Student Perceptions of the Importance of Evolutionary Knowledge in Medicine: A Case Study from an Undergraduate Anatomy & Physiology Course

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Abstract

Biological evolution is not emphasized in medical education and undergraduate anatomy and physiology courses. This omission in medical education has contributed to the development of a number of avoidable medical problems such as antibiotic resistance in bacteria. This article presents the results of a survey administered to undergraduate anatomy and physiology students that aimed to understand student opinions on the importance of teaching evolution to medical professionals. Results of the survey suggest that students believe biological evolution has played a major role in shaping human anatomy and physiology and that medical professionals should understand biological evolution. The goal of this manuscript is to raise awareness for the importance of teaching evolutionary concepts in undergraduate anatomy and physiology so that future medical professionals can use this knowledge to better serve their patients. doi: 10.21692/haps.2017.028

Key Words: evolution, health, opinions

Introduction

Biological evolution is a central theme in the study of modern biology. This sentiment is reflected by the widespread belief among biologists that “nothing in biology makes sense except in the light of evolution”; a statement that was made by Dobzhansky in 1973. The forces involved in evolutionary change, such as natural selection (Darwin 1859), can be observed across all levels of biological organization from cells to ecosystems. Accordingly, most biologists would agree that these evolutionary processes have played a pivotal role in shaping the structure and function of the human body (Bull 1994, Nesse 2007).

Despite the widespread understanding that evolution has helped shape the anatomy and physiology of the human body, the training of medical professionals generally puts little, if any, emphasis on understanding the role of biological evolution in human medicine (Nesse et al. 2010). Instead, medical research and practice tend to emphasize proximate questions (e.g. “How does this drug work?”) while simultaneously deemphasizing ultimate questions (e.g. “Why does this drug work?” (Nesse 2007). However, many evolutionary biologists, and other proponents of the emerging discipline of “Darwinian” or “Evolutionary” medicine (Bull 1994, Nesse 2007), believe that a thorough understanding of evolutionary concepts and ultimate questions is the key to understanding the natural history, pathology, and treatment of numerous human diseases (Bull 1994, Nesse 2007).

Indeed, numerous topics pertaining to human medicine, such as the susceptibility to disease and prevalence of human diseases, would make more sense when viewed in the light of biological evolution. For example, the virulence patterns of human pathogens can be better understood by studying the evolutionary relationships (e.g. evolutionary arms race) between pathogens and their hosts (Bull 1994, Levin 1996, Dethlefsen et al. 2007). Numerous scholars have argued that virulence patterns are shaped and maintained by selection pressures acting on both the pathogen and the host (Levin 1996, Dethlefsen et al. 2007). For example, viruses that have fast transmission times, such as Ebola, tend to have high virulence due to decreased selection pressure favoring the survival of its host (Dethlefsen et al. 2007). Additionally, high virulence is often seen in pathogens that have long histories of infecting animals, but only recently began being transmitted to humans (Bull 1994). Understanding the dynamics of this evolutionary relationship is fundamental to developing effective long-term treatments for these diseases.

Another major problem faced by modern medicine is the evolution of antibiotic resistance among bacterial pathogens. However, this problem could have been mitigated, or avoided altogether, if medical professionals had a deeper functional understanding of the evolutionary forces, such as natural selection, that shape antibiotic resistance. Thus, the lack of emphasis on training medical professionals in evolutionary concepts has created a major global human health concern.

The simplest method of unifying the fields of evolutionary biology and medicine, and thus increasing the efficacy of medical efforts to combat disease, is to increase the awareness and understanding of evolutionary topics.
pertaining to medicine among medical professionals. Owing to this lack of emphasis on evolutionary knowledge in medicine, there is a fundamental divide in the education of students pursuing strictly biology majors and those pursuing degrees in pre-health professions.

While evolutionary concepts are a staple of most undergraduate biology classes, courses geared towards pre-health professionals, such as Anatomy and Physiology, do little to expose students to the importance of biological evolution in human medicine. This is partly due to the lack of emphasis in the medical field on encouraging the study of evolution and the lack of perceived importance of evolutionary knowledge among medical professionals. This lack of emphasis pervades the instructional concepts and techniques used in pre-health professions courses, such as anatomy and physiology, in which little, if any, evolutionary knowledge is transferred to students.

This begs the question of whether pre-health profession students should be taught evolutionary concepts as they relate to course concepts, such as the structures and functions of the human body in anatomy and physiology courses. This study aimed to analyze the opinions and knowledge of undergraduate students pertaining to biological evolution and its importance in medicine. The study was geared towards anatomy and physiology since this class is a requisite for many pre-health professions and is where most pre-health professionals get their foundational knowledge of the human body.

**Methods**

**Study Population**

This survey was conducted at a two-year, open-access college located in the Midwestern United States of America. The college serves approximately 6,000 undergraduate students who complete the first two years of their undergraduate degrees at the college before transitioning to other campuses. Undergraduate students who were enrolled in Anatomy and Physiology I (A&P I) during the Fall 2016 semester were used as the study population. Students generally take this course to fulfill requirements for various allied health programs at the college, such as nursing, dental hygiene, and radiologic technology.

**Data Collection**

Anonymous online surveys were distributed to students enrolled in the course during the first two weeks of the semester via a link posted to either their online course management system (Blackboard) or sent to students directly via their campus email address. To encourage participation and honesty in answering the survey questions, students were informed that their participation in the survey was completely voluntary, that their identities would not be disclosed, and that participation would not influence their grade in any way. To ensure anonymity, the survey was designed to dissuade students from providing identifying information such as student numbers, and email addresses. All participants agreed with the terms of participation prior to completing the survey. The survey was intended to take approximately fifteen minutes to complete under normal circumstances. While completing the survey, students were allowed to skip questions that they chose not to answer and withdraw from participation in the study at any time.

The Institutional Review Board of the University of Cincinnati approved the study (Study ID 2016-1084) as exempt from IRB oversight. Informed consent was obtained from all participants.

**Survey Design**

The survey was designed to include two major parts. The first part included Likert-scale questions to gauge student perceptions of the importance of evolutionary knowledge for the medical field and their opinions on learning evolution while taking Anatomy and Physiology. Likert-scale questions asked students to rate their opinions using the following scale: strongly disagree, disagree, neither agree nor disagree, agree, or strongly agree. The second part of the survey included open-response questions allowing students to demonstrate their understanding of evolutionary concepts and provide rationale for their answers to Likert-scale questions. Table 1 shows the questions asked in the survey.
<table>
<thead>
<tr>
<th>Rational for Question</th>
<th>Survey Question</th>
<th>Type of Question</th>
<th>Number of Respondents</th>
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</thead>
<tbody>
<tr>
<td>Demographics &amp; Student Background</td>
<td>Q1: Prior to this class, have you taken a college-level human anatomy &amp; physiology class?</td>
<td>Yes/No</td>
<td>36</td>
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<td></td>
<td>Q2: Prior to this class, have you previously taken a human anatomy &amp; physiology course at [name of college]?</td>
<td>Yes/No</td>
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<td>Opinions of Importance of Evolution to Human Medicine</td>
<td>Q3: Antibiotic resistance in bacteria is a major human health concern.</td>
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<td>Q4: Medical professionals (e.g., physicians, nurses, etc.) should understand how bacteria become resistant to antibiotics.</td>
<td>Likert-scale</td>
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<td>Q5: Antiviral resistance in viruses is a major human health concern.</td>
<td>Likert-scale</td>
<td>33</td>
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<td>Q6: Medical professionals (e.g., physicians, nurses, etc.) should understand how viruses become resistant to antiviral medications.</td>
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<td>Q7: Biological evolution plays an important role in human health.</td>
<td>Likert-scale</td>
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<td>Q8: Biological evolution plays an important role in human medicine.</td>
<td>Likert-scale</td>
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<td>Q9: Medical professionals (e.g., physicians, nurses, etc.) should understand biological evolution.</td>
<td>Likert-scale</td>
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<td>Q13: Students attending medical school should be required to study biological evolution.</td>
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<td>Q14: Students pursuing a nursing degree should be required to study biological evolution.</td>
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<td>Q15: Students taking Anatomy &amp; Physiology should be taught about biological evolution.</td>
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<td>Q16: Human anatomy is influenced by biological evolution.</td>
<td>Likert-scale</td>
<td>33</td>
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<td></td>
<td>Q17: Human physiology is influenced by biological evolution.</td>
<td>Likert-scale</td>
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<td>Q18: Studying human anatomy from an evolutionary perspective would help me learn the topic better.</td>
<td>Likert-scale</td>
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<td>Q19: Studying human physiology from an evolutionary perspective would help me learn the topic better.</td>
<td>Likert-scale</td>
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<td>Testing Understanding of Biological Evolution &amp; Explaining Opinions</td>
<td>Q20: In one or two sentences, please define the term “Biological Evolution.”</td>
<td>Open Response</td>
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<td>Q21: Please explain how bacteria become resistant to antibiotics.</td>
<td>Open Response</td>
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<td></td>
<td>Q22: Please state why you do or do not believe it is important for medical professionals (e.g., physicians, nurses, etc.) to understand biological evolution.</td>
<td>Open Response</td>
<td>26</td>
</tr>
</tbody>
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Table 1. Survey Questions Asked to Respondents
Data Analysis

The percentage of students responding to each Likert-scale category was plotted for survey questions 3-19. Rubrics were constructed for scoring the open response questions Q20 and Q21 (Table 2). For Q20 and Q21, one point was awarded when a respondent correctly included each of the criteria listed in Table 2. This allowed for the quantification of knowledge on evolutionary processes among respondents. To determine if a relationship existed between student opinions of biological evolution and their knowledge of the subject, correlation analyses were conducted on student scores to open response questions and the opinions they gave to various Likert-scale questions. Student scores for Q20 were correlated to their opinions given in Q9 to analyze the relationship between perceived importance of medical professionals understanding biological evolution and student knowledge of biological evolution. Student scores for Q21 were correlated to their opinions given in Q4 to analyze the relationship between their perceived importance of medical professionals understanding the causes of antibiotic resistance and their ability to explain how bacteria become resistant to antibiotics. To conduct these analyses, Likert-scale opinions were first translated into numerical scores using the following scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, and 5 = Strongly Agree. These numerical scores were then correlated to the numerical scores earned by respondents for Q20 and Q21.

Results

A total of 36 students completed the survey during the first two weeks of the Fall 2016 semester. Table 1 shows the number of students that answered each survey question. Of the 36 total respondents, 12 had previously taken an Anatomy & Physiology course before, but only one had taken that course at the college at which this survey was conducted.

The results show that the majority of students surveyed believe that antibiotic and antiviral resistance represents a major human health concern and that medical professionals should understand how these resistances arise. The vast majority of students surveyed believed that antibiotic resistance is a major human health concern (64% strongly agree, 33% agree) and that medical professionals should understand how bacteria become resistant to antibiotics (61% strongly agree, 36% agree). To a lesser extent, students believed that antiviral resistance is a major human health concern (42% strongly agree, 36% agree) and that medical professionals should understand how viruses become resistant to antiviral medications (52% strongly agree, 36% agree).

Responses to survey questions regarding the importance of biological evolution in the field of human medicine showed that students viewed the concept of biological evolution as important. Forty-eight percent of students surveyed stated they agreed (21% strongly agree, 27% agree) that human physiology is influenced by biological evolution, with no students disagreeing at any response level. Fifty-four percent of students stated they agreed (24% strongly agree, 30% agree) and that medical professionals should understand how viruses become resistant to antiviral medications, with only 3% disagreeing.

The vast majority of students believed that biological evolution plays an important role in human health (21% strongly agree, 64% agree) and human medicine (27% strongly agree, 52% agree). Collectively, 85% of students believed that medical professionals should understand biological evolution, with no students disagreeing at any response level. Concomitantly, 85% of students believed that it is important for medical professionals to learn about biological evolution. Perhaps most telling, 84% of respondents agreed that it was important for their personal physician to understand biological evolution.

Interestingly, although the vast majority of students agreed that biological evolution is important to human medicine, there was less agreement with the necessity of medical and nursing students to learn the topic. Although 63% of respondents agreed (24% strongly agree, 39% agree) that learning biological evolution is important for Anatomy & Physiology students, 30% of respondents had no opinion and 6% disagreed with the statement.
63% of students agreed (21% strongly agree, 42% agree) that students taking Anatomy & Physiology should be taught about biological evolution, while 9% disagreed (6% disagree, 3% disagree strongly). Sixty percent of students believed that medical schools should require medical students to study biological evolution (27% strongly agree, 33% agree), while 33% had no opinion and 6% disagreed.

Similar opinions were shown when students were asked if nursing students should be required to learn biological evolution (18% strongly agree, 39% agree, 12% disagree). Roughly half of students agreed that studying human anatomy (51%) and human physiology (48%) from an evolutionary perspective would help them learn the topics better, while a much smaller percentage (12% and 15%, respectively) disagreed.

Open response questions revealed that survey respondents had a poor overall understanding of biological evolution and its impact on the emergence of antibiotic resistance (Figure 2). When defining “Biological Evolution” respondents scored an average of 1.46/5 (SD = 1.24) and a median score of 1/5 (25% percentile = 0.75, 75% percentile = 2). Many students stated they did not know how to define the term “Biological Evolution”. When asked to explain how bacteria become resistant to antibiotics, respondents scored an average of 1.04/5 (SD = 1.43) and a median score of 1/5 (25% percentile = 0, 75% percentile = 1). Many of the students did not mention biological evolution in their answers to this question.

Overall, students showed a weak correlation between the opinions they provided of evolutionary topics on Likert-scale questions and their knowledge of evolutionary topics. Although many students responded that they agreed or strongly agreed with the statement “Medical professionals should understand biological evolution”, there was a weak correlation between opinion and ability to successfully define biological evolution ($r^2 = 0.242$). Additionally, while many students agreed or strongly agreed with the statement “Medical professionals should understand how bacteria become resistant to antibiotics”, there was a weak correlation between opinion and ability to explain how bacteria become resistant to antibiotics ($r^2 = 0.166$).

**Discussion**

The data garnered from the survey administered in this study elucidate three important principles. First, anatomy and physiology students viewed evolution-based topics in human medicine as major human health concerns that need further attention from medical professionals. As future medical professionals, these students recognize the importance of these topics, and are, in many ways, the only people who can succeed in counteracting these phenomena. Second, a large percentage of anatomy and physiology students agreed that biological evolution has had important implications for human anatomy and physiology and that learning evolution would help further their knowledge of human anatomy and physiology. This result was somewhat unexpected given the pervasive resistance that the field of human medicine has had to incorporating evolutionary concepts.
Finally, the survey shows that many of the A&P students surveyed lacked a fundamental understanding of the processes involved in biological evolution. Thus, the take home message is that the students surveyed believe that biological evolution is an important topic for medical professionals to learn, but have a very poor understanding of the processes involved. These results may be the result of the lack of educational emphasis for this student population to learn evolution.

Biological evolution remains a controversial topic for many students and instructors (Herman 2013) and it is common to encounter some resistance to learning biological evolution. Additionally, it is common for students to carry their misconceptions about biological evolution into class and for students to retain these misconceptions despite the best efforts of their teachers. Tran et al. (2014) showed that even upper-level biology majors struggle with evolutionary concepts and misconceptions but that discussion of evolutionary concepts helps alleviate these misconceptions. Despite the potential controversy and difficult teaching evolution to undergraduates, the importance of transferring this knowledge to allied health students remains paramount to avoid a future of avoidable medical conundrums such as the increased prevalence of antibiotic resistance.

One of the major challenges that instructors may face is picking appropriate topics in anatomy and physiology in which to integrate evolutionary concepts. However, over the course of the two semesters of anatomy and physiology that most allied health majors are required to take, there are numerous avenues for instructors to interject evolutionary concepts. For example, when discussing the skeletal system, instructors could discuss the structural differences between the anatomy of the lower extremities and pelvic girdle in humans compared to quadruped animals, which is a reflection of the anatomical changes needed to accommodate bipedal locomotion. When discussing the structure and function of the human brain, evolutionary comparisons could be drawn among various primates and mammals to elucidate that human evolution has led to the enlargement of the cerebral cortex relative to body mass, which has permitted increased intelligence and tool use in humans that are not observed in non-human mammals. The number of examples that can be used to elucidate the effects of biological evolution on human anatomy and physiology are plentiful and do not need to occupy a large portion of the course to be effective.

A thorough understanding of biological evolution is fundamental to the study of all fields of biology, including human medicine. By deemphasizing the importance of biological evolution when teaching human anatomy and physiology, students pursuing degrees in health professions are put at a major disadvantage and the effects of an ill-prepared workforce can be felt in the quality of health care services. More attention should be given to teaching biological evolution and correcting misconceptions in foundational courses like anatomy and physiology in order to set students up for lifelong success and prevent avoidable health crises, such as the development of antibiotic-resistant bacteria.

About the Author
Mark Tran, PhD is an Assistant Professor of Biology at the University of Cincinnati Blue Ash College. He teaches Human Anatomy & Physiology and Introductory Biology courses.

Literature Cited