

**PROMOTING INTERDISCIPLINARY RESEARCH IN
DEPARTMENTS OF MEDICINE:
RESULTS FROM TWO MODELS AT BOSTON UNIVERSITY
SCHOOL OF MEDICINE**

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ABSTRACT

We have sought to broaden our department's research capacity using two different interdisciplinary approaches. First, we created the Evans Center for Interdisciplinary Biomedical Research (ECIBR) — a virtual center that promotes and funds Affinity Research Collaboratives (ARCs) initiated by faculty from within and outside Boston University (BU). Of the 11 funded ARCs, the 4 ARCs in existence for a minimum of 3 years have a total of 37 participants, 93 co-authored publications, and 33 new grants. Second, the Department of Medicine (DOM) created a Section of Computational Biomedicine in 2009 to enhance analytical and computational expertise in the DOM. After 3 years, the section is comprised of 10 faculty members and 21 trainees. The faculty members have collaborated with 20 faculty members in other sections or departments and secured 12 extramural grants (totaling ~\$20 million in direct costs). The ECIBR and the Section of Computational Biomedicine represent new organizational approaches to stimulating innovation in research in a DOM.

INTRODUCTION

The evolving opportunities in clinical care, education, and research require optimization of the organizational structures in academic medicine. Because Departments of Medicine (DOMs) have a critical role in leading academic medicine, it will be increasingly important for DOMs to be organized in a manner that maximizes their efficiency and effectiveness. DOMs are traditionally organized in sections or divisions according to their clinical, training, and research missions. Accordingly, nearly all DOMs have sections of cardiology, pulmonary medi-

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cine, gastroenterology, infectious diseases, endocrinology, general internal medicine, hematology-oncology, rheumatology, and nephrology. In some departments, geriatrics or dermatology is included and in others these specialties are outside the DOM. The sectional structure has been very well aligned with the specialty training pathways of the American Board of Internal Medicine and Accreditation Council of Graduate Medical Education, as well as with the clinical mission. This section structure is also matched with the institute structure of the National Institutes of Health in many cases. Nonetheless, as DOMs seek to both lead and take advantage of research advances and new technologies, the conventional section-based structure may be insufficient to cultivate broad-based research programs.

Growing understanding of the common biologic processes that occur in a diverse array of cell types, organs, and tissues has created a new opportunity to more rapidly prevent, diagnose, and treat disease. For example, the molecular and cellular pathways controlling inflammation and fibrosis are pertinent to disease processes in every specialty of internal medicine. Increasingly, the power of consilience in medical research has become more evident (1). The power of new technologies that generate high-throughput molecular datasets and phenotype large patient populations open up mechanistic and intervention studies for human disease. New computational approaches designed to model biologic systems and networks have created new approaches to modulate human pathophysiology in a more holistic and integrated manner.

The opportunities in interdisciplinary research have prompted academic leaders to create additional structures to enhance interdisciplinary and interdepartmental research (2). These strategies typically include identification of priority areas such as cancer, neurosciences, inflammation, and emerging infectious diseases, through a “top down” strategic planning process. These efforts have facilitated work across disciplines and have become successful models for interdisciplinary research. However, these centers require substantial institutional investment to start and sustain the programs, and have created fewer opportunities for individual faculty members within the institution to more spontaneously identify and leverage new research directions.

Traditional academic structures and practices have not consistently supported interdisciplinary research (3–5). For example, fund flows in academic centers generally follow departmental or center structures. The sharing of funds across these entities in a manner that would enhance collaborative programs is not consistent or well developed. As noted above, DOMs have traditionally prioritized section/division

structures that are aligned with the clinical and clinical training mission, rather than the research mission. Disciplines have distinct language and culture that must be overcome to foster interdisciplinary research. Academic promotion is typically based on one's success as an independent investigator. Success as a collaborator, although encouraged and frequently necessary, is not generally rewarded in the promotion process of research-intensive DOMs. These opportunities and challenges create the need for new research paradigms that supplement the traditional section-based organization of DOMs. Therefore, we implemented two new research structures designed to enhance interdisciplinary research in a research-intensive DOM: a departmental center — the Evans Center for Interdisciplinary Biomedical Research, and a new section — the Section of Computational Biomedicine. Our initiatives were intended to provide individual faculty with the resources and the opportunity to pursue new research directions. We describe herein how these initiatives were established, their goals, and results from the first 3-year follow-up period.

To provide context for understanding the initiatives described below, the nature of the Department of Medicine at Boston University School of Medicine and Boston Medical Center should be described. The department is comprised of 434 faculty members including more than 100 members with a PhD, has 250 members who are funded through research grants, and has an annual research budget of approximately \$120 million. In addition to the traditional organ-based sections, the DOM has five research sections: Preventive Medicine, Clinical Epidemiology, Biomedical Genetics, Vascular Biology, and the new section described below - Computational Biomedicine.

EVANS CENTER FOR INTERDISCIPLINARY BIOMEDICAL RESEARCH

The goals of the Evans Center for Interdisciplinary Biomedical Research (ECIBR) were to create and test a faculty-driven approach to the development of interdisciplinary research; enucleate new research areas that take advantage of the scientific environment in and outside the DOM; build meaningful bridges outside Boston University School of Medicine, especially including other academic and commercial institutions; create new training opportunities for graduate students and post-doctoral fellows; and to provide the groundwork for new areas of translational research. In essence, we sought a “bottoms-up” approach that would create and facilitate opportunities for faculty to pursue new approaches of shared interest.

The ECIBR was established in early 2009 as a “virtual” center under the leadership of a part-time scientific director (Katya Ravid) assisted by an administrator. A series of meetings were held with faculty in and outside the DOM to explain the goals of the ECIBR and to solicit their input to optimize the effectiveness of the ECIBR. Faculty members were then invited to seek funding for research groups which we termed “Affinity Research Collaboratives” (ARCs). To successfully compete for funding, the ARCs were required to contain faculty members from within and outside the DOM, include a new and compelling research plan, have a training component and seminar series, and to be distinct from any existing centers or programs at Boston University (BU). Ideas for ARC themes were envisioned primarily by investigators and, in a few cases, by the ECIBR Director. The ARCs were typically developed by 8 to 15 core faculty members and refined with substantive input from the ECIBR Director. ARCs were reviewed through a peer-review process by investigators within and outside the DOM. The ARCs were typically provided \$50-75,000 per year and were required to compete for funding on an annual basis. The funds were used for pilot studies, seminars, and trainee support, but not faculty salary. In addition to the establishment of the ARCs, the ECIBR also established “pre-ARCs” as a prelude to a formal application for ARC funding. The ECIBR supported meetings and mini-symposia organized by the pre-ARCs to facilitate collaborative relationships before a formal ARC application. To better recognize and enhance the collaborative milieu, “Collaborator of the Year” annual awards were established in several categories. The DOM provided all funds to support the ECIBR, including the ARCs.

Since inception in 2009, the ECIBR has funded 11 ARCs. These include: “Protein Trafficking and Neurodegenerative Diseases,” “Sex Differences in Adipose Tissue: Mechanisms and Role in Disease Risk Associated with Obesity,” “Mitochondrial Dynamics in Health and Disease,” “Regenerative Medicine: The Boston University Induced Pluripotent Stem Cell (iPSC) Bank,” “Blood Microbiome,” “Cardiovascular Consequences of Metabolic Disease,” “Biomarkers of Disease: A Proteomics Approach,” “Calcium Homeostasis in Health and Disease,” “Mechanisms and Treatment of Arterial Stiffness,” “Obesity, Cancer and Inflammation,” and “Nanotheranostics.” Of the 11 ARCs funded, 4 have been in existence for 3 years. The 4 3-year-old ARCs have a total of 37 core participants from multiple departments within and outside of BU, and have published 93 co-authored publications during this period, and were awarded 33 grants. The 11 ARCs in existence for 1 to 3 years have involved 150 participating faculty members, 25 of whom

have primary appointments outside BU, 65 graduate students, and 30 post-doctoral fellows. During the period from early 2009 through late 2011, ARC participants have published 184 publications on ARC-related work and 48 have obtained new extramural grants (including one program project grant from the NIH) (Table 1). Notably, the success rate for ARC grant applications to date has been approximately 50% — much higher than for our department as a whole. As might be expected the ARC participants greatly enhance their interactions with new and existing faculty. The quantitative assessment of social networks within the ECIBR and the potential impact on scientific collaborations has been previously described (6).

SECTION OF COMPUTATIONAL BIOMEDICINE

The second major initiative designed to enhance interdisciplinary research was also in response to faculty expertise and interest. The goals in establishing the Section of Computational Biomedicine were to create a new structure to enhance the expertise and infrastructure for developing interdisciplinary computational approaches to large biomic or molecular datasets; promote research in biologic systems and networks related to human disease; create training opportunities for subspecialty fellows, bioinformatics students, and post-doctoral fellows; and leverage emerging computational methods to develop novel diagnostic and therapeutic strategies.

Additional programmatic rationale for establishing a Section of Computational Biomedicine in our DOM was to address the emerging and critical need to translate the rapid advances in high-throughput genomics into all the specialty areas of internal medicine. The post-genomic era has not only shifted the translational research paradigm from studies of single genes or pathways to large-scale studies of genome-wide datasets, but has also highlighted a key role for clinically trained computational biologists to identify important patterns in the increasingly complex datasets produced by high-throughput technologies. These growing datasets and the emerging computational tools have profoundly altered biomedical research, and they are destined to stimulate an explosive growth in diagnostic, preventive, prognostic,

TABLE 1
Metrics of Affinity Research Collaboratives

	Number of Participants	Number of Publications	Number of Extramural Grants
Total for all ARCs (2009–11)	150	184	48
Four 3-year-old ARCs	37	93	33

and therapeutic approaches to the practice of medicine. The need for clinically trained leaders from multiple disciplines who will play a proactive role in guiding these developments is crucial to realize the clinical benefit from these scientific advances.

The Section of Computational Medicine was established in 2009 under the direction of a Chief (Avrum Spira) and using start-up funds provided by the DOM. Since 2009, 10 faculty members (3 with MD degrees, 7 with PhD degrees) and 21 post-doctoral fellows and graduate students have joined the section. Infrastructure was comprised of high throughput sequencers and high capacity analytic and storage systems for processing large genomic datasets.

The section faculty are collaborating with 20 faculty members from five different departments and six different sections within the DOM. Examples of active projects in the section include rapid identification of infectious pathogens in clinical specimens via next-generation sequencing, construction of a pre-cancer genome atlas to characterize the early molecular events associated with carcinogenesis, developing gene expression profiles as predictor of environmental carcinogenicity, identification of new therapeutic targets for COPD using *in silico* connectivity mapping, development of a genomic biomarker to predict prognosis of lymphomas, and establishing personalized approaches to lung cancer chemoprevention using airway gene expression signatures. Since the section was formed in 2009, the faculty members have secured 12 new extramural grants totaling \$20 million in direct funds. The collaborative opportunities for the section have continued to accelerate in its fourth year of existence.

DISCUSSION

We have described two different organizational paradigms designed to enhance the interdisciplinary research enterprise in a DOM. These two examples are provided with the strong belief that DOMs must adapt and evolve their research structures to take full advantage of the capacity of new technologies and knowledge across disciplines to favorably impact human health. However, these examples are not provided with the intention to replace conventional section and division structures—those will continue to be needed for the breadth of missions of DOMs and for their disease focus.

The ECIBR and Section of Computational Biomedicine have succeeded in facilitating new research directions for our department. The key elements in the success of the ECIBR in enhancing interdisciplinarity in our department have been the “bottoms-up” approach of

engaging faculty in the creation of new research directions. Critical to the success have been: effective visionary leadership by the Director, additional funds to support new research initiatives, requisite involvement by faculty members representing different disciplines, engagement of participants from outside the DOM and School of Medicine, an educational component, internal peer review in maintaining quality control, and creation of awards to recognize effective individual collaborators.

The success of the Section of Computational Biomedicine is attributable to the vision and leadership of the section chief, investment in enhancing infrastructure and empowering individual faculty members, a rigorous training environment for students and post-doctoral fellows, and the successful development of new computational approaches to define biologic and disease networks. The section has had a very strong appeal for faculty, students, and post-doctoral fellows interested in working in a DOM on clinically important problems. In addition, the section has been highly attractive to medical residents and fellows interested in clinical investigation through training in computational sciences.

As we seek additional strategies to enhance interdisciplinary research in our DOM, challenges persist despite the success of the two programs described above. Our academic promotion system continues to struggle with how to recognize achievement of individual faculty members working in interdisciplinary teams. The success of several of the ARCs has created new opportunities to mature the ARCs into freestanding programs. Funding of these programs beyond what they are able to generate from research grants will become a new challenge. We will have to judiciously balance the funding of new ARCs with that of more mature successful programs. We will also need to more effectively distribute indirect funds according to how the indirect costs are incurred by the interdisciplinary teams.

The challenges that lie ahead for the Section of Computational Biomedicine are no less daunting. As sequencing technologies continue to rapidly evolve, the infrastructure needed to support storage, analysis, and dissemination of these growing datasets will be more difficult to sustain. Integrating these emerging molecular datasets with clinical data from electronic medical records is yet another frontier that will need to be crossed. The biggest challenge, however, may rest with our ability to identify and influence physicians at all levels of training within internal medicine and other specialties of medicine who are willing and able to pursue additional training in this discipline. This represents a critical need if we are to produce the next generation of

physician-scientists who will be leaders in applying and stimulating the development of post-genomic technologies to clinical research and the practice of medicine.

The ECIBR and Section of Computational Biomedicine also illustrate the potential benefit of investing in interdisciplinary groups of faculty and new infrastructure designed to facilitate the discovery process. To meet our obligation of improving the health of the public, we will have to create other examples of organizational approaches to building capacity of our research programs in addition to those conferred by the traditional structure of DOMs.

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DISCUSSION

Schiffman, Providence: David, how have you drawn in students, residents, and fellows and addressed our mission of nurturing and treasuring our younger colleagues? Has your approach been generalized to include these groups?

Coleman, Boston: That's a good question. So, we've done that in several ways. One is that fellows and students have been put on some of the projects that these two initiatives have sponsored; secondly, they have a very robust seminar series; and lastly, the Evans Center has just announced establishment of fellowships to fund a portion of the salary of fellows who are working within these research collaboratives. One of the really important lessons that I didn't stress adequately that your question illustrates is that graduate students and the post-doc fellows are really important sources of bridging these collaboratives, and that's a social network that I think we should continue to develop.