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Anatomists Provide the Foundation for Learning Pathophysiology

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Abstract

The need for interdisciplinary graduate training programs which prepare students to conceptualize the application of their research in clinical settings continues to grow. Though several programs have been cultivated to address this need, demand still outweighs supply. The following describes a curriculum developed with the intent of incorporating medical knowledge into a PhD graduate training program. Development of this Molecular Medicine program by the Cleveland Clinic Lerner College of Medicine in collaboration with Case Western Reserve University was funded by the Howard Hughes Medical Institute “Med into Grad” initiative. The core curriculum of this program begins with a foundation in Human Physiology and Disease course in which anatomy faculty introduce students to a basic overview of gross anatomy structure and function. This course is followed by five fundamental basic science courses, a composite course focusing on principles of clinical and translation research, a course on laboratory techniques and three, 12-week research rotations. In the second year of the program, students begin their dissertation research, complete their qualifying examination, and partake in an individually-tailored Clinical Experience course. Interdisciplinary graduate programs like this provide another venue for faculty in anatomical sciences to help aspiring translational scientists relate basic science knowledge to human pathophysiology and health.

Keywords

gross anatomy education; anatomy teaching; pathophysiology education; graduate education; curriculum; basic science faculty; integration; translational research

Introduction

The emergent need to bridge the gap between laboratory research and clinical medicine to improve human health through educational initiatives has been on the fore-front of academic medicine news for several decades. In 1964 the National Institute of General Medical Sciences (NIGMS) developed a Medical Scientist Training Program (MSTP) to educate scientists who are able to function in both the basic science and clinical research

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environment (NIGMS, 2011). More recently, initiatives from the Markey Trust (NRC, 2004) and the Howard Hughes Medical Institute (Kuehn, 2006) have attempted to address the need to integrate medical knowledge into graduate education to facilitate the “bench to bedside” process.

Extending training through the MSTP program or requiring multiple postdoctoral appointments following graduate school will not address the national need to sustain the translational research pipeline (Dance, 2011). Basic (PhD) scientists already are older before obtaining their first NIH grant (average age of 42 in 2010 as compared to 36 in 1981) and have fewer opportunities to obtain tenure-track faculty positions (Collins, 2010). We believe the future of biomedical investigation requires interdisciplinary PhD training programs where the intent from the onset is to produce graduates who understand human physiology and pathophysiology.

Molecular Medicine Program

In 2007, the Cleveland Clinic Lerner Research Institute implemented a PhD program in Molecular Medicine (MMED) in collaboration with Case Western Reserve University (CWRU) to incorporate medical knowledge into graduate training. The MMED program focuses on integrating pathophysiology and clinical medicine into graduate education without extending training time. Its development was funded by the Howard Hughes Medical Institute’s “Med into Grad” initiative (Kuehn, 2006) and is consistent with National Institutes of Health Roadmap directives (Zerhouni, 2003). Prospective students must complete undergraduate courses in; General Biology, General Chemistry, Organic Chemistry and Biochemistry. They are also strongly encouraged but not required to complete a course in Molecular and/or Cell Biology. The first and second year of the curriculum is comprised of core and elective courses, journal club, laboratory rotations and clinical experiences (Table 1).

Required elements of the 13-month core curriculum begin with a course providing a solid foundation in human physiology and disease. This is followed by five fundamental courses encompassing Cellular/Molecular Biology, Metabolism, Genetics, and Immunology. The core curriculum concludes with a composite course focusing on principles of clinical and translation research, which includes ethical and regulatory issues along with biostatistics and epidemiology. Concurrent with required course work in Year 1, students complete a course in laboratory techniques and three, 12-week research rotations at the Cleveland Clinic, the university or affiliated teaching hospitals. Enrichment activities are interspersed throughout the program (i.e., student-run journal club, seminar series with medical students, weekly opportunity to participate in autopsy conferences with fixed specimens, etc.) so that students can develop their research abilities and network with faculty.

In Year 2 of the program, students start their dissertation research, complete a Clinical Experience course, and take their qualifying examination. The Clinical Experience, which is individualized for each student and supervised by a clinical mentor, includes clinical elements (i.e., inpatient and clinics as well as surgical observation, diagnostics, histology, radiology and clinical research team experiences) specific to each student’s field of research and dissertation topic. Students complete the formal curriculum with two elective courses offered by CWRU’s School of Graduate Studies.

In the inaugural year, 45 prospective students applied to the program with a total of nine students matriculating. Each year the number of applications submitted has steadily increased with a total of 72 applicants received in the most recent year. To date, the program has enrolled 40 students (18% underrepresented minorities) and awarded three graduates with PhD degrees in Molecular Medicine from CWRU.

Our program attracted applicants with nontraditional backgrounds (i.e., engineering, computer science, mathematics, etc.) seeking research careers related to human health. This diversity presented an unanticipated challenge during the Introduction to Human Physiology and Disease course in Year 1 because a subset of students lacked sufficient anatomy/histology knowledge to learn human pathophysiology. To address this need, program leadership recruited members of anatomy faculty in the Cleveland Clinic Lerner College of Medicine (CCLCM) to introduce students to gross anatomy of several systems including; Nervous, Cardiovascular, Respiratory, Gastrointestinal, Urinary and Reproductive. In these two-hour weekly sessions anatomy faculty presented material on the overall function of these systems, a description of the included organs and structures, and clinically relevant correlations related to pathophysiological processes. Students complemented anatomy instruction with electronic resources and optional attendance at weekly autopsy conferences with fixed specimens. Over 95% of the 40 enrolled graduate students rated the Human Physiology and Disease course as “Good” or “Excellent” when completing the end of course evaluation. Anecdotally, students said they found the anatomy sessions invaluable because it gave them a reference point for material discussed later in the week. For instance, one student wrote on the course evaluation, “Anatomy lectures were very instrumental to my understanding of physiology as I had little previous knowledge of anatomy or physiology”.

Discussion

The growing complexity of science will require graduate students who possess a broad understanding of human biology and disease (Arias, 1989) and have the flexibility to work on multi- and interdisciplinary teams (Flexner, 2009). We learned early on during the Introduction to Human Physiology and Disease course in this PhD program that beginning graduate students from diverse backgrounds did not have sufficient exposure to anatomy to learn human pathophysiology. Given this need, we encourage faculty in the anatomical sciences to seek opportunities through formal course work (Askew and Heffelfinger, 1998) or enrichment activities (Follen, et al., 2007) to contribute to the foundational knowledge that will help aspiring scientists integrate medical concepts into their understanding of human health and disease. In fact, including faculty from basic science and clinical departments as instructors in these educational initiatives should model the type of collaborative relationships needed to take science from the bench to the bedside (Arias, 1989; Bush et al., 2006). Our graduate students certainly appreciated the clinical relevance that basic scientists and physicians added when teaching in the core curriculum of this Molecular Medicine PhD program. Thus, we believe developing training programs which emphasize pathophysiological concepts and include clinic experiences will foster trainees’ interest in translational research (Follen, et al., 2007) and will help narrow the gap between basic and clinical scientists (Hall, 2002; Resifo and Phelan, 2011).

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LITERATURE CITED

- Arias IM. Training basic scientists to bridge the gap between basic science and its application to human disease. *N Engl J Med*. 1989; 321:972–974. [PubMed: 2779621]
- Askew DS, Heffelfinger S. Graduate education in microscopic anatomy. *Anat Rec*. 1998; 253:143–146. [PubMed: 9811122]

- Busch R, Byrne B, Gandrud L, Sears D, Meyer E, Kattah M, Kurihara C, Haertel E, Parnes JR, Mellins ED. Medicine on a need-to-know basis. *Nat Immunol*. 2006; 7:543–547. [PubMed: 16715061]
- Collins F. Scientists need a shorter path to research freedom. *Nature*. 2010; 467:635. [PubMed: 20930798]
- NRC. Bridging the Bed-Bench Gap: Contributions of the Markey Trust. 1. Washington, DC: The National Academies Press; 2004. National Research Council. Committee on the Evaluation of the Lucille P. Markey Charitable Trust Programs in Biomedical Sciences, Board on Higher Education and Workforce Policy and Global Affairs Divisions, National Research Council; p. 134
- Dance A. The best of times and the worst of times: Postdocs balance the joys of pure research with tough working conditions. *HHMI Bull*. 2011; 24:24–29. URL: http://www.hhmi.org/bulletin/may2011/pdf/postdoc_life.pdf.
- Flexner C. Our students, our selves: Multidisciplinary training is changing who we are. *Clin Transl Sci*. 2009; 2:256–257. [PubMed: 20443903]
- Follen M, Peek K, Crain BT. New pathways to educate future translational researchers: early education for undergraduates. *Gynecol Oncol*. 2007; 107:S50–S55. [PubMed: 17825389]
- Hall JE. The promise of translational physiology. *Am J Physiol Heart Circ Physiol*. 2002; 283:H803–H804. [PubMed: 11834472]
- Kuehn BM. PhD programs adopt bench-to-bedside model to speed translational research. *JAMA*. 2006; 295:1506–1507. [PubMed: 16595749]
- NIGMS. Medical Scientist Training Program. National Institute of General Medical Sciences; Bethesda, MD: 2011. National Institute of General Medical Sciences. URL: <http://www.nigms.nih.gov/Training/InstPredoc/PredocOverview-MSTP.htm>
- Resifo LL, Phelan GR. The cultural divide: Exploring communication barriers between scientists and clinicians. *Dis Model Mech*. 2011; 4:423–426. [PubMed: 21708897]
- Zerhouni E. The NIH roadmap. *Science*. 2003; 302:71–72. [PubMed: 14526071]

Table 1

Required first and second year coursework with number of credit/contact hours for graduate students enrolled in the Molecular Medicine PhD program at Cleveland Clinic Lerner College of Medicine of Case Western Reserve University.

Year 1		
Summer	Semester 1	Semester 2
Critical Tools for Research I (28 contact hours) Introduction to Human Physiology and Disease (4 credits)	Cell Biology (2 credits) Metabolism and Introduction to Pharmacology (2 credits) Critical Tools for Research II (30 contact hours)	Nucleic Acids, Gene Expression and Gene Regulation (3 credits) Mammalian Genetics, Genomics, and Bioinformatics (2 credits) Host Defense: Infection and Immunity (3 credits)
Molecular Medicine Frontiers/Journal Club (2 contact hours/week)		
Laboratory Rotation (12 weeks)	Laboratory Rotation (12 weeks)	Laboratory Rotation (12 weeks) Choose thesis home laboratory
Year 2		
Summer	Semester 1	Semester 2
Principles of Clinical and Translational Research (4 credits)	Elective Coursework (3 credits)	Elective Coursework (3 credits)
Thesis Committee assembled	Clinical Experience (30 minimum contact hours; students encouraged to continue experience throughout Years 3–5 of graduate program)	Qualifying Examination
Clinical Mentor chosen	Student led Journal Club (2 contact hours/week)	
Thesis Research		