interests of its trainees. Many cite systemic flaws within the current academic system that could be improved to help trainees adapt to evolving academic and industrial environments. These include low rates of obtaining federal funding for research, insufficient financial compensation, a stagnant trend in available faculty positions and exceedingly long training periods, among others^{3,5,9,10}. Given this current situation, it is easy to understand how graduate and postdoctoral trainees can become disenchanted with the existing academic climate.

For self-preservation, today's trainees often consider a more diverse range of career paths^{7,8,11}. Careers outside academia are no longer described with the potentially pejorative term 'alternative'. Of course, some trainees may have a 'punch-drunk' passion for science² and feel that a tenure-track faculty position is their main goal. Even in the current academic environment, these individuals are likely to remain intensely motivated to join the realm of academic biomedical research and commit to seeking faculty positions as they progress through the milestones of a typical academic career trajectory. Conversely, an increasing proportion of trainees are unsure about the traditional academic path and are interested in redirecting themselves toward opportunities

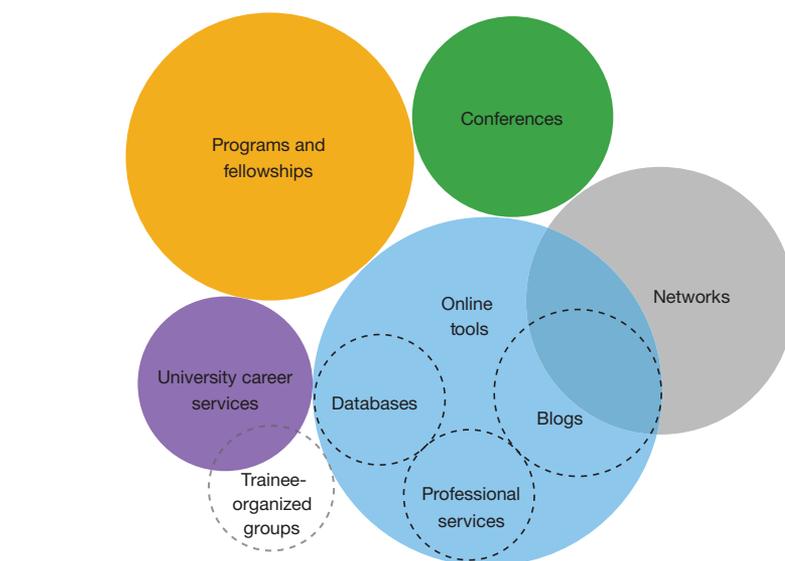


Figure 1 Emerging organization of resources across several domains. The map depicts the overlap and interaction between informative resources available for trainees. The sizes of the bubbles are only for illustrative purposes and do not represent the actual proportions of the domains.

outside academia^{8,11}. Often, we hear common refrains from colleagues: "What else can I do? Do I have necessary skills to move outside academia? Which industry fits me best? Will I have the support from my department and research advisor in pursuing jobs outside the academe?" These are just a few of the myriad questions they face. Unfortunately, some trainees may simply lack the information necessary to make an informed decision about their post-training careers^{3,12-14}. In fact, this issue is highlighted prominently in the most recent report from the National Academy of Sciences examining the postdoctoral experience¹⁴. The report notes that in order to make informed decisions, doctorate recipients need detailed information about the current job market, and calls for host institutions

and mentors to put more effort into making trainees aware of the wide variety of career paths available for those with PhDs. Most importantly, the report proposes that action is required by all stakeholders, including funding agencies, host institutions, professional societies, research mentors and the trainees themselves. Indeed, we agree with the report and others^{3,12,15} that a substantial degree of responsibility lies with trainees, who must be active participants in their future and use all available resources to learn about available career paths.

There is now a rather large repository of knowledge and resources about careers for scientists across a range of sectors. In recent years, this body of resources has continued to grow, and given that tenure-track jobs

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are becoming increasingly more difficult to obtain^{10,16,17}, this trend is likely to continue. In the context of increased interest in improving awareness of non-academic career paths, this article highlights the large diversity of the available resources. Additionally, we illustrate the challenges trainees face as they become more aware of the resources that are available for learning about non-academic paths. The goal is not to showcase the entire spectrum of resources but to identify particular examples illustrating the ever-expanding repository of resources that can help trainees navigate their future. Our aim is to encourage trainees—especially those early in their training—to explore the vast array of resources that are now available so as to acquire the knowledge necessary to make informed decisions about their own careers. Considering the increasing resources available for support, we further propose that trainees also harbor a certain degree of responsibility to become active participants going forward.

Growing number of resources

There is presently a general consensus on the need to expand training opportunities and exposure in non-academic careers for graduate and postdoctoral trainees^{3,12–14}. In recent years, a number of programs have been developed at the industry, university, private and federal levels to support career transitions for PhDs. In addition to these formal programs, there are numerous online services, blogs, databases, networks, books and articles that focus exclusively on the non-academic path (**Supplementary Tables 1–4**). Where does one start? At first glance, it can seem overwhelming. However, a closer look reveals some important divisions among the resources that are reasonably accessible. **Figure 1** provides an initial framework for surveying the landscape.

Programs and fellowships. At the federal level, a number of programs have been created to broaden experiences for graduate students and postdoctoral fellows across several sectors. The US National Institutes of Health (NIH) recently launched the Broadening Experiences in Scientific Training (BEST) program to provide support for institutions to develop innovative approaches in training biomedical sciences graduate students and postdocs for diverse career opportunities. To date, a total of 17 institutions have received this award, and more are likely to follow suit in the coming years. Similarly, the National Science Foundation (NSF) has a relatively new initiative called the NSF Research Traineeship (NRT) that seeks to encourage the development of innova-

tive models of training graduate students to develop the skills and knowledge to help them pursue a range of science, technology, engineering and mathematics (STEM) careers. Several programs and fellowships for those interested in science policy provide opportunities for such individuals to shape various policy issues while still leveraging their biomedical training. They include the American Association for the Advancement of Science (AAAS) Science and Technology Fellowship, the Christine Mirzayan Science & Technology Policy Graduate Fellowship and the California Council on Science and Technology (CCST) program. The full list of policy fellowships can be found through AAAS's website at <http://www.aaas.org/page/fellowship-resources>. This is a must-visit database for those interested in science policy. The database can be filtered by stage of career and by interest, which makes it very easy to go through the many opportunities in the area of policy. All of these programs seek to provide first-hand exposure to policy-making and implementation across a number of sectors including energy, the environment, public health, congressional diplomacy, security and agriculture. According to the AAAS¹⁸, approximately 40–50% of their fellows continue to work in the policy arena, 20–25% return to their previous sector of employment and another 20–25% use the experience as a door to new opportunities. Recipients of the Christine Mirzayan Fellowships (http://sites.nationalacademies.org/PGA/policyfellows/PGA_044687) have gone on to hold positions at the NIH, the US Department of Defense and Department of Energy, and the World Bank.

In their searches through potential non-academic paths, trainees will also stumble on opportunities for PhDs in the area of data science¹⁹. Training programs for this career path include the Data Incubator in New York City, the Berkeley Institute for Data Science in California, the Moore-Sloan Data Science Fellows Programs at New York University and the University of Washington, the Data Science for Social Good Summer Fellowship at the University of Chicago, and the Insight Data Science Fellows Program based in Silicon Valley and New York City. Fellows in these programs work with mentors in industry to find solutions to real-life problems. The programs provide a way for PhD candidates and postdocs to make the transition into the field of data science, which continues to grow with the ever-increasing amount of data collected every day²⁰. Careful analysis of each program is required to assess fit for individual candidates. A search of the web reveals an even larger collection of fellowships and programs (**Supplementary Table 1**) covering various

areas including scientific writing, bioethics, leadership development, technology transfer and industry. However, many of the programs and especially fellowships are useful mostly for those who already know which non-academic path they want to pursue.

Online resources. Fortunately, a significant number of opportunities and resources exist online for trainees who are looking to acquire knowledge on how to venture into the non-academic space but are unsure of the path to take. The key for trainees is to know how to navigate the large body of information that is out there, much of which is freely available. We have categorized the different types of resources (**Fig. 1**), which include professional online networks, career development tools, professional career services, databases, university offices and blogs. Perhaps the most important of all the available resources online are professional online networks. These allow like-minded individuals to interact and share insights throughout their journeys as they pursue their non-academic goals. A number of groups across several non-academic domains can be found on professional platforms such as LinkedIn (**Supplementary Table 2**). Trainees interested in learning more about specific fields can use such groups to network both with fellow trainees and with those who have already made the transition. Joining such groups presents an opportunity for trainees at any stage of training to get real-world advice and insights into careers outside academia. For example, members of the PhD Careers Outside Academia group on LinkedIn routinely post articles on non-academic job positions, questions about career choices and networking issues, job announcements, suggestions on useful resources and general inspirational comments. Like the other social network professional groups, PhD Careers Outside Academia provides an accessible space for trainees to talk about making the jump into the non-academic world.

Outside such networks, one can also find resources and tools distributed across several different domains (**Supplementary Table 3**). One tool that can be found across many graduate student and postdoctoral websites is the interactive web-based Individual Development Plan (MyIDP; <http://myidp.sciencecareers.org>)²¹. This tool allows trainees to conduct self-evaluations, assessment, career exploration and goal setting and also to network. The ability to do self-evaluations and set specific, measurable, action-oriented, realistic and time-sensitive (SMART) goals is rather important. This is something that trainees must do throughout their training in

order to determine what they value most and how such values change with time. By doing so, trainees will be able to make the necessary course corrections along the way as they refine the career path that they are both suited for and passionate about. Many postdocs and mentors who have worked on an IDP have found it to be useful overall¹².

The National Postdoctoral Association (NPA) also serves as a resource for trainees while also representing the unique interests of postdocs. In addition to advocating for postdocs across the country, the NPA hosts a suite of career planning information (for example, Postdoctoral Association Toolkit, the postdoctoral core competencies document and the quarterly *POSTDOCKET* that often features useful articles). It is worth mentioning that some of the online material requires NPA membership. Lists of non-academic jobs can also be found through BioSpace, *The Chronicle of Higher Education's* Vitae, Inside HigherEd, BioCareers, Science Careers and NatureJobs, just to name a few. These listings can provide a better understanding of the career landscape and of the skills that employers are seeking in the workplace. In addition to job listings, Science Careers and NatureJobs offer large archives of articles, booklets, blog entries and commentaries on non-academic career paths for PhDs.

What if a trainee is looking for professional help? Interestingly, there are also a growing number of professional services targeting PhDs who are interested in making the transition outside of academia²². We found services from Cheeky Scientist, Alt Academix, Science-RX, SciPhd and PhDs at Work, to name only a few (**Supplementary Table 3**). Founded by a former graduate student, Cheeky Scientist is a well-known service offering access to a team of consultants who work with clients to help them make the transition to careers outside academia. Additionally, it also offers tips and advice through its blog, which publishes articles across a number of topics. A suite of blogs across the internet can offer similar information to trainees (**Supplementary Table 4**).

Host institutions. Support also exists at the level of individual institutions through local university offices, career services departments, graduate student groups and postdoctoral offices. The key advantage of host institutions is that they are able to design seminars, panel discussions, networking sessions, classes and workshops that cater specifically to the needs of their local trainee populations. Examples of trainee-organized groups include the Biotechnology and Life Sciences Advising (BALSA) at Washington University in St.

Louis¹⁰, the University of California–Berkeley and Boston-area Postdoc Industry Exploration (PIEP) Programs²³, the Science Policy Careers Group, Consulting Associates and StartX at Stanford University²⁴, the Entrepreneurs Club at the Massachusetts Institute of Technology, the Princeton University Graduate Consulting Club, and the more recent Future of Research³ and Berkeley-based Beyond Academia conferences (<http://www.beyondacademia.org/>) organized by graduate students and postdocs.

Of course, this is only a small fraction of the trainee-organized initiatives that exist at various PhD-granting institutions. Chances are that a trainee's institution will have a website with a list of the resources that it

offers. If not, it is worth perusing the websites of other institutions to find out what resources they offer. Additionally, many scientific conferences (for example, those of the Society for Neuroscience and the Society for Experimental Biology) now offer career development sessions to help young scientists understand the full breadth of options available so that they can make informed choices about career paths that may take them beyond academia.

An important consideration

Our purpose here in showcasing the many resources for exploring non-academic paths is to help trainees understand that there is growing support for them if they choose to pursue careers outside academia. It is well known that the infrastructure of biomedical research in the United States has aspects that could benefit from reform⁵. Another significant issue in this discussion is the need for trainees to take responsibility for their own careers. Yet it is also important to also be aware of obstacles, such as time limitations, that may preclude trainees from pursuing these resources.

At both the graduate and postdoctoral stages, trainees are focused on cultivating impactful research questions, designing experiments to answer those questions, running the experiments, analyzing data and publishing their findings in peer-reviewed journals. Classic training in experimental design and execution is typically combined with a variety of other responsibilities: making research presentations, researching the field, preparing manuscripts, mentoring other lab members, learning relevant research techniques and attending conferences or society meetings. It

would appear that there is very little remaining time to explore meaningful career trajectories. However, trainees must understand that the process of exploring careers outside the academe will intrude into research time if they do not take steps to avoid this. Scouring the web for information, attending panel discussions, conducting informational interviews, doing summer internships and so forth require planning to ensure that the trainee's research is not compromised. Trainees have to manage

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their time carefully so that they can fully assess their career options without affecting their research progress and lengthening their time to graduation. Much of the responsibility does lie with the

trainee. Although time is limited, developing SMART goals, as previously suggested¹², will go a long way toward helping a trainee manage his or her time effectively.

With the growing number of resources, it is clear that it will only get more difficult for trainees to sort through the available information. There is no review system for these resources, and it is not clear whether such a system is possible or warranted given the uniqueness of each trainee's needs. Thus, trainees are left to their own devices to figure it out themselves, which can be overwhelming and may leave some trainees a little confused as to where to start. With limited time, it is possible for trainees to get disgruntled and delay the important task of making a plan of attack. As mentioned earlier, an IDP is a potentially important place for trainees to start the process of evaluating their skills and developing SMART goals, as is consulting institutional career service offices. Of course, it is useful when trainees' faculty advisors are willing and able to help. If this is not the case, it is advisable for them to search for additional advisors either within or outside their departments to help them navigate the road ahead.

Thinking about the future

There are several avenues worth exploring that must involve all stakeholders in the biomedical research system in order to provide increasing benefits for trainees in the future. One option is to focus more strongly on career planning at the undergraduate level²⁵. Universities can improve the ways in which they inform undergraduates interested in a biosciences PhD about the options available to them after they

finish graduate school. Research universities typically recruit students to their graduate programs through conferences and also during the various summer undergraduate research experience programs that they host. The undergraduate summer research programs at many universities present a prime opportunity for faculty, administrators and senior graduate students to engage undergraduates about the various doors a PhD degree can open. These programs can also integrate workshops designed to allow students to learn about careers outside the academy and the skills necessary to be successful in them. More importantly, such information should be made available to all undergraduates interested in pursuing PhDs, especially in the life sciences. Additionally, professors can increase their awareness of these non-academic pathways and highlight the wide range of available careers for their students and mentees. Such a system of support would demonstrate to undergraduates that they are joining a research community that supports their diverse interests and will continue to help them as they pursue their future career goals.

Knowledge of the range of career options alone, however, will not be sufficient to prepare students for their career goals. On a longer time scale, future policies requiring both federal and university programs to explicitly mention how the training and exposure allows trainees to pursue both academic and non-academic options would be incredibly beneficial. This can already be observed in similar initiatives such as NIH's Broadening Experiences in Scientific Training (BEST) program (<http://grants.nih.gov/grants/guide/rfa-files/RFA-RM-13-019.html>). We envision training programs including detailed data on career outcomes²⁶ as an additional indicator of success, among other measures. Some good examples of this come from Stanford University²⁷ and MIT (<https://gecd.mit.edu/resources/data>) where data summarizing career paths of PhD students from different departments is shared to the respective university communities. Such data will be useful for trainees as they decide on a particular career path to follow.

Overall, the support for PhDs working outside academia is steadily growing. In fact, many former trainees are writing and giving talks about their diverse career paths and experiences^{28–30}. Such stories can be an

important source of inspiration and have the potential to improve both the creativity and confidence of subsequent biomedical trainees. Lastly, a concerted worldwide effort and increased awareness of former doctoral trainees will help secure jobs across a number of areas both within and outside academia. This is important given that expansion of higher education systems has increased PhD output in many countries³¹. With respect to developing nations, we see resource-rich countries with well-established PhD and postdoctorate systems sharing knowledge with developing countries on the best practices in constructing PhD and postdoctorate systems³².

Taken altogether, the current academic culture will continue to change to keep up with the increased acceptance, and expectation, of most PhDs pursuing non-academic jobs. Amid the negative rhetoric of the current academic environment, it can be difficult to see the positive initiatives that are increasingly being developed. We strongly support the idea that scientific training should remain a central focus in biomedical PhD training programs. However, it is in trainees' best interest that their institutions prepare them for gainful employment upon completion of that training. The key to achieving this goal is to ensure that the next generation of PhD graduates are aware of the options and have the necessary core training to be able to use their skill sets to access careers outside as well as within academia. Increased distribution of PhDs across various non-academic disciplines can have a significantly positive effect. Both the scientific community and society as a whole stand to benefit tremendously³³. More than ever, scientific trainees have numerous tools and resources at their disposal in planning and navigating their careers, creating a unique and exciting opportunity for self-empowerment and active participation in shaping their own career paths.

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