Teaching and Learning Anthropology Journal
Vol. 1, No. 1 (2018), pp. 25-36

ARTICLE

Integrating Anthropology and Biology: Comparing Success Rates and Learning Outcomes for University-Level Human Evolution Courses

Amy L. Rector*, Lisa M. Day, Kelsey D. O'Neill, Marie Vergamini, Lauren Volkers, Diego A. Hernandez, Brian C. Verrelli

Virginia Commonwealth University

**Corresponding author, arverrelli@vcu.edu*

Abstract

Curriculum development in biological anthropology requires instructors to generate learning outcomes for both anthropology and biology majors. However, these students have substantially different backgrounds. Anthropology curricula do not always require biology prerequisites, and many instructors are concerned that anthropology majors may not be as prepared to learn biology content. As bioanthropological research increasingly relies on genetics and phylogenomics, a strong emphasis needs to be put on integrating biological content into anthropology courses. The core-level "Human Evolution" course at Virginia Commonwealth University is taught under an anthropology rubric. The course is divided into four primary units: two units cover topics that are also explored in lower-level biology courses (e.g., DNA inheritance) and two units focus on paleoanthropological topics (e.g., hominin taxonomy). Here, we compare results of course assessments between anthropology and biology majors across four semesters to determine whether students in the two majors performed differently on units with "biology" content versus "anthropology" content. A series of statistical tests reveal that overall, anthropology and biology majors are earning comparable final grades in the course. Additionally, when assessment results for units with differing content are contrasted, anthropology and biology majors scored comparably on "anthropology" content units. However, in some semesters, biology majors scored statistically significantly better in the "biology" units than in "anthropology" units, and in one semester, anthropology majors scored statistically significantly better than biology majors in "biology" content. These results suggest that it is biology majors, rather than anthropology majors, who are deficient in an integrated bioanthropological perspective. We recommend that anthropology and biology departments consider introducing an integrated curriculum that is interdisciplinary rather than multidisciplinary by design.

Keywords: *human evolution; anthropology; biology; integrative education*

Introduction

Evolutionary theory is a unifying theme in biological inquiry (Dobzhansky 1973). Given that biological anthropology is the study of humans as biological organisms (American Association of Physical Anthropologists 1996; Gundling 2010), teaching the application of evolutionary theory is also key to anthropological study. Most analyses of the efficacy of teaching evolution in the classroom focus on biology courses, where evolutionary theory is applied quite broadly to explain global biodiversity with only minimal discussion of our own taxon (Linhart 1997; Lloyd-Strovas and Bernal 2012; White et al. 2009). However, university-level courses in biological anthropology directly address evolution in the human lineage (e.g., White et al. 2009). Although effectively teaching and communicating evolutionary theory is famously difficult for a variety of pedagogical and sociocultural reasons, including student religious beliefs and anti-intellectualism (Jensen and Finley 1996; Lloyd-Strovas and Bernal 2012; Smith 2009; Wilson 2005), teaching about evolution within the context of biological anthropology adds the complexity of requiring students to not only understand the science, but to apply it to themselves and the history of their own lineage. In non-anthropological university-level courses, evolutionary theory is more likely to be presented on the general backbone of organismal diversity unconstrained by the specific applications related to human life, culture, and social history.

At Virginia Commonwealth University (VCU), undergraduate students can enroll in the upper-level "Human Evolution" course either to fulfill a requirement for the anthropology major or to complete a required lab elective for the biology major. The Human Evolution course is offered under an anthropology rubric and is framed from a biological anthropology perspective. At the time of this study, the course used a textbook that divides materials into two main sections: one that is "biological" in nature and includes topics like DNA inheritance, evolutionary mechanisms, and taxonomy; and one that is more "anthropological" in nature, covering the human fossil record and human and primate behavior (Stanford et al. 2013). Students in the two undergraduate majors have opportunities to enroll in introductory courses in biology and anthropology as general education requirements. However, the majority of anthropology majors (about 60 percent) have not taken a college-level biology course before enrolling in Human Evolution, and a larger majority of biology majors (about 80 percent) have not taken any other anthropology courses before enrolling in Human Evolution.

The fact that more than half of the anthropology majors in the Human Evolution course at VCU have not enrolled in any prior biology courses is relevant to their differential preparation for the class compared to biology majors. Anthropology courses rarely cover many of the biological topics related to evolution (Table 1). Moreover, despite the importance of evolutionary theory to anthropological study, most university-level anthropology textbooks—whether focusing on cultural or biological anthropology--do not provide consistent or single definitions of evolution (White et al. 2009). As a result, anthropology majors are not guaranteed to have had any prior exposure to

evolutionary theory or even to crucial basic scientific concepts to prepare them for the Human Evolution course.

Table 1. Breakdown of Biology and Anthropology Unit-Specific Content

Unit type	Content	Covered in introductory BIOL* courses?	Covered in introductory ANTH* courses?
Biology	Evolutionary thought	Yes	Rarely
	Cell and molecular structure	Yes	Rarely
	DNA inheritance	Yes	Sometimes
	Evolutionary forces and species variation	Yes	Rarely
	Phylogeny reconstruction	Sometimes	Rarely
Anthropology	Primates and primate behavior	No	Yes
	Hominin fossil record	No	Yes
	Interpreting behavior from fossils	Sometimes	Sometimes
	Evolution of human language	No	Yes
	Human variation and behavior	No	Yes

*BIOL and ANTH denote specific biology and anthropology courses, respectively, offered at VCU

At the same time, biology majors enroll in the Human Evolution course with little or no background in anthropology, putting them at a disadvantage in preparation for the anthropological materials covered in the course. Multiple studies have explored the way pedagogical approach, social factors, and the acceptance of evolution (Lloyd-Strovas and Bernal 2012) affect student performance in classes focused on the study of evolution. Fewer studies have assessed how students in different programs of study perform in these courses. One study of majors and non-majors in introductory biology courses found that non-majors often outperformed majors on assessments, especially those related to ecology and evolution (Sundberg and Dini 1993). However, majors and non-majors in that study were placed in different course sections with different pedagogical strategies and goals. Even fewer studies have focused specifically on courses dealing with *human* evolution. Lloyd-Strovas and Bernal (2012) summarized the results of 26 studies related to

the teaching of evolution in higher education. They found that only two suggested including a discussion of the evolution of humans, specifically, as a strategy for increasing student understanding (Nelson 2000; Wilson 2005).

A Human Evolution course that serves both anthropology and biology majors is hampered by different sets of students being underprepared for different aspects of the course content, yet this course remains a crucial part of the path towards scientific and evolutionary literacy in both curricula (Alters and Nelson 2002; Cunningham and Wescott 2009). Our experience in the classroom with both anthropology and biology majors suggests that there is a real need to identify and mitigate deficits in background preparation to ensure that students meet the learning objectives. How can different programs of study best prepare students and instructors to succeed in a course that is often described as contentious, unimportant, and, at best, optional (Brem, Ranney, and Schindel 2003; Cunningham and Wescott 2009; Moore 2006; Smith 2009)?

The current study addresses how students in different majors perform in the Human Evolution course at VCU when assessments are based on more typically "biological" vs. "anthropological" materials. Specifically, given the paucity of data and assessments of this nature, we are interested in determining whether anthropology and biology students receive significantly higher grades in their respective areas in a course that combines lecture and laboratory activities. We predict that anthropology majors will outperform biology majors in "anthropology" unit content and that biology majors will outperform anthropology majors in "biology" unit content. This unique dataset allows us to examine the assumptions we may make about the prior backgrounds of students with different undergraduate majors, and it sheds light on how to more fully integrate a Human Evolution course into successful science curricula.

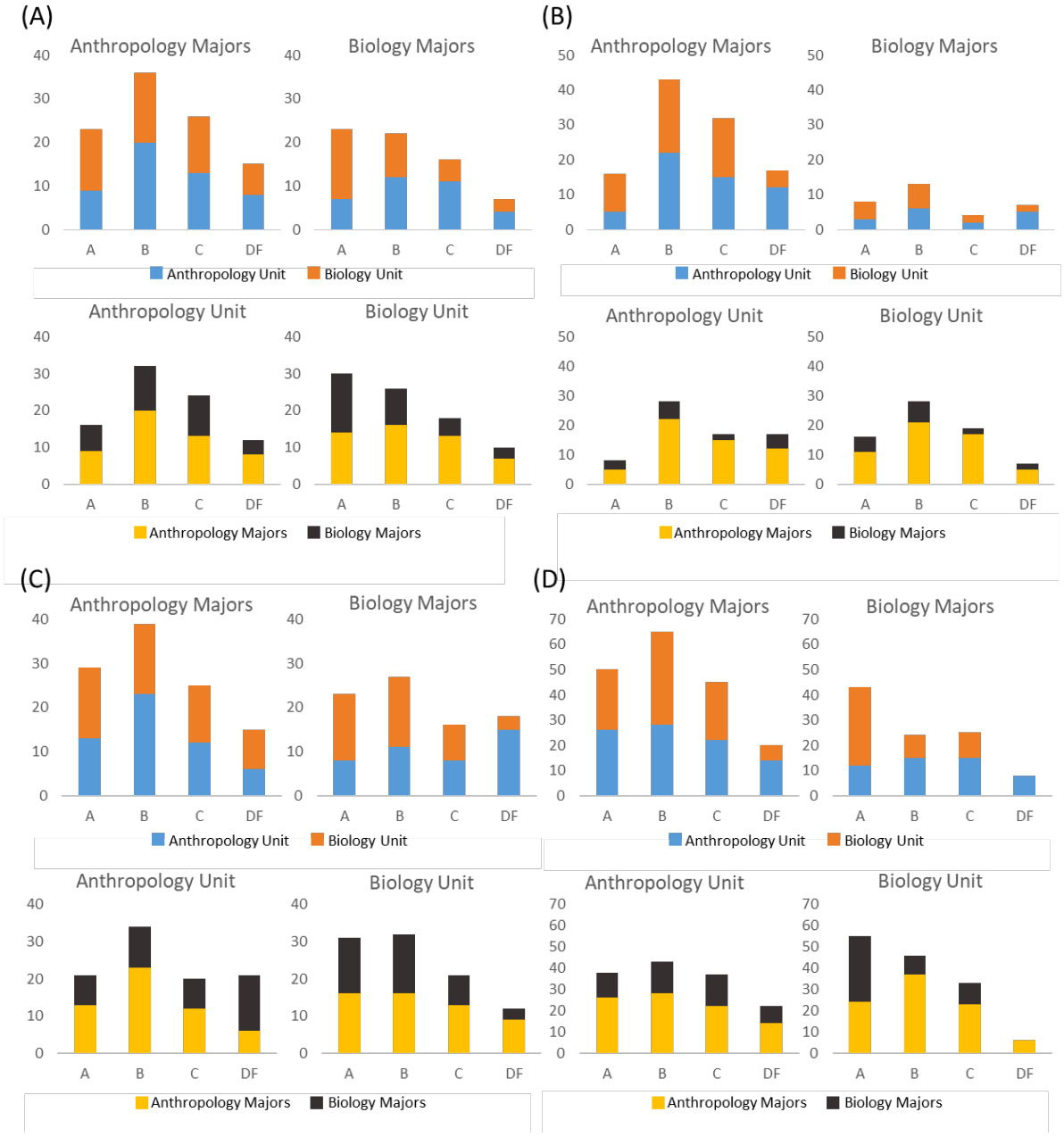
Materials and Methods

Performance in the Human Evolution course over four semesters (and four years) at VCU was assessed for 184 undergraduate students majoring in either anthropology or biology. For the duration of this study, only one professor taught the Human Evolution course at VCU. The majority of students in this upper-level course are in the third or fourth year of their programs of study. In the first two years of assessment, lab-based activities were directly integrated into lecture, but in 2013, a separate lab period was introduced as a required co-requisite with the lecture. The textbook and lab activities remained the same, but the lab period allowed for an increased emphasis on active learning, with more time to explore through hands-on activities and more time for open interaction among students and between students and the instructor. The introduction of the lab section enabled biology majors to take the course as a required lab-based elective, and the course's enrollment increased. Assessments in lab were made separately from those in lecture.

Grades received by anthropology and biology majors on "anthropology" and "biology" units (Figure 1), as well as overall course grades, were statistically compared

within and between majors using chi-square tests of independence (Table 2). The null hypothesis of this statistical test is that the sets of categorical variables, as student majors and course content units, are independent of each other, and that no association exists among these variables in course performance. That is, the null expectation is that biology and anthropology majors will perform equally on "biology" and "anthropology" course units. This statistical approach was integral to our analysis as there are likely differences in performance by biology and anthropology majors in the Human Evolution course.

Figure 1. Distribution of grades across majors and content units.
(A) 2011, (B) 2012, (C) 2013, (D) 2014



By partitioning this performance into two variables simultaneously, we can identify how student course performance is related to course content and major. Specifically, we used this analysis to first test for heterogeneity within majors by examining whether biology majors' grades were similar on "biology"- and "anthropology"-specific content (as in Table 1), and whether anthropology majors' grades were similar on "biology"- and "anthropology"-specific content. Second, we tested for heterogeneity within a topic unit by examining whether biology and anthropology majors' grades were similar on "biology" content and then whether biology and anthropology majors' grades were similar on "anthropology" content. In these analyses, we examined grades as two categories of pass (A, B, and C combined) vs. fail (D and F combined). We also again examined grades as four individual categories of three passing grades (A, B, and C), and the DF grade category. Bonferroni corrections were applied to our p-values as data were multiply compared within and between majors, which violates any independence of the statistical outcomes.

Table 2. Comparisons of Grades Between Units and Majors in the Human Evolution Course at VCU

Year	**2011**	**2012**	**2013**	**2014**
# of students in class	**42**	**23**	**48**	**71**
Comparison between units				
Biology majors	$p<0.10$	$p<0.64$	$\mathbf{p<0.01}$	$\mathbf{p<0.0002}$
Anthropology majors	$p<0.65$	$p<0.32$	$p<0.53$	$p<0.20$
Comparison between majors				
Biology unit	$p<0.28$	$p<0.68$	$p<0.42$	$\mathbf{p<0.0002}$
Anthropology unit	$p<0.86$	$p<0.31$	$p<0.03$	$p<0.87$
Final grades	$p<0.15$	$p<0.69$	$p<0.57$	$p<0.16$

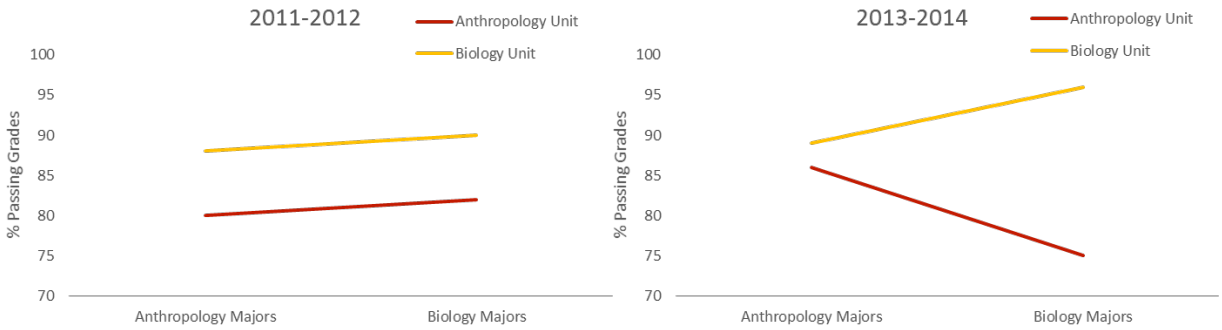
NOTE: Results in bold are significant after Bonferroni correction.

Results

The courses assessed during the first two years of this analysis, 2011-2012, were smaller in size and included integrated lab activities. In these two years, no significant differences were found with respect to anthropology and biology majors' final grades. However, when the separate lab section was introduced in 2013 and the class size increased, anthropology and biology majors performed differently in some unexpected ways (Table 2). In both 2013 and 2014, biology majors earned higher grades, with a higher percentage of students passing, on the "biology" units than on the "anthropology" units. Anthropology majors had similar passing percentages on "biology" vs. "anthropology" units (Figure 2). However, when specific grades (e.g., A, B, C, DF) were compared for each of the "biology" and "anthropology" course units

between the majors, both groups of students scored equally well on the "anthropology" units, but anthropology majors scored significantly better on the "biology" units than biology majors (Figure 1). For final overall grades (e.g., A, B, C, DF), anthropology and biology majors did not earn significantly different grades.

Figure 2. Percentage of passing grades shown for Anthropology and Biology majors on content from "Anthropology" and "Biology" units in the Human Evolution course for 2011-2012 compared to 2013-2014.



Discussion

"Human Evolution" is a biological anthropology course that integrates learning outcomes that are core to both biology and anthropology curricula. Given the differential preparation of anthropology and biology majors for this course, we expected that anthropology majors would outperform their biology cohort in "anthropology" unit content, and that biology majors would outperform their anthropology cohort in "biology" unit content. Our results suggest that the integration of anthropological and biological knowledge in this Human Evolution course is more nuanced. The integration of this knowledge may require an interdisciplinary approach so that these learning outcomes can be introduced and reinforced throughout each curriculum, rather than top-loaded into an upper-level Human Evolution course.

The introduction of the separate but required lab section in 2013 was part of an overall pedagogical shift in several anthropology courses. Cunningham and Wescott (2009) surveyed biological anthropology classes and recommended paring down the amount of information to allow for more active learning (following Jensen and Finley 1996). The lab section at VCU was specifically designed to reinforce the lecture materials with more group-based and hands-on activities. The Human Evolution lab at VCU was the first anthropology lab that most anthropology majors were required to take, and in many cases, it was the first lab class they had ever taken. However, lab sections are both common and required in VCU's biology program. The evident adjustment for anthropology and biology majors, as reflected by their assessments in lecture, was thus

unexpected. Anthropology majors' performance was consistent in "biology" and "anthropology" units, but biology majors began performing better in the "biology" units than in the "anthropology" units.

A key point is that while we are discussing the "biology" and "anthropology" units as separate units with different disciplinary origins for this study, the "biology" content for the Human Evolution course nearly always uses humans or primates as the example organism. This inherent bias may explain the most unexpected result: in the last semester of the study, anthropology majors outperformed biology majors in the "biology" unit assessments. We may think at the outset that biology majors, who are not focused on any one organism in their introduction to evolutionary theory in lower-level courses, may perform better in upper-level human evolution courses because they need only apply their general background knowledge about evolution to yet another organism. However, our results imply the opposite.

Given that biology majors rarely encounter humans as a study organism and that anthropology majors rarely engage in scientific discourse where humans or their relatives are *not* the study organism, perhaps our results reflect that anthropology majors are more prepared and willing to see humans as a focus of scientific inquiry. In fact, a brief survey of introductory biology textbooks used in Virginia higher education reveals that the majority of these texts (about 60 percent) only discuss humans as a study taxon in one chapter devoted to *Homo sapiens* rather than integrating humans into each chapter or learning objective. Even in upper-level evolutionary biology texts, often only a final chapter of the book is dedicated to "Human Evolution." To undergraduate biology majors, this structure implies that there are evolutionary biological theories or processes that are specific to the human species. This structure creates an unnecessary dichotomy and apparently confuses students. Providing consistency across humans and other organisms with respect to evolutionary biology content would not only be more accurate, it would be more efficient. Biology majors would be better prepared for a course like Human Evolution if biological anthropology content—or simply the use of humans as examples of taxa that experience evolutionary forces like any other organism—was more often integrated into the introductory biology curriculum. For example, the application of evolutionary biology is especially important to understand human relatedness to other non-human primates, historical human movement Out of Africa, and malarial resistance. These topics are predicated on fundamental knowledge of phylogenetics, migration and gene flow, and natural selection and adaptation, and they should be integrated into the respective course units along with other organismal examples. In fact, because many biology majors are interested in medical and health-related fields, integrating examples that are unique to human evolution, such as antibiotic resistance and drug addiction, would not only more readily engage biology majors, but would make the content more easily digested.

While the results of our analyses suggest that anthropology majors are understanding the key biological concepts taught in Human Evolution, we would still argue that many anthropology majors are not as scientifically literate as they should be. At VCU, the

Human Evolution course is the only biological anthropology course that majors are required to take. Often those students who are more interested in sociocultural anthropology, and thus have not taken any prior biological anthropology courses, struggle when they reach this upper-level course. While their scores were not included in the current study, we noted that the only students to withdraw from the Human Evolution course over the four study semesters were anthropology majors who left the course during the "biology" unit content. This unfortunate phenomenon underscores another key aspect of the interplay between anthropology and biology in courses like Human Evolution: the integration of humanities and STEM fields is crucial to producing well-rounded students who can apply critical approaches to real world problems faced by humans today. Humans, like all organisms, are the result of evolutionary pressures, and problems like disparities in health outcomes between populations can best be understood with an evolutionary framework. The integration of humanistic studies, such as the relationship between socioeconomic status and health, into this STEM framework is integral for relevance and context for these questions. Initiatives designed to specifically integrate humanities courses in STEM curricula are multifaceted, but they include an emphasis on highlighting the "social relevance" of the materials (Busch-Vishniac and Jarosz 2004). A curriculum that prepares students to ask and answer these questions is inherently both anthropological and biological at its core, and an interdisciplinary program of study must by definition address how these biological topics are applied, contextualized, and relevant to humans.

While our study produced multiple results, some of which may be unexpected, we understand the limitations and challenges still ahead. This dataset and analysis is the first to directly address the diversity of our students' anthropology and biology backgrounds and to examine the effects of this diversity both within and between content units. However, some questions remain unresolved. As human evolution courses attract students with a wider diversity of backgrounds (i.e., majors in sociology, psychology, and even engineering enroll in our course), we need to be even better prepared as faculty to address the learning needs of these students. Active learning environments, where the use of in-class assessment is used, are key to understanding this diversity and to evolving our courses on-the-fly. For example, pairing formative assessments, which engage students' knowledge base before and during the delivery of new material, with summative assessments, which evaluate students' knowledge base after the material is covered, can allow instructors to identify which students and what content needs further attention.

We were able to dissect out how variation exists across multiple years and multiple lecture and lab design structures; however, we now argue even more strongly that a larger and more longitudinal dataset, possibly even across institutions, is needed to answer additional questions. While we see significant differences within years within units/majors, we want to examine whether these differences are linked to class size, student demographics, and/or the influences of multiple instructors and teaching styles.

In addition, a study that examines how students perform on "biology" and "anthropology" unit content at both the introductory and advanced course levels would be relevant to our conclusions. These additional studies would allow us to identify how and where students acquire and apply prior background knowledge to general vs. human-focused problems in evolutionary biology. The intention of this study was to identify and assess trends in learning outcomes in the fields of biology and anthropology, where evolution has long been taken for granted as a point of intersection. From a broader perspective, as evolutionary biology becomes more integrated into many disciplines in STEMM (i.e., Science, Technology, Engineering, Math, and Medicine), we need empirical data to validate the success of this integration across more diverse fields.

Conclusions

Instead of different courses geared towards the individual disciplines of biology and anthropology, an integrated biology and anthropology curriculum would better prepare students in both majors for courses in human evolution. Biology majors may be underprepared for thinking about humans as organisms of study, and given that biological anthropology uses the tools, techniques, and methods of biological study to uniquely ask questions about humans, anthropology majors are often not as scientifically literate as they should be. We suggest a different approach: an integrative and interdisciplinary curriculum that provides in-class active learning environments for students to share knowledge from both disciplines and that integrates examples of humans as organisms throughout all courses. This approach would likely produce stronger students in each program of study by allowing students to understand not only how humans are the product of evolution, but also why that knowledge is important to broader questions about human origins, social and cultural diversity, and genetic and infectious disease differences across populations. At the crux of this improvement is the need for instructors to be better prepared to address the diversity of students' backgrounds through the use of active learning environments that pair formative and summative assessments to gauge students' knowledge base. As degree programs and entire science disciplines become more functionally interdisciplinary, we must expect a more student-centric and adaptable curriculum to evolve.

Acknowledgements

Thanks to Drs. Laurie Kauffman and Jessica Westin for organizing the "Triumphs and Tribulations in Teaching" symposium at the 2015 annual meeting of the American Association of Physical Anthropologists, and for allowing us to be a part of it. We would also like to thank the Undergraduate Research Opportunities Program, the School of World Studies, and the Department of Biology at Virginia Commonwealth University. Many thanks to the many anthropology and biology students who have taken the Human Evolution course at Virginia Commonwealth University.

References

Alters, Brian J., and Craig E. Nelson. 2002. "Perspective: Teaching Evolution in Higher Education." *Evolution* 56 (10): 1891–1901. doi:10.1111/j.0014-3820.2002.tb00115.x.

American Association of Physical Anthropologists. 1996. "AAPA Statement on Biological Aspects of Race." *American Journal of Physical Anthropology* 101 (4): 569–70. doi:10.1002/ajpa.1331010408.

Brem, Sarah K., Michael Ranney, and Jennifer Schindel. 2003. "Perceived Consequences of Evolution: College Students Perceive Negative Personal and Social Impact in Evolutionary Theory." *Science Education* 87 (2): 181–206. doi:10.1002/sce.10105.

Busch-Vishniac, Ilene J., and Jeffrey P. Jarosz. 2004. "Can Diversity in the Undergraduate Engineering Population Be Enhanced Through Curricular Change?" *Journal of Women and Minorities in Science and Engineering* 10 (3): 255–82. doi:10.1615/JWomenMinorScienEng.v10.i3.50.

Cunningham, Deborah L., and Daniel J. Wescott. 2009. "Still More 'Fancy' and 'Myth' than 'Fact' in Students' Conceptions of Evolution." *Evolution: Education and Outreach* 2 (3): 505–17. doi:10.1007/s12052-009-0123-6.

Dobzhansky, Theodosius. 1973. "Nothing in Biology Makes Sense except in the Light of Evolution." *The American Biology Teacher* 35 (3): 125–29. doi:10.2307/4444260.

Gundling, Tom. 2010. "Human Origins Studies: A Historical Perspective." *Evolution: Education and Outreach* 3 (3): 314–21. doi:10.1007/s12052-010-0248-7.

Jensen, Murray S., and Fred N. Finley. 1996. "Changes in Students' Understanding of Evolution Resulting from Different Curricular and Instructional Strategies." *Journal of Research in Science Teaching* 33 (8): 879–900. doi:10.1002/(SICI)1098-2736(199610)33:8<879::AID-TEA4>3.0.CO;2-T.

Linhart, Y.B. 1997. "The Teaching of Evolution--We Need To Do Better." *Bioscience* 47 (6): 385–91.

Lloyd-Strovas, Jenny D., and Ximena E. Bernal. 2012. "A Review of Undergraduate Evolution Education in U.S. Universities: Building a Unifying Framework." *Evolution: Education and Outreach* 5 (3): 453–65. doi:10.1007/s12052-012-0435-9.

Moore, Randy. 2006. "What Are Students Taught about Evolution?" *McGill Journal of Education* 42 (2): 177-187.

Nelson, CE. 2000. "Effective Strategies for Teaching Evolution and Other Controversial Topics." In *The Creation Controversy and the Science Classroom*, 19–50. Arlington, TX: NTSA Press.

Smith, Mike U. 2009. "Current Status of Research in Teaching and Learning Evolution: II. Pedagogical Issues." *Science & Education* 19 (6-8): 539–71. doi:10.1007/s11191-009-9216-4.

Stanford, Craig, John S. Allen and Susan C. Antón. 2013. *Biological Anthropology: The Natural History of Humankind*. New York: Pearson Education, Inc.

Sundberg, Marshall D., and Michael L. Dini. 1993. "Science Majors vs Nonmajors: Is There a Difference?" *Journal of College Science Teaching* 22: 299–304.

White, Jess, Craig D. Tollini, W. Aaron Collie, Meredith B. Strueber, Linda H. Strueber, and Jonathan W. Ward. 2009. "Evolution and University-Level Anthropology Textbooks: The 'Missing Link'?" *Evolution: Education and Outreach* 2 (4): 722–37. doi:10.1007/s12052-009-0176-6.

Wilson, David Sloan. 2005. "Evolution for Everyone: How to Increase Acceptance Of, Interest In, and Knowledge about Evolution." *PLoS Biology* 3 (12): e364. doi:10.1371/journal.pbio.0030364.