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Success and the next generation of physician-scientists

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In Sore Need of a Plumber

John Wyngaarden sounded the alarm in 1979, warning that the physician-scientist workforce is imminently endangered [1]. Subsequent work by numerous individuals and organizations has bolstered consensus that a critically serious problem exists, and a renewed sense of urgency was voiced just last year [2]. Much attention has been paid to conserving the habitat in which physician-scientists grow and develop. Some have likened physician-scientist training to pipework [3]. Milewicz *et al.* published an image of a pipe wherein trainees begin their journey in a joint MD–PhD program and travel along a long leaky pipeline, ultimately leading to an R01 grant [4]. This framework operationalized the problem of the workforce shortage by focusing attention on reducing attrition along the pipeline. This pipework evolved and captured more complexity [5]. Joint MD–PhD and MD-only trainees enter this still-leaking pipe system, making their way to a few more endpoints: the traditional academic track, clinician educator track, and clinical track. Rather than continuing the search for a competent plumber, we argue for stakeholders to reconsider the appropriateness of this framework for the next generation of physician-scientists.

Looking Down the Pipe

The pipe's opening is more complex than funneling people into joint MD–PhD programs, although this track remains the most direct pathway to becoming a physician-scientist. The majority of outcome studies focus on graduates of the joint MD–PhD program, missing out on several "subspecies" of physician-scientists. When the National Institute of General Medical Sciences (NIGMS) released a new Medical Scientist Training Program (MSTP) Funding Opportunity Announcement (PAR-19-036), they encouraged programs to consider alternative entry points [6]. Some begin with a PhD and then pursue medicine. Many, a portion of whom are international, begin with MD degrees and then obtain research training. Of the MD-PhDs who completed training in the social sciences and humanities by 2000, nearly half of respondents completed their PhD after residency and less than 10% obtained their MD-PhD through a joint MD-PhD program [7]. A physician-scientist's clinical training could be in osteopathic medicine, dentistry, veterinary medicine, or other health professions. These diverse entry pathways are often lost within the pipework.

We challenge the assumption that success must be an R01-supported, primarily research-driven academic medicine position. In a 2003 survey of nearly 500 MD-PhD students in their final years of training, almost 60% of respondents disagreed with defining a physician-scientist as "someone who holds at least an MD and performs research as his/her primary professional activity," seeing teaching and patient care as a crucial part of their careers [8]. A recent qualitative study identified that personal definitions of success varied by career stage and gender of the researcher [9]. This highlights discrepancies among stakeholders, trainees and physician-scientists as to what constitutes success. Furthermore, in the 2018 Association of American Medical Colleges (AAMC) National MD-PhD Program Outcomes Study of alumni from 80 joint MD–PhD programs, 68% were full- or part-time faculty members and about 13% worked at the NIH, other federal agencies, or in industry. Of those in faculty positions, 17% indicated having an 80% or greater research effort; only 50% of respondents spent more than half their time on research [10]. Although, joint MD–PhD programs are succeeding in placing the majority of their graduates in academia or government at much higher rates than MD-only programs, it is notable that only 12% of trainees meet the popular narrative of physician-scientist success: an 80:20 research-to-clinical academic position. This suggests that the narrative of success has to be revisited.

Growing Toward a New Framework

As physician-scientists in training, we are acutely aware of the challenges of fitting to a narrowly, predefined mold. Our generation is more diverse than ever, emphasizing the need to foster a

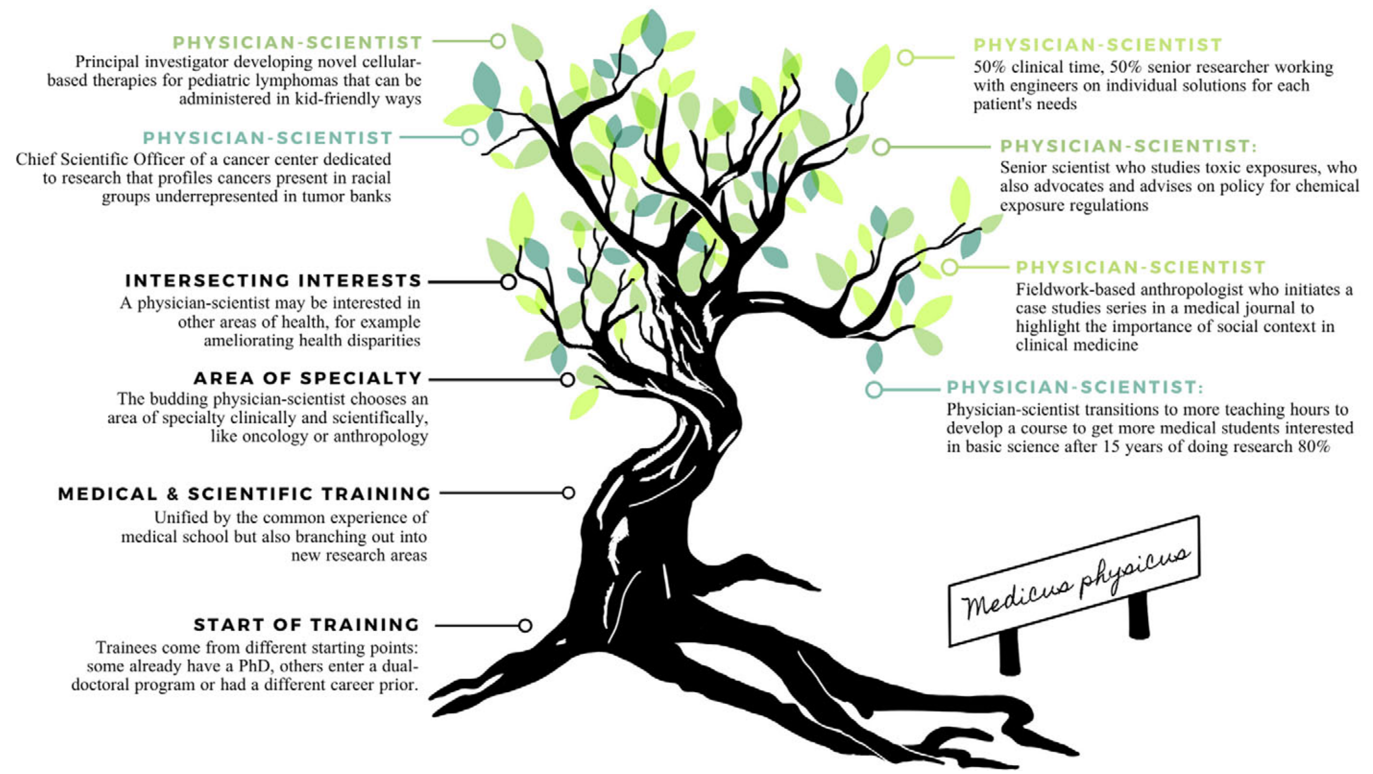

Fig. 1. Re-envisioning the physician-scientist training pipeline within an arboreal framework: *Medicus physicus*.

physician-scientist community that values diverse perspectives [11]. NIGMS has responded by explicitly stating MSTP programs must embrace a diversity of scientific approaches and graduate studies [6]. Now is the time to reconsider whether the current plumbing analogy, where there is only a linear path from A to B, remains appropriate for the next generation of physician-scientists.

Given the multiple entry pathways and numerous destinations, we propose reconceptualizing the pathway from a linear, leaky pipeline to that of a living tree, which we have taxonomically named *Medicus physicus* (Fig. 1). Trainees hailing from many life and research experiences have their careers anchored by their perspective, like roots. Unified through the rigors of clinical and scientific training, like the trunk, toward the common goal of improving patient care, trainees branch into their own niche and contribute to the tree in their own way as leaves on a tree. Extending the analogy, leaves intake various inputs in exchange for new outputs similar to how a physician-scientist builds on work done by predecessors to transform those discoveries into new questions, understandings, ideas, and therapies. This framework recognizes the difficulty in evaluating physician-scientists by the same criteria, because each physician-scientist has their own microenvironment with different cultures, resources, and politics. There is no predetermined destination but rather an endpoint of varied and rich contributions of the physician-scientist community.

Revisiting Metrics of Success Within the *M. physicus* Framework

Two important metrics of success are NIH grants and peer-reviewed publications. When we consider the diversity of the next generation of physician-scientists, the glorification of NIH funding over all other sources becomes dubious. Within a pipeline framework, the linear progression of NIH awards (i.e. F grants for trainees, early-career K grants, and R grants for mid-to-late-career researchers) is sensible. Yet these only fund a small portion of physician-scientists: 21% and 6% of those surveyed by the AAMC received K awards and were principal investigators on an NIH grant, respectively [10]. Additionally, there are considerable disparities in NIH funding for women [12,13] and underrepresented minority groups [13]. These disparities largely disappear when other funding sources are considered [13], suggesting that defining success through attainment of NIH-only grants overlooks and undervalues important work done by women or underrepresented minorities. Our *M. physicus* framework recognizes and celebrates when scholars receive funding from alternative sources such as government contracts, industry funding, or foundation grants. Other grant mechanisms that also aimed to solve imminent health problems often do so through a different lens or expertise, which is just as valuable.

Physician-scientists have a responsibility to the public whose taxes help fund our research and residency training. Moreover, the training that allows us to translate scientific jargon into the patient care setting also positions us to be leaders and educators in the community. Yet, many peer-reviewed publications remain behind paywalls, inaccessible and unintelligible to the public [14]. Academia does not reward physician-scientists who invest time translating their work into public-facing media, such as news articles, blogs, interviews, editorials, or podcasts – all of which are meaningful to establishing a young physician-scientist's expertise.

Science is becoming a team-oriented venture. Some physician-scientists may not become principal investigators but thrive as a

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senior scientist within a laboratory that matches their clinical interests or as a member of a multidisciplinary team that combines basic science, patient care, and public health while sharing responsibility for securing funding. Physician-scientists also advance translational solutions through industry or entrepreneurial endeavors. Their work might be better captured by the number of patents, projects in development, or patient impact. Others are interested in sharing their talents across the globe, partnering with the local scientific community, nongovernmental organizations, foundations, and governments to develop a local physician-scientist workforce to serve the needs of that area. These paths may lead to publications, but their success may also be defined by the number of new physician-scientists trained, laboratories supported, patents earned, new regulations or laws passed, or courses created to inspire more medical students to engage with basic science. Thus, applications for grants, awards, programs, recognitions, affiliations, and tenure should encourage physician-scientists to share the full story of their accomplishments, especially if those accomplishments do not fit neatly into the categories of funding or research output.

Conclusion

Our *M. physicus* framework adapts to changing environmental challenges: growing economic and family pressures, changing culture, new technologies, and evolving clinical demands. Unlike the rigid pipeline, a tree can grow into new spaces previously unimagined: each physician-scientist has to determine how they will use scientific and clinical discoveries to develop new strategies and tools for the benefit of society. For many, the best pathway likely remains academic medicine but rather than problematizing other pathways as "attrition," we should recognize those physician-scientists who see a different way of connecting and serving the public with science. Focusing success narrowly on quantitative measures like NIH funding, papers, and years in academia creates a mold that stifles the potential contributions trainees can make to science, medicine, and humanity. Stakeholders need to recognize that there are multiple roads to developing the physician-scientist workforce and multiple measures of impact and success. There is a need to cultivate an environment that supports trainees at different timepoints along their trajectory across different pathways. The leaves on the traditional 80:20 academic medicine branch of *M. physicus* may appear endangered but the canopy of successful physician-scientists continues to flourish.

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