Evolutionary Biology in the Medical School Curriculum

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The principles of evolution are finding new applications in medicine, but little is known about the role of evolutionary biology in medical curricula. To determine which aspects of evolutionary biology are included in medical curricula and the factors that influence this, a questionnaire was sent to all deans at North American medical schools who are responsible for curricula. The questionnaire asked about content areas in the curriculum, their perceived importance, and the factors that influence the amount of coverage given to those areas. Forty-eight percent of the deans who responded considered evolutionary biology important knowledge for physicians. Only 32 percent of the respondents reported that their schools covered at least 8 of 16 core topics in evolutionary biology, and only 16 percent of the schools reported having any faculty with a PhD in evolutionary biology. Lack of time in the curriculum and lack of faculty expertise are the main perceived impediments to increased teaching of evolution. We conclude that the role of evolutionary biology as a basic medical science should be carefully considered by a distinguished group of biologists and medical educators. In the meanwhile, undergraduate educators need to recognize that, for now at least, most future physicians must learn evolutionary biology as undergraduates if they are to learn it at all.

Keywords: Darwinian medicine, evolutionary biology, medical education, curriculum

Efforts to bring the principles of evolutionary biology to bear on the problems of medicine have grown rapidly in recent years (Williams and Nesse 1991, Ewald 1994, Nesse and Williams 1995, Stearns 1998, Trevathan et al. 1999, Greaves 2001). In the area of infectious disease, for instance, long-standing recognition of antibiotic resistance has been augmented by new, sophisticated models of how selection shapes increases, as well as decreases, in levels of virulence, according to their benefits for pathogens (Ebert 1998, Levin et al. 1999). Also, defenses against infection, such as fever and immune responses, are now interpreted as the products of an evolutionary arms race in which stasis is likely to be fatal and effective defenses are likely to be costly and causes of disease in their own right (Ewald 1995). The maintenance of sexual reproduction despite the huge fitness costs of halving the proportion of an individual's genes in each offspring (as compared with asexual reproduction) may be explained by the benefits of varying the targets that pathogens attack (Hamilton and Zuk 1982, Wilkinson et al. 1998). In genetics, old models of mutation–selection balance are being augmented by systematic analysis of the selection forces that may maintain the presence of alleles that increase vulnerability to disease, whether by heterozygote advantage or other means. More broadly yet, physicians are now seeking not only proximate explanations for why some individuals get sick and others do not but also complementary evolutionary explanations for why we all have bodies that are vulnerable to so many diseases. For instance, many diseases result from the mismatch between our modern environment and the environment in which we evolved (Eaton et al. 2002). Examples range from atherosclerosis to myopia. Recent evidence suggests that the benefits of modern hygiene have serious costs in lack of exposure to infections that stimulate inhibitory aspects of the immune system, thus perhaps accounting for rapidly rising rates of allergic and autoimmune disorders (Rook and Stanford 1998, Bach 2002). Although natural selection does not shape diseases themselves, it is responsible for many aspects of bodily design that leave us vulnerable to diseases. Major tasks for Darwinian medicine include explaining why these vulnerabilities remain, despite the force of natural selection, and how this knowledge can assist medicine and promote public health.

The benefits of using evolutionary ideas to understand disease are becoming widely recognized both in research, where thousands of relevant reports have appeared, and in the many new undergraduate courses on Darwinian medicine. In the curricula of medical schools, however, the role of evolutionary biology remains uncertain. A brief questionnaire study conducted in the United Kingdom in 1997 reported responses from 20 of the 30 medical schools surveyed (Short 1994). The question "Is evolutionary theory regarded as relevant for the training of doctors?" was answered in the affirmative by 75 percent. Eleven UK schools reported having "teaching sessions in animal/human evolution included in the medical curriculum," and 18 included population genetics.

No comparable data are available for North American medical schools. To begin to fill this gap, we sent a one-page letter and questionnaire to each medical school dean in North America listed by the Association of American Medical Colleges as responsible for the medical curriculum of his or

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her institution. The survey, conducted under the auspices of the World Federation of Medical Education, asked 30 questions that covered five areas: (1) medical school prerequisites, (2) topics in the required medical curriculum, (3) faculty resources, (4) deans' impressions regarding the importance of evolution education, and (5) reasons why increasing coverage of evolutionary biology might be difficult. Responses were received from 50 schools.

Deans at 24 of these 50 schools (48 percent) answered "yes" to the question "At your medical school, is evolutionary biology regarded as important knowledge for physicians?" However, only three schools require a course in evolutionary biology as a prerequisite for matriculation, and only two have "a distinct course or lecture sequence that presents evolutionary biology as a basic medical science." Among the 30 complete responses to the question "Outside of a specific course on the topic, about how many lecture or contact hours are devoted to teaching [evolutionary biology]?" 10 deans reported 0 hours; the median for the other 20 responses was 4 hours. Only 8 (16 percent) schools reported having any medical school faculty with a primary specialty of in evolutionary biology.

As shown in table 1, more than half of the schools reported covering core topics involving basic genetics and pathogen evolution. Evolutionary explanations for vulnerability to disease were covered in 10 to 25 percent of schools, while fewer than 10 percent reported covering fundamental principles such as kin selection and the distinction between proximate and ultimate explanations.

Table 2 summarizes responses to the question "Which of the following factors would likely make it difficult for your medical school to incorporate or increase evolutionary biology teaching in the medical curriculum?" Two reasons were cited by more than half of schools: "lack of curriculum time" and "lack of faculty expertise." "Lack of confidence in the scientific status of evolutionary biology" and "concerns about political controversy" were issues at only a few schools. Only one item was cited by more than 5 percent of the schools as a "major impediment": "lack of time in the curriculum," which was cited by 31 percent.

Table 1. Percentage of medical schools reporting coverage of topics related to evolutionary biology.

Topic	Percent
Antibiotic resistance	94
Virulence evolution	83
Population genetics	79
Selection for disease genes	72
Mutation selection balance	55
Levels of selection	51
Host–pathogen arms races	43
Novel environment causing disease	30
Tradeoffs	26
Comparative anatomy	21
Defense regulation	20
Life history evolution	19
Design flaws from path dependence	17
Primate phylogeny	9
Kin selection	9
Proximate/ultimate distinction	5

This study has several limitations. Although the sample was incomplete, an inevitability because of the deans' busy schedules, it was nonetheless large enough to convey an estimate of the amount of evolutionary biology in the curricula of North American medical schools and its perceived importance. A more serious problem is the lack of a method to determine whether respondents understood the questions; several noted in the margins that they did not recognize some of the listed concepts, which, of course, adds unreliability to the reports about the topics covered. The lack of an accurate recognition of certain topics may help explain the apparent discrepancy between the high percentage of schools that reported teaching the somewhat technical topic of levels of selection (51 percent) and the very small percentage that reported covering elementary concepts such as kin selection (9 percent) and the distinction between proximate and ultimate explanations (5 percent) (table 1).

A more comprehensive study would require backing from a major US medical education organization to increase the response rate for a questionnaire that would require considerably more time from respondents. The questionnaire would need to define the concepts in more detail, confirm respondents' understanding of them, and determine the coverage of each content area in each curriculum. An optimal study would go further and verify what is actually presented and what medical students actually learn. Such a definitive study would be worthwhile. The information gathered here is sufficient, however, to show that North American medical schools do not teach evolutionary biology as a core basic science and that their curricula fail to cover many fundamental evolutionary principles and concepts. The simplest explanation for these shortcomings is that fewer than half of the schools regard evolutionary biology as important knowledge for physicians. A third of the deans said that "lack of agreement about the relevance of evolutionary biology" might make it difficult to augment teaching in evolutionary biology. These responses are not surprising: Few physicians have had a chance to learn evolutionary biology, and few medical schools have any faculty with specialized expertise in the subject. Together, these factors have severely limited opportunities for medical educators to consider how evolution can be useful for medicine.

Another possible explanation could be that educators believe that evolution is already covered adequately in the undergraduate curriculum. To evaluate this possibility, one of us (R. M. N.) informally surveyed first-year medical students about their background in evolutionary biology. Only about 15 percent of entering students reported having had a course in evolution, and even fewer reported familiarity with current core issues in the field, such as levels of selection, the origins of sex, and the evolution of virulence. A study of first-year medical students in Australia found that

64 percent had studied no evolutionary biology, and 27 percent believed that species did not evolve by natural selection (Short 1994).

A more proximate explanation for the absence of evolutionary biology could be in the process that determines the curriculum. According to interviews with medical educators, members of curriculum committees often advocate for increased time for their own content areas. Most schools have no faculty with expertise in evolutionary biology, which would naturally result in little (or no) curriculum time devoted to the topic.

Finally, a historical explanation may be important. In the early 20th century, Abraham Flexner's famous report marked the beginning of systematic basic science education in medicine. At that time, evolutionary biology was in a period of eclipse (Ghiselin 1969), so there was little reason to include it. Since the synthesis with genetics in the middle of the last century, and subsequent major discoveries in paleontology and molecular biology, the explanatory power of evolution has grown substantially (Mayr 1982, Alcock 2001). Only now, however, is it being applied systematically to medicine; one article reported over 1200 recent articles at the interface of medicine and evolution (Stearns and Ebert 2001). Other basic sciences that have been incorporated into the curriculum, such as genetics, have more direct applications to specific clinical conditions. An evolutionary approach to disease has yet to demonstrate that it is indispensable to finding new ways to prevent or cure specific diseases, but it already has major practical implications for some problems, including vaccine design and antibiotic resistance (Nesse 2001, Stearns and Ebert 2001). Furthermore, such an approach provides the same kind of basic foundation for understanding the body as physiology and anatomy do, and its perspective on the history of our species is parallel to what embryology provides for understanding individual development. Yet, as demonstrated by this study, medical students neither come with a good preparation in evolutionary biology nor do they learn it as a basic medical science.

We conclude that the proper role of evolutionary biology in the medical education needs to be considered by medical curriculum committees, in consultation with evolutionary biologists (Charlton 1997, Nesse and Williams 1997). If national medical education leaders conclude that physicians should learn at least the fundamentals of evolutionary biology as they apply to medicine, the gap could be filled by a combination of new undergraduate prerequisites, model medical curricula, and appropriate board examination questions to ensure that medical graduates have a basic understanding of evolutionary biology comparable to their understanding of other basic medical sciences.

Table 2. Percentage of medical schools reporting factors that make it difficult to incorporate teaching evolutionary biology.

Factor	Percent
Lack of curriculum time	87
Lack of faculty expertise	53
Lack of funding	34
Lack of agreement about relevance	33
Difficult finding/hiring qualified faculty	24
Political controversy	11
Lack of confidence in scientific status of evolutionary biology	5

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