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Author manuscript

Cancer Res. Author manuscript; available in PMC 2016 December 15.

Published in final edited form as:

Cancer Res. 2015 December 15; 75(24): 5202–5205. doi:10.1158/0008-5472.CAN-15-2077.**Essential Components of Cancer Education****Danny R. Welch^{*1}, Toni M. Antalis^{*2}, Kerry Burnstein^{*3}, Linda Vona-Davis^{*4}, Roy A. Jensen^{*1}, Harikrishna Nakshatri^{*5}, Anna Riegel^{*6}, Douglas R. Spitz^{*7}, Dennis K. Watson^{*8}, and George J. Weiner^{*9}**

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Modern cancer therapy/care involves the integration of basic, clinical and population-based research professionals using state-of-the-art science to achieve the best possible patient outcomes. A well-integrated team of basic, clinical and population science professionals and educators

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Conflict of Interest – The authors declare no conflicts of interest.

working with a fully engaged group of creative junior investigators and trainees provides a structure to achieve these common goals. To this end, the structure provided by cancer-focused educational programs can create the integrated culture of academic medicine needed to reduced the burden of cancer on society. This summary outlines fundamental principles and potential best practice strategies for the development of integrated educational programs directed at achieving a work force of professionals that broadly appreciate the principals of academic medicine spanning the breadth of knowledge necessary to advance the goal of improving the current practice of cancer care medicine.

NCI-designated cancer centers are a principal mechanism by which the NIH and NCI fosters and coordinates a broadly based cancer research effort intended to understand the disease at multiple levels and to impact significantly cancer incidence, mortality and treatment. The newest cancer center program guidelines incorporate requirements for centers seeking comprehensive designation to detail plans for cancer education efforts spanning the spectrum of the lay public, trainees, researchers and clinicians (PAR-13-386). Although most, if not all, cancer centers (even those aspiring NCI designation) integrate cancer education efforts across their program activities, the members of the Cancer Biology Training Consortium (CABTRAC; (1)) thought it worthwhile to provide input, with consultation from NCI and cancer center leadership, into the content of cancer education.

NCI-designated cancer center educational components are required to be integrated, coordinated, consistent and evaluative (PAR-13-386). Training elements must be incorporated into the overall strategic plan of cancer centers and coordinated across all of the research, clinical, and delivery disciplines, meaning that there are educational components integrated into (but not necessarily equally in) all programs. While the specifics of the training efforts are tailored to the needs and resources available within a given research program, that training needs to be effective and the quality of education must be consistently outstanding and outcomes evaluable.

The challenges in meeting this requirement are that different groups require specialized content and that each specialty and sub-specialty, while not necessarily speaking a different language, often speak different dialects. Certain cross-cutting elements are fundamental to all fields, including researchers, patients and care givers. Cancer education efforts need to be integrated to support the ultimate goal of improving the current practice of cancer medicine. Education within cancer centers needs to assure cross-training and exposure to a broad range of disciplines. Doing so reduces the persistence of silos which will, in turn, facilitate the ultimate objective of cancer centers – rapid translation of discoveries into clinical practice. In this *Perspective*, we focus on the education of researchers and care givers.

An implicit tenet of our approach is that effective education of cancer professionals is prerequisite to the highest quality community education. To this end, there are certain basic skills and knowledge that every cancer professional needs. There is also advanced knowledge that specialists require; the latter is not the focus of this *Perspective*. Rather, we focus on the common elements of knowledge that every cancer professional should have, proposing a framework upon which each cancer center can build educational programs and considerations for quality assessment and improvement. All recommendations are couched

in the recognition that advances often occur at the intersection of disparate fields, a continuously evolving and ever-expanding knowledge base, increasingly complex medical care delivery and reimbursement climate, different pedagogic approaches, and the increasing need to have specialized knowledge.

Acknowledging that not all cancer centers or institutions are identical in size, resources, organizational structure (e.g., free-standing vs. matrix) or expertise, a one-size-fits-all approach to cancer education is both impractical and unrealistic. Not every cancer center is NCI-designated, but all still educate aspiring cancer professionals and the public.

Each cancer center has multiple educational stakeholders

Who are the educational stakeholders? Access to cancer education should ideally be provided to every employee associated with cancer discovery research, clinical delivery and outcomes assessment (Table 1). In the United States, the trend has been toward fewer young people entering STEM (science, technology, engineering, mathematics) fields (2, 3). Yet, people coming from non- biomedical fields (physics, computer sciences, engineering, social sciences) are increasingly having an impact on cancer discovery and care. Therefore, it is imperative that cancer centers attempt to accommodate education of non-traditional contributors. And education should not be limited to only personnel in traditional ‘professional’ roles. Secretaries and receptionists field phone calls from patients seeking referrals or access to trials; so, having some basic knowledge of cancer fundamentals would logically improve the efficiency of connecting patients with the right specialist or sub-specialist.

A core assumption when considering cancer education is that basic or foundational, laboratory research is part of a continuum which leads to translational research and eventual clinical practice via dissemination and delivery of knowledge (4, 5). Every member of that continuum performs essential work to bring new discoveries into clinical practice and creates a culture of integration where all members of the cancer research/therapy act in concert to achieve their common goals. At each stage of development, there are hurdles that thwart progress. Too often, the languages of each segment are not fully understood by people up- or down-stream. Therefore, a key objective for every cancer center educational plan will be to reduce those barriers and create a common knowledge base that encourages the integration of activities spanning the whole continuum from basic research to improving clinical care.

Any comprehensive educational program incorporates both technical knowledge as well as honing of ‘soft skills.’ These components can be presented in didactic or Socratic styles; face-to-face or online; continuously or dispersed throughout the tenure of training. While process is important, content is more critical. Targeted therapies will change how oncology is practiced within the next 10-20 years. Therefore, training of medical care practitioners about the newest scientific discoveries is just as essential to progress in the field as it is for laboratory researchers to understand practical clinical needs.

Critical technical knowledge in cancer

CABTRAC previously provided recommendations regarding research training in cancer biology (6). Of course the intensity of training for doctoral and postdoctoral researchers will be greater for these topics than for other disciplines (Table 1). Foundational coursework needs to include: the updated ‘hallmarks’ of neoplasia, including the intrinsic dysregulation of signal transduction (receptors and signaling cascades), mutagenesis, regulation of cellular proliferation and death, DNA repair, cancer genetics and epigenetics, developmental biology (including stem cells and their niches), tumor-stromal interactions, pathobiology, and tumor progression (angiogenesis, invasion, metastasis) and heterogeneity. Exposure to emerging technologies (including imaging, genomics, proteomics, and metabolomics), biostatistics, informatics, data interpretation, ‘big data’ analysis using publically available tools, cancer disparities (including differences in susceptibility, therapy response and health care delivery), and basic experimental design (i.e., control groups, concepts of adequate statistical power, reproducibility, etc.) is essential. Pros and cons of experimental models (e.g., mammalian vs non-mammalian; xenograft vs syngeneic models vs PDX vs cell lines) need to be incorporated into the system. Regulatory/ethical aspects of using specific models/reagents for research are too often overlooked in many education programs.

Analogously, clinically focused physicians, nurses and care givers receive more intensive training in therapeutic and chemoprevention strategies (including cytotoxic chemotherapies, immunotherapy, hormonal therapy, radiotherapy and gene therapy), clinical trial design, diagnostics and imaging compared to most laboratory-based personnel. Considerations regarding cost and relative impact should also be integrated. In the field of population science, investigators including those focused on epidemiology and cancer prevention and control, receive training focused on techniques for extracting and analyzing data from large data sets including, but not limited to, long-term observational studies in large populations.

Cross-training is essential

Institutions involved in both basic cancer research and clinical care need to develop a culture of integrating knowledge from different specialties. Each specialist will necessarily focus on his/her area(s), but awareness (if not a modest working knowledge) of topics outside of one's discipline is essential to accelerating the translation of laboratory discoveries into clinical practice. Just as the delivery of cancer care has moved toward clinical navigators and a coordinated treatment plan involving multiple clinical and nursing specialists, laboratory research is marching toward more ‘team science.’ This is a positive development that is to be encouraged, but lab-based researchers need to be exposed to clinical cancer as much as clinically-based care deliverers need to update themselves on advances that will eventually impact patient care. Both groups should interact frequently with population scientists and outcomes researchers. Throughout the educational continuum, educators and learners (regardless of level) are in a co-equal partnership to improve knowledge and skills.

However, in addition to the different languages represented, there are practical considerations for the professional development of the faculty. University or cancer center promotion and tenure committees must develop plans that do not penalize researchers,

clinicians and ancillary care professionals for contributing to larger programs. Metrics need to be collectively defined so that scholarly activities within more communal efforts are appropriately recognized and rewarded.

Professional development is also key to comprehensive cancer education

Cancer education is not solely about facts regarding the etiology and treatment of the disease. It is also about humanization of the disease. While fortunately changing, many young cancer researchers have never met a cancer patient nor can they appreciate the challenges patients and families face when diagnosed. Whenever possible, young researchers should interact with patients during the course of their research training. Involving patient presentations provides a completely different perspective and renewed motivation. Likewise, too few medical professionals interact with laboratory researchers. Doing so would help researchers focus on issues deemed most important by those delivering care.

There are other non-technical skills that should be accessible to everyone at a cancer center. Clear communications, whether oral or written, with people with different backgrounds, people skills (compassion, empathy, caring), continual learning, time-management, budgeting, critical thinking and logic are all skills that can be developed and honed. A comprehensive educational program absolutely must include professional development opportunities in each of those areas. Interacting with, or better yet involving, patient advocates adds value to research and helps in professional development and helps to educate the general public regarding benefits of investing in fundamental research. Similarly, every person in cancer discovery and clinical practice is faced with ethical dilemmas. Every cancer center employee needs to be aware of the importance of responsible conduct in the laboratory, clinic and in public places.

Bridging Disciplines and Providing Opportunities

An important goal of a cancer center's educational strategic mission is to provide training programs that facilitate trans-disciplinary translational cancer research efforts that stem from a mature understanding of clinical oncology. Trainees should try to bridge the disciplines of fundamental cancer biology, clinical oncology and cancer care delivery and community-based cancer control so that they may address unmet research questions that span the full clinic-to-bench-to population spectrum and *vice versa*. This objective can be achieved by implementing a system of co-mentoring and integrated programming/curricula.

To illustrate, we present an example for a doctoral graduate student; however, analogous scenarios can be developed for others. Dual mentoring between a “traditional” biomedical research mentor and a physician mentor is one pathway towards integrating training in fundamental cancer biology with clinical oncology. A physician mentor provides clinical perspective on issues of cancer prevention, diagnosis, prognosis, management and treatment of cancer patients and clinical research approaches. Trainees may elect to “shadow” their physician mentors in clinic and/or interact in other venues. Ideally, a physician mentor would be a member of the student's mentoring committee. An added benefit is that the interactions generate opportunities for collaborations, leveraging the educational and

research missions of cancer centers. However, such co-mentoring is achievable only when institutions devise tools to recognize contributions of physician mentors in graduate/professional education.

Development of formal seminar series and curricula can effectively bring together cancer center members (clinical and research) and biomedical trainees. For example, trainees doing basic research may be paired with clinical fellows to give periodic presentations centered around thematically-related cancer research interests on disease/translational topics. Courses, seminars, journal reviews in which collaborating fundamental science and clinical faculty participate also provide valuable examples to trainees. Numerous opportunities already exist and could include participation in: Tumor Boards; Site Disease Groups; Clinical Research or Pathology Conferences, Protocol Review Committees and Compliance/Safety Review (IRB, IACUC) committees.

Many graduates of doctoral programs and medical schools have minimal exposure to teaching techniques and opportunities. To partly overcome time and reimbursement limitations (see below), integration of postdoctoral fellows and residents into teaching of graduate students and medical students should be considered. These opportunities will provide them with the chances to hone necessary communication and organizational skills, while providing experience in a supervised setting. Even if they choose not to pursue academic careers, the skills are widely applicable.

Similar elements need to be integrated into medical, nursing and public health education (for cancer centers affiliated with medical, nursing, public health or allied health schools). In recent years, cancer education has commonly been distributed throughout the curricula (i.e., organ- or systems-based), rather than as a distinct cluster of diseases with different cellular origins (7). Opinions differ regarding the merits of this approach; however, it is indisputable that understanding of the underlying mechanisms driving cancer improves the ability to deliver higher quality medical care.

The use of individual development plans (8) ensures communication between trainees and mentors and allows for training experiences to be more personalized. Customization of training plans can aid trainees in identifying their passions as well as assist mentors in preparing trainees for a wide range of career opportunities. Importantly, these plans need to be regularly (at least annually) reviewed and revised and mentoring/educational teams need to meet face-to-face regularly (at least annually, but preferably more often).

Challenges and Opportunities

There are multiple practical challenges associated with implementation of an integrated educational program (Table 1), including limited clinician time for non-revenue generating activities; adapting existing clinical activities so that they are accessible to trainees without greatly increasing the work load of faculty; maintaining scientific, medical, or experimental focus and rigor for trainees while promoting educational opportunities in clinical oncology, identification of funding mechanisms for pre-doctoral, post-doctoral and research residency trainees who would otherwise be covered full time on their mentors' grants or clinical activities. Privacy regulations can also limit opportunities for shadowing. While training

grants are great, what do newer or emerging cancer centers do if existing post-doctoral/pre-doctoral pools are not sufficient for NCI T32 rules for a ratio of 3:1? How can young learners be enticed to pursue careers in cancer research and oncology? How can different educational missions be leveraged within individual programs (basic and clinical)? How do the educational missions leverage resources of the cancer centers?

These issues and questions involve complex issues and solutions will be both shared and unique to each Cancer Center. A key to advancing cancer education is sharing of best practices, which is how CABTRAC was organized for graduate education. Whenever possible, cancer center leadership should seek to be actively involved in teaching the teachers. By doing so, the needs of cancer education can be more efficiently and more effectively delivered. There should also be continuous evaluation and quality improvement strategies for cancer education.

In identifying these issues and making recommendations, we have purposely avoided prescribing a specific process. Educators at every institution must customize delivery and exposure to the foundational education program based upon the cultures and resources at their respective institutions. Otherwise, the challenges would be even more daunting. Rather, we have focused on addressing the question: What does everyone in the cancer center need to know? Once learners are provided with that information, then advanced topics can be provided to specialists; opportunities given to young people who wish to contribute to cancer discovery and care; and, helpful information provided to the public so that they can better prevent cancer and improve outcomes.

Acknowledgments

All of the authors have been generously supported by grants from the National Cancer Institute as well as many other agencies, foundations and gifts. DRW is the Hall Family Professor of Molecular Medicine and is a Kansas Bioscience Authority Eminent Scholar. The opinions represented in this perspective are those of the authors and do not necessarily represent those of their respective institutions.

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Table 1
Critical components of cancer education

Stakeholders	<ul style="list-style-type: none"> \$ Everyone involved in discovery or delivery of cancer care, including basic researchers, clinicians, population scientists • Patients and families of cancer patients • Personnel interacting with patients and their families
Content	<ul style="list-style-type: none"> • Foundational technical knowledge with specialized options • Training for teachers \$ Incorporates cross-training • Integrates professional development, responsible conduct, ethics
Organization	<ul style="list-style-type: none"> • Institution-specific \$ Customizable • Incorporates best practices • At every level throughout the organization • Coordinated • Evaluable
Challenges	<ul style="list-style-type: none"> \$ Reimbursement and funding models \$ Accessibility \$ Privacy \$ How to encourage recruitment into oncology-related fields \$ How to best disseminate best practices

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