editorial

Career Enrichment Opportunities at the Scientific Frontier in Radiation Oncology

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In this burgeoning era of precision medicine, artificial intelligence, and immunotherapy, there is a perceived lack of training opportunities for radiation oncologists in the relevant genomics, informatics, and immunology disciplines. In the article accompanying this editorial, Mouw et al[1] report results of a survey of 117 practicing radiation oncologists and trainees, many of whom thought that current training opportunities in these areas are "absolutely" or "moderately" insufficient. Furthermore, many respondents agreed that these disciplines could provide important career advancement and future research opportunities.

Although it is entirely possible that these specific results may represent a biased or limited assessment because of the survey methodology itself, it is clear that this is a reflection of the times. Indeed, as one might expect, it highlights the emerging importance and enthusiasm surrounding each of three key advances from recent years: (1) precision medicine, (2) artificial intelligence, and (3) immunotherapy (a topic that was recently awarded the 2018 Nobel Prize in Medicine). These areas represent a proverbial frontier, with many of the analogous caveats, challenges, and opportunities that might accompany a gold rush.

In recent years, the National Institutes of Health and other funding agencies and foundations have allocated or awarded significant funding for research as well as training in each of these strategic areas. For instance, the National Institutes of Health's Big Data to Knowledge (BD2K) initiative[2] has spawned many significant training programs and educational tools to facilitate careers in data science. Although BD2K funding has been minimal in radiation oncology–specific domains, it has provided legitimacy to data science efforts in general. There has also been a proliferation of funding opportunities for cancer immunotherapy and precision medicine, via support from numerous foundations and larger efforts such as the National Cancer Institute's Cancer Moonshot and the Precision Medicine Initiative.

Relevant expertise in each of these disciplines is distributed fairly broadly across institutions. However, it is increasingly recognized that the challenges and scope are too daunting for most individuals or institutions to excel in isolation. Moreover, the growth of many disparate, uncoordinated efforts probably represents a systematic waste of resources with a high opportunity cost. In this context, large coordinating efforts (eg, the American College of Radiology's Data Science Institute for artificial intelligence in medical imaging,[3] the Radiogenomics Consortium[4] for linking genetic variants with radiotherapy response, and the Parker Institute for Cancer Immunotherapy[5]) represent compelling approaches to maximize transformative potential.

To be both successful and sustained, such efforts require considerable resources and planning. It is unreasonable for every institution—much less every individual—to be a domain expert in all (or even any) of these domains. However, it is entirely reasonable for trainees and the broader professional community to have a basic and operational understanding of machine learning algorithms, cancer genetics and precision oncology, and the cancer immune microenvironment and immunotherapeutic strategies, especially as they relate to radiotherapy. For instance, radiation oncology practitioners should understand the clinical significance of lung cancer variants such as EGFR T790M, which may drive acquired resistance to targeted therapy.[6]

We may not yet know the future state of each of these fields, but their relevance to patient care is already considerable. We would thus be wise to integrate relevant background and basics into residency curricula, as suggested by Mouw et al.[1] For instance, centrally produced training modules could be widely distributed for integration into radiobiology and radiation physics coursework (eg, via high-quality massive open online courses). For the vast majority of residency trainees, we suspect that such modular self-administered online content would help bridge the gap required for basic familiarity and domain knowledge vocabulary without an onerous imposition of additional time in these cutting-edge domain spaces. Modules could be scaled or replaced as paradigm-shifting novel content becomes incorporated into the standard educational offerings.

Motivated learners desiring or requiring more focal development in any individual subarea(s) could elect additional enrichment opportunities. For instance, intensive immersive skills workshops, such as the ECCO-AACR-EORTC-ESMO Workshop on Methods in Clinical Cancer Research[7] or the American Institute for Radiologic Pathology's short course on radiology-pathology

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correlation,[8] provide successful examples for the development of recurring onsite or offsite enrichment opportunities for trainees at all levels, particularly when training resources or expertise are otherwise limited at their respective institutions. Radiation oncology residents may also choose to leverage the increasing research time within many training programs for skills enrichment.[9] Moreover, lifelong learning advocates have a shared responsibility to create and leverage learning platforms that can be disseminated to a broad spectrum within the radiation oncology continuum.

We should also promote and reward advanced fellowship and postdoctoral training pathways as a means to cultivate relevant scientific leadership and expertise in the field, and we may need to consider incentives for select talented trainees (eg, via accelerated training opportunities akin to the Holman Pathway). Although several programs exist (eg, the MD Anderson/National Institute of Biomedical Imaging and Bioengineering–funded FRONTI2ER informatics track for residents and fellows,[10] the National Cancer Institute–Food and Drug Administration Information Exchange and Data Transformation (INFORMED)[11] data science fellowship,[12] and Oregon Health & Science University's Fellowship in Clinical Informatics: Radiation Oncology Track[13]), these initiatives have to date graduated few trainees. This is probably because of their recency of development combined with a general hesitancy among trainees toward prolonged training (an issue in its own right that may require shifts in expectations). In addition, these types of opportunities may be infeasible to extend to programs of limited size without sufficient breadth or depth of core informatics expertise.

TABLE 1. FIRE (foundation, immersion, refinement, and expertise through experiential learning) Longitudinal Engagement Concept

	Foundation	Immersion	Refinement	Expertise
Curricular approach	Didactics (local) and competency-based online learning (scalable)	Administrative or research group involvement	Real-time case studies, directed readings, and active laboratory/group membership	Experiential opportunities with authentic management/research skills application
Extracurricular skill development	Skills and project alignment	Exposure to interaction with internal and external thought leaders, experts, vendors, pharmaceutical partners, and professional societies	Continued project stewardship	Project summation (acquisition of systems, implementation, and deployment)
Extradepartmental engagement			Regional (ie, Clinical and Translational Science Awards) or national meeting exposure	Standards or topic-specific committees (national, international, and/or special interest groups) participation
			Immersive intensive skills workshops	
Genomics/bioinformatics example	Core ACGME curriculum; departmental didactic offerings; and scalable online curricula such as MOOCs	Observational shadowing exposure to laboratory or bioinformatics at home facility	Hands-on experiences with core facilities and researchers at home institute	
			Dedicated research project development and publication (eg, via Holman Pathway)	
Clinical informatics example	Core ACGME curriculum; departmental didactic offerings; and scalable online curricula such as MOOCs	Engagement with departmental or institutional electronic medical record, picture archiving and communication system, information technology, or other informatics specialists	Development of a quality assessment/quality improvement project with informatics components	
			Medical physics or imaging analysis projects that intersect with informatics processes	
			Electronic health record–based health services research	
Immuno-oncology example	Core ACGME curriculum; departmental didactic offerings; and scalable online curricula such as MOOCs	Mentorship by medical oncologist or other immuno-oncology experts	Basic, translational, or clinical immuno-oncology study participation	
			Shadowing/internship experiences/mini-sabbatical with immunotherapy-focused pharmaceutical partners	

NOTE. Adapted from Rao and Gilbertson[9]
Abbreviations: ACGME, Accreditation Council for Graduate Medical Education; MOOCs, massive open online courses.

Radiation oncology may benefit from the models of skills enrichment established among other specialty residencies, such as the FIRE (foundation, immersion, refinement, and expertise through experiential learning) model of iterative mentored informatics training in pathology.[14] Herein, we propose an analogous longitudinal engagement approach for the integration of advanced genomics, informatics, and immunotherapy content and skill development examples that are applicable to radiation oncology trainees (Table 1). Such a model could readily be extended to other emerging subdisciplines of interest.

Finally, we should not lose sight of emerging frontiers in diagnosis and therapy. While the American Society for Radiation Oncology has recently cosponsored summits on big data and immunotherapy, its first think tank meeting (June 2018) was appropriately focused on the additional emerging areas of nanotechnology and biomarkers, which may rightly reflect these fields' future importance and potential. Should we be proactively anticipating training and other needs in these additional fields?

A gold rush generally produces winners and losers, but hopefully we can reframe current paradigms to better coordinate effort and investment, develop curricula and grow expertise, and democratize access for the benefit of all. Should we choose to heed the observations of Mouw et al, we may anticipate that the value proposition of radiation oncology will continue to evolve in a positive direction and will ultimately lead to superior outcomes for patients with cancer.

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