The Importance of Basic Science and Research Training for the Next Generation of Physicians and Physician Scientists

Donald B. DeFranco and Gwendolyn Sowa

Department of Pharmacology and Chemical Biology (D.B.D.), Department of Physical Medicine and Rehabilitation (G.S.), and Ferguson Laboratory for Orthopaedic Research, Department of Orthopaedics (G.S.), University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania, 15261

Now more than ever, medical educators at all levels are tasked with delivering foundational concepts and content necessary for the next generation of physicians and physician scientists to incorporate evidence-based medicine into their clinical practice and research. Physicians need the skills to evaluate the quality and relevance of content that they are incorporating to their expanding medical knowledge database. The emphasis of modern medical education should therefore focus on acquiring, interpreting, and applying new knowledge rather than committing old (and rapidly outdated) knowledge to memory. Whether encountering a patient with an unfamiliar set of symptoms and numerous comorbidities or a gap in mechanistic understanding of a complex biological or physiological process, medical and scientific knowledge must be applied appropriately to be effective. Furthermore, assessments of the outcomes of that application to the patient or an experimental observation must be robust if conclusions are to be reached that advance our understanding of patient care or fundamental biological processes.

However, instruction or training in evidence-based medicine presents a challenge to medical educators, because the depth of mechanistic understanding of physiological and pathophysiological process has exploded. Quantum leaps have been made in our understanding of human biology advanced by the solving of DNA structure in 1953 and sequencing of the first human genome in 2003. The depth in our understanding of fundamental processes in human biology and disease is seen at every level, genetic, molecular, cellular, and system wide. However, despite this explosion of scientific knowledge, the time devoted to basic science instruction in most medical school curricula has been shrinking rather than expanding. We should all expect more from our medical students than a snap-chat, wiki-knowledge level of basic science processes. Moreover, we must recognize that the process of knowledge acquisition is equally as important, if not more so, than the actual knowledge acquired. Because the recall of stored content can be so rapid and effortless in the digital age, how can we expect the current generation of students to be excited and inspired by delivery of content merely for content's sake?

"Medical schools throughout the country are recognizing the value of medical student engagement in research. Rigorous hands-on training in the scientific method will aid in the integration of basic science knowledge with clinical decision-making and ultimately enhance patient care."

In 1910 (1), Abraham Flexner published his report on the state of medical education in the United States and Canada that fundamentally reformed medical schools in North America with curricular and policy recommendations that remain essentially intact in today's landscape of medical education. Flexner himself was instrumental in the founding of one of the first American medical schools (ie, the

ISSN Print 0888-8809 ISSN Online 1944-9917
Printed in U.S.A.

Received November 3, 2014. Accepted November 3, 2014.

University of Rochester; http://www.urmc.rochester.edu/about-us/history-of-urmc.aspx) to incorporate his provocative ideas on medical education from its inception. An important component of that report was the recognized need for significant basic science instruction in medical schools. We doubt that Flexner and his contemporaries could have imagined the biological discoveries that were to be made in the ensuing 100 years that have provided the modern physician and scientist with such a deep understanding of human biology and disease. However, one of the fundamental tenants of the Flexner report regarding the importance of scientific instruction in medical school must be retained for the next generation of physicians and physician-scientists to overcome challenges to modern medicine that can potentially have an acute, global impact on human health or gradually erode the quality of life of chronic disease sufferers.

A number of articles dating back at least over 30 years (2, 3) have reported on the values of integrating basic science instruction at all levels of medical school instruction to clinical diagnosis but highlighted the difficulties inherent in a variety of approaches to implement this integration. With the expanding base of scientific knowledge, students will benefit less from simply focusing on committing this rapidly changing dataset to memory. We instead need to focus on training future clinicians to effectively use the information, which is now literally at their fingertips, to the individual patient that they are treating with a rational and organized approach. We believe that this important milestone can be accomplished through engagement of medical students in research and scholarly activities. The fundamental principle that guides this core component of medical student education is that hands-on experience with the scientific method will enhance its application to future research or clinical practice. Furthermore, this approach promotes curiosity among students as they seek to incorporate their own insights into an unresolved scientific or medical problem. The fact that basic science knowledge can enhance clinical diagnosis skills is well documented (3, 4), and integration of such information in clinical decision-making using a rigorous scientific approach can enhance patient care. Moreover, there will be cause to be optimistic about the ability of future physicians to be even more accurate in their diagnoses and provocative in their discoveries if we as medical educators can inspire our students to embrace the scientific method in their everyday clinical and research practices.

Put simply, as scientists, we make a set of observations, formulate a hypothesis to explain those observations, devise methods and experimental or scholarly approaches to test that hypothesis, evaluate data generated from our experiment to either validate or refute the hypothesis, and then generate a new or expanded hypothesis to further enhance our understanding of the process that is being studied. The same principles can be applied to patient care. A physician makes a set of observations of their patient's condition, formulates a diagnosis to explain those conditions, orders tests and further clinical evaluations to test that diagnosis, evaluates test results to either validate or refute their diagnosis, and finally applies that knowledge to treat the patient and advance their own understanding of the unique conditions in that individual patient to enhance their clinical diagnosis skills. Therefore, it seems obvious that direct experience in a research or scholarly project of their own design, particularly a longitudinal experience, would enhance a skill set beneficial to the physician, physician-scientist, and patient alike.

Variable approaches may be appropriate to implement wide-scale scientific training in our medical schools. Major research-driven medical schools have sufficient basic and clinical faculty to accommodate a required medical student research project for either an uninterrupted year, as at Duke University School of Medicine, or a 4-year longitudinal experience that includes preliminary instruction in medical logic, research methodology, and analysis, as at the University of Pittsburgh School of Medicine. Modestly sized medical schools may still find opportunities for their students through creative engagement in community-based scholarly projects that still maintain the principles of scientific method (ie, hypothesis design and testing) or develop partnerships with medical schools with sufficient faculty resource to accommodate visiting students.

As basic and clinical science faculty, we have an obligation to instill in our trainees at all levels, premedical, undergraduate medical, and graduate medical, the importance of the scientific method in navigating the complex world of human biology. Only then can we hope for this next generation of scientists, physicians, and physician-scientists to continue to advance the human condition.

Donald B. DeFranco, PhD
Gwendolyn Sowa, MD, PhD

Acknowledgments

Address all correspondence and requests for reprints to: Donald B. DeFranco, PhD, Professor and Vice Chair of Medical Education in the Department of Pharmacology and Chemical Biology, Associate Dean for Medical Student Research, University of Pittsburgh School of Medicine, Pittsburgh, PA, 15261. E-mail: dod1@pitt.edu.

Disclosure Summary: The authors have nothing to disclose.

References

1. **Flexner A.** *Medical Education in the United States and Canada. A Report to the Carnegie Foundation for the Advancement of Teaching*. Bulletin No. 4. Boston, MA: Updyke; 1910.
2. **Patel VL, Dauphinee WD.** Return to basic sciences after clinical experience in undergraduate medical education. *Med Educ*. 1984;18:244–248.
3. **Spencer AL, Brosenitsch T, Levine AS, Kanter SL.** Back to the basic sciences: an innovative approach to teaching senior medical students how best to integrate basic science and clinical medicine. *Acad Med*. 2008;83:662–669.
4. **Woods NN, Neville, AJ, Levinson AJ, Howey EH, Oczkowski WJ, Norman GR.** The value of basic science in clinical diagnosis. *Acad Med*. 2006;81(10 suppl):S124–S127.