Heralding the 200th anniversary of Darwin’s birth, Randolph Nesse\(^1\) affirms, in the December 2008 issue of The Lancet, his vision that the basic science curricula of medical schools should include evolutionary biology. Nesse argues that a Darwinian perspective provides a central scaffold for the diverse facts of medical education. He even suggests that an understanding of evolution can be useful in the doctor–patient encounter. He writes, for example, “When a patient asks how it can be safe to use drugs to relieve cough or fever, the physician can explain the smoke-detector principle.” This principle suggests that evolution has erred on the side of false alarms (i.e., a cough does not always indicate a major illness), and therefore suppressing the cough is not necessarily harmful.

By calling for the inclusion of evolutionary biology, Nesse is not calling for revolution. He is simply asking that the basic science storytelling of medicine fall in line with the storytelling of biology. Nesse is calling for consistency. For those planning research careers in infectious disease and oncology, there are probably good reasons to pick up an evolutionary biology book. But, for those countless medical graduates who plan on pursuing a different research focus and for the vast majority of doctors who plan on primarily caring for patients, the case for Darwinian medicine is weak. The approach’s deficiency may in part be reflected in the fact that, though Darwinian medicine was proposed more than 10 years ago,\(^2\) its incorporation has been scant at best. However, the case for Darwinian medicine does serve one important purpose: it forces us to revisit the issue of consistency. If evolutionary biology is not clearly relevant to the clinic, what of the other basic sciences, the principal portion of the first and second years of medical school?

We live in a new era of medicine. The Cardiac Arrhythmia Suppression Trial (CAST)\(^3\) and other major medical trials have highlighted ways in which reasoning from scientific principles, that is, storytelling, is not only insufficient for clinical decision making but also can be harmful. The CAST trial taught us that even drugs with sound pathophysiologic rationale could increase mortality. In light of the huge body of work in top-down, empiric research (which often falls under the heading of evidence-based medicine [EBM]), taking seriously suggestions such as Nesse’s becomes harder. Nonetheless, Nesse is right to ask for consistency. Questioning the continued relevance of other sciences, including molecular biology and biochemistry, therefore seems reasonable. Ultimately, the pursuit of the basic sciences in medical education does make sense, but its primacy should be revoked. Medical educators should move toward a new model, one that declares the doctor–patient interaction as the most fundamental. This approach may serve as a new paradigm: encounter-based medical education.

A Not-So-New Paradigm

Before we visit the idea of an encounter-based curriculum, examining the roots of EBM is worthwhile. The Evidence Based Medicine Working Group\(^4\) first articulated the foundation for this shift in The Journal of the American Medical Association (JAMA) in the early 1990s. The group wrote,

“A new paradigm for medical practice is emerging. Evidence-based medicine de-emphasizes intuition, unsystematic clinical experience, and pathophysiologic rationale as sufficient grounds for clinical decision making and stresses the examination of evidence from clinical research.”

The article argued that the central task of EBM was to encourage physicians-in-training to ask clinically relevant questions, appraise the literature critically, and formulate a plan of action; however, the group emphasized postgraduate medical education and did not comment on the role EBM should occupy in the medical school curriculum. The group did not envision EBM supplanting the basic
Two things are worth noting here. The first is that physicians have come a long way from that "dearth." By 1998, one group found that evidence from randomized controlled trials could support the majority of general medical decisions, and today that percentage is likely even higher. The second consideration is that while understanding the basic sciences and pathophysiology may make one feel more comfortable deciding when to generalize data, it does not guarantee that one is in fact more often correct in those generalizations. The instances in which pathophysiologic approaches to problems differ from evidence-based approaches illustrate where the issue of primacy comes to a head.

Such instances are becoming increasingly common. For example, let's envision a 60-year-old woman who presents with easy fatigability and impaired concentration. During her workup, her physician incidentally finds that she has a serum calcium of 10.8. A physician who remembers the pathophysiology of hypercalcemia reflexively orders a PTH and finds it elevated at 104. This physician then makes a diagnosis of primary hyperparathyroidism and notes that the patient has the sequelae of hypercalcemia. A nuclear imaging scan localizes the increased activity to the right inferior parathyroid. From a pathophysiologic standpoint, removing the malfunctioning gland to alleviate the symptoms would make sense. However, when investigators randomized patients just like this woman either to surgery or observation, they found that, though the procedure makes sense, it simply does not work. No significant change in the quality of life exists between the surgery group and the observation group, and 2002 consensus guidelines not to operate are in accordance with this finding. Many other cases come to mind in which the best storytelling from the basic sciences is at odds with empiric data. These include arthroscopic knee surgery for osteoarthritis, mammography screening for women in their 40s, inotropes for heart failure, and, most recently, routine prostate-specific antigen screening. These cases span the range of interactions between doctor and patient: prevention, screening, diagnosis, therapeutics, and even physical exam maneuvers and findings. In the modern world, reasoning from basic science principles is not just insufficient for forming firm clinical conclusions; it is often misleading as well. This problem of insufficient, sometimes misleading information brings us back to Nesse's call for Darwinian medicine and the very core of undergraduate medical education. If empiric clinical data always trump reasoning from the basic sciences, why does the latter occupy the epistemic position of primacy in medical education?

**Why Problem-Based Learning Is Not in Itself a Solution**

One might contend that educational strategies such as problem-based learning (PBL) are already challenging the superiority of the pathophysiologic rationale. PBL, originally developed at McMaster University, is a method of student-directed study that uses a clinical problem or scenario as a starting point for students to define their own learning objectives. Prima facie, it offers a solution to the problem I have outlined above, and many have described and implemented it hand-in-hand with EBM. However, PBL is fundamentally a method of learning. It is not a claim on what should be learned. Diane Wood summarizes PBL this way: "PBL is not about problem solving per se, but rather it uses appropriate problems to increase knowledge and understanding."

In fact, as it is commonly implemented, PBL allows medical students to explore the very same basic science curricula traditionally associated with the first and second years, simply in a more active manner. Students taught via PBL demonstrate no differences in knowledge-based assessments than those taught in a traditional lecture setting, and one systematic review of PBL has shown that, at best, only weak evidence indicates it leads to improved understanding of EBM.

**Epistemic Primacy in Medical Education: The Encounter-Based Curriculum**

Now—more than 15 years since the JAMA article and the subsequent explosion of the evidence-based movement—is the time for medical educators to revise how they teach students. Encounter-based medicine is the proposal that the doctor–patient encounter be elevated to the central subject of study. Patients seek care from physicians for many reasons. If we abstract these encounters, we find at least two kinds. The more common occurs when a patient presents with a chief complaint or concern. The purpose of this type of medical transaction is to move forward in ways that have been shown to address those concerns meaningfully. At other times the visit is routine, the result of a desire to prevent future medical concerns. This type of visit, too, should proceed in a manner that has been empirically validated. For each sort of encounter, students should determine—given the patient’s concern and the encounter’s empiric differential—what the relevant history is and what the distracters (facts and/or data that do not alter the course of decision making) are—that is, which physical findings push them one way or another, which are the best diagnostic tests to sort the differential, which treatments have been shown to work, and which are justified merely by storytelling. This model may, of course, change as health care teams supplant the traditional doctor–patient dyad. Students may then ask the question, “How can I, as a team member, assist in creating evidence-based encounters?” Notably, elective procedures, which constitute the livelihood of many physicians, may often fall into one or both of these categories (concern-based or preventative), and thus these abstract questions are relevant not just for general internal medicine but (with slight modifications) for the work of all clinical specialties.

Encounter-based medical education is the idea that the doctor–patient encounter is the central transaction of medicine, and it allows physicians to distinguish clinically relevant information from anecdotes and storytelling. Nesse’s example of the smoke-detector principle nicely illustrates this point. Patients should not take medications that suppress fever because of some idea that natural selection has set a low threshold for fever, but because evidence shows that the medication has improved outcomes for patients just like the one seeking care or...
that it relieves symptoms without causing other harms. The answer to Nesse’s hypothetical question, “How can this be safe?” is simply, “We have found it to be not only safe, but also effective.”

Encounter-based medicine would replace the basic science courses of the preclinical years with classes in reasoning, decision making, landmark medical literature, effective searching, critical appraisal, statistics, and uncertainty. An encounter-based curriculum would begin with the content of a third-year internal medicine clerkship text; students would study the differentials and diagnoses of the most common chief complaints and would gradually move to the specialties. The tempo would allow initially for vocabulary building but would very soon pick up pace. An encounter-based curriculum could be taught either through PBL or in a more traditional lecture setting. The traditional lecture setting may make an encounter-based curriculum feasible where cost or instructor availability prohibits PBL. Finally, the preclinical years would culminate with a textbook of pathophysiology like Robbins & Cotran, which would serve not as a justification for how medicine is practiced but, rather, as a catalog of scientific models that drive research and technology.

The knowledge of the basic sciences is of paramount importance to the physician–scientist who hopes to contribute to today’s knowledge base. But even the MD–PhD student must grant that empirical clinical research is the mainstay of the biomedical enterprise. Gaining early exposure to graduate biology courses—as is currently the practice—is warranted for physician–scientists, though they should undertake these curricula concurrently with coursework geared toward the prospective clinicians. The clinicians should encounter the molecular sciences toward the end of their medical school experience as a demonstration of the depth of modern medical understanding—not as a replacement for any of the skills previously learned. And, to acknowledge Nesse’s call for consistency, including the principles of natural selection (though omitting the just-so-stories that plague evolutionary biology) seems reasonable.

It would be a disservice not to highlight what is philosophically the richest area within this new curricular strategy—the coursework in uncertainty. Many elements of the doctor–patient encounter fall squarely under this heading: uncertainty in the accuracy of a diagnostic test, uncertainty in the efficacy of treatment, and uncertainty among alternative strategies. How long should a patient remain on anticoagulant medication if it is currently untested? When should a neurosurgeon stop resecting the margins of a tumor? Uncertainty may become more commonplace both as technology outpaces our ability to evaluate it and as we move into the era of personalized medicine. Sometimes, uncertainty can be addressed by shared decision making—making transparent the doctor’s dilemma and asking the patient to consider his or her values. But, often, uncertainty falls solely within the doctor’s purview. Historically, physicians have appealed to pathophysiology in these moments. For the patient with an allergy to lidocaine in need of local anesthetic, conventional wisdom is to rule out the amide class of drugs, choosing instead among the ester class. The primacy of the basic science legitimizes this sort of reasoning—and demonstrates its insufficiency. In addition to selecting an alternative and being aware of cross-reactivity, a physician must also consider the specific response to the drug, the possibility of arterial infusion (particularly to the head and neck), and the possibility of confounding substances such as latex. Although the best resolution to this question still lacks great evidence, coursework in uncertainty would provide a systematic method to this and similar clinical dilemmas. Additionally, in those cases for which truly no data exist, how should physicians proceed? What are the implications of the following treatment strategy: the sicker the patient, the better to attempt an untested treatment; the healthier the patient, the better to hold off? An interdisciplinary course taught by physicians, philosophers, and decision-making scholars has the potential to foster clarity and consistency in even the most uncertain encounters.

The Value of Basic Science

Thus far, I have suggested that the current method—two years of basic science presented as the foundation for clinical medicine—sanctions physicians’ tendency to elevate storytelling over empiricism. In fact, direct evidence shows that some physicians do make this error. Tatsioni and colleagues selected theoretical benefits that were subsequently overturned by randomized controlled trial data and then tracked articles that persisted in supporting the original claim. One of these claims was that vitamin E provides cardiovascular benefit; the findings of the HOPE trial contradicted this supposed benefit. Tatsioni et al. constructed a “qualitative list of counterarguments made to defend vitamin E effectiveness despite contradictory evidence.” Vitamin E defenders summoned the basic science rationale vociferously, passionately, and very nearly constantly. Tatsioni and colleagues specifically note that “diverse biological mechanisms were invoked in support.” This tendency to elevate storytelling, often overlooked by supporters of basic science, thus seems a very real concern.

Nicole Woods is one educator whose work has sought to defend the value of the basic sciences in medical education. But Woods does not defend basic science as epistemic truth; rather, she defines science loosely, as a means of providing conceptual links that are “clear, plausible, and stable.” She writes that “even the accuracy of the information seems to have little impact on the value of biomedical knowledge in helping novices retain and use clinical information to diagnose a case.” Woods’ work supports storytelling only as a mnemonic device, which to some degree proves my point. These robust links within basic science die hard, but where do they leave patients in the face of contrary data (or a contrary story) 5 or 10 years into practice—with doctors who are unwilling to accept that the vitamin E hypothesis could be mistaken?

Basic science knowledge does have an immeasurable value, which is why I question only its primacy. The value of the basic sciences is not independent of validity; however, their value is precisely because of their validity. Basic science plays a role in the statistical analysis of top-down research. Some have cited biological plausibility as a consideration for proper Bayesian data interpretation of clinical trials. And, though the precise role that plausibility should play is subject to debate, basic science knowledge is clearly a prerequisite for...
spiritued discussion of novel research. Perhaps another reason to teach basic science in epilogue is just that: to provide a working model that unites many clinical findings which drive research and debate.

Truth and Medical Practice

The argument I offer here is not entirely new. Other writers have waged similar criticisms of the premedical curriculum, arguing that the required coursework—a year of calculus, organic chemistry, and physics—is irrelevant for nearly all clinicians and researchers. Even the Institute of Medicine (IOM) has touched on the themes of this paper, questioning the continued dominance of basic science in medical education. In its 2003 report, Health Professions Education: A Bridge to Quality, the IOM makes this observation:

The formal curricula of health professional schools are dated almost as soon as students graduate. The traditional emphasis [ . . . ] on the basic mechanisms of disease and pathophysiological principles [ . . . ] is outdated in light of this [EBM] ever expanding knowledge base.

But EBM, clinical trials, and expert guidelines are themselves not above nuance, revision, and contradiction. Understanding the relevance of inclusion and exclusion criteria, knowing the number needed to treat, and perceiving when and how to apply results beyond the population originally studied are all part of a constellation of skills required to practice good medicine in the modern age. Quality benchmarks derived from trials more than a decade ago may not always remain applicable; for example, the standard of care of beta-blockers after myocardial infarction (MI) was largely elucidated in a prevascularization era, but the Chinese mega-study COMMIT suggests that beta-blockers’ value may be questionable for modern patients who come in on an ACE inhibitor and leave a few days after cardiac catheterization. The vagaries of endothelial dysfunction of the coronary arteries do not guide clinicians in these situations; rather, their adeptness at reading and interpreting clinical research, and their ability to remain abreast of the literature, guide them. When are guidelines ironclad, and when might they be reversed? Under what conditions does the truth of an observational study rival the best-randomized controlled trial? When are the results of novel research likely to be true, and when are they likely to be false? As physicians begin to apply the methods of empiricism to evidence itself, a number of interesting and clinically relevant facts emerge. The skill set required to apply evidence to the clinical encounter has grown beyond what prospective physicians can reasonably master in scattered lectures during their third and fourth years. This skill set is rightly scholarship in and of itself, which brings us back to the IOM.

The idea that knowledge can become dated may perhaps be more familiar to physicians as this educational proverb: “Half of what you are taught as medical students will in 10 years have been shown to be wrong. And the trouble is, none of your teachers know which half.” Fifty years of physicians have been educated with some variation of this maxim. And for most of the 20th century, it was likely fairly accurate. The progress of empiricism, however, puts it in question. Today, physicians often know which half will be proven wrong. Physicians know, for instance, that when they give the drug simvastatin to patients with angina or previous MI who have elevated total cholesterol, they can expect a 30% reduction in all-cause mortality compared with those taking placebo. This fact was and will always be true, verified by multiple randomized controlled trials. However, its corollary, the basic science story that simvastatin (like all statins) acts through the inhibition of the enzyme HMG-CoA reductase lowering LDL cholesterol through its downstream effect, may very well not survive the test of time. In fact, it has already come under scrutiny: Statins likely have pleiotropic effects, and LDL levels may not solely guide their use.

This is the value of an encounter-based strategy—learning how to separate the facts of clinical research that are replicated and universal from those which are singular and ephemeral, learning how to act soundly without having to ceaselessly consult UpToDate, and learning to be prudent regarding conditions for which, as of today, no reliable evidence exists. Beginning with the medical encounter and teaching outward may leave students in the strongest position to confront the pivotal, yet still emerging, role of evidence in modern medicine.

For most of modern medical education, students have studied scientific principles of the body in health and disease. Using these principles, they have deductively treated illnesses, modifying their models on the basis of experience, anecdote, and scientific fad. The basic science curriculum of the first two years is a vestige of this method. Its primacy is antiquated. Medical educators need instead to move toward an encounter-based medical curriculum. A century ago, Abraham Flexner recognized that to flourish, medical education needed generational reassessment and reinvention. The idea of an encounter-based curriculum may serve as our modern vision of relevance and excellence in medical education.

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