

# Reproductive Science for High School Students: A Shared Curriculum Model to Enhance Student Success<sup>1</sup>

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## ABSTRACT

The lack of a national reproductive biology curriculum leads to critical knowledge gaps in today's high school students' comprehensive understanding of human biology. The Oncofertility Consortium developed curricula that address the basic and clinical aspects of reproductive biology. Launching this academy and creating easy-to-disseminate learning modules allowed other universities to implement similar programs across the country. The expansion of this informal, extracurricular academy on reproductive health from Northwestern University to the University of California, San Diego, Oregon Health & Science University, and the University of Pennsylvania magnifies the scope of scientific learning to students who might not otherwise be exposed to this important information. To assess the experience gained from this curriculum, we polled alumni from the four centers. Data were collected anonymously from de-identified users who elected to self-report on their experiences in their respective reproductive science academy. The alumni

survey asked participants to report on their current academic standing, past experiences in the academy, and future academic and career goals. The results of this national survey suggest the national oncofertility academies had a lasting impact on participants and may have contributed to student persistence in scientific learning.

*high school reproductive education, oncofertility, reproductive education, reproductive health, reproductive science, STEM education*

The lack of a national standard for reproductive biology curriculum creates knowledge gaps for today's students, generating barriers to a comprehensive understanding of biological functions. Such knowledge gaps are particularly prevalent in lower income communities that have limited access to extracurricular scientific opportunities [1]. Today there are nearly 50 million students attending K-12 public schools in the United States [2] yet many of these students do not have adequate access to comprehensive reproductive biology curricula. Indeed, reproductive biology is often oversimplified to connote sex education, and of the meager 22 states (and the District of Columbia) that do mandate sex education in the United States, only 13 require that, when provided, this instruction must be medically accurate [3]. Even at the collegiate level, curricula on human reproductive biology are difficult to find, with only a handful of universities focusing on the reproductive sciences. To partially address these issues, Northwestern University launched the Oncofertility Summer Academy (OSA), a free, on-campus, high school education program taught by Northwestern University scientists and professors that educates students about reproductive health from biology through fertility preservation procedures for oncology patients [4]. Students complete curriculum modules in the areas of mitosis, meiosis, the reproductive system, pregnancy, cryobiology, cancer, epigenetics, and oncofertility to engender an integrative understanding of reproductive biology and better prepare the future generation of leaders in the reproductive sciences. The learning goals include providing students with hands-on laboratory and clinical activities, preparing students for rigorous collegiate science classes and careers, allowing students to develop relationships with scientists, doctors, and other professionals, and empowering students with reproductive health knowledge. High school science teachers and higher education staff seek to engage students in laboratory and clinical activities, develop curricu-

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lum modules to link to classroom work, reconnect with the love and reason for teaching, and create a network of science teachers that spans the nation. Holistically, this program seeks to create biology curriculum that is relevant and intellectually based and provide continuous engagement beyond the high school diploma. This same Northwestern University curriculum model ([www.whsp.northwestern.edu](http://www.whsp.northwestern.edu)) has been adapted by the University of California, San Diego (<http://repromed.ucsd.edu/oncofertility/>), Oregon Health & Science University (<http://www.ohsu.edu/xd/research/centers-institutes/onprc/public-outreach/oncofertility-curriculum.cfm>), and the University of Pennsylvania (<http://irm.med.upenn.edu/science-impacting-the-clinic/education-outreach/pars/>), expanding the scope of scientific learning across multiple national settings. The OSA model addresses 1) the paucity of training in reproductive science at the high school level, 2) the need for increased access to advanced reproductive science teaching for all students, particularly underserved, minority communities, and 3) the demand for a collective model of reproduction education that can be adapted across multiple institutions. The OSA program contextualizes reproductive biology within basic research and care for oncology patients whose fertility may be compromised due to treatment. Framing reproductive biology within the field of oncofertility allows students to develop concepts from basic science through clinical application.

It was predicted that a translational approach to reproductive science education could be particularly impactful for populations who express interest and aptitude in science, but do not have adequate access to extended educational programs. Multiple studies have shown that there is a serious shortage of undergraduates pursuing degrees in certain science and medical fields; indeed, in 2008, only 14% percent of all undergraduates in the United States were science, technology, engineering, or math (STEM) majors [5]. Furthermore, rates of persistence and advancement in STEM careers are even more tenuous [6], particularly for populations that have not yet achieved parity in STEM fields, such as women, minorities, and students of low socioeconomic status [7]. Three of our four program sites have therefore limited enrollment to females and prioritized minority students in an effort to improve equity at this stage in the science and medicine pipeline. In order to best assess student outcomes from program alumni, each program site receives annual Institutional Review Board approval to conduct longitudinal and survey-based assessments to program participants. All subjects were asked to sign a research consent form to ensure their rights and welfare was protected in the collection of these data.

The administered alumni survey yielded a 40.55% response rate from collective alumni of the Northwestern, University of California, San Diego, Oregon National Primate Research Center, and the University of Pennsylvania programs. Respondents represent a wide range of racial and ethnic diversity with

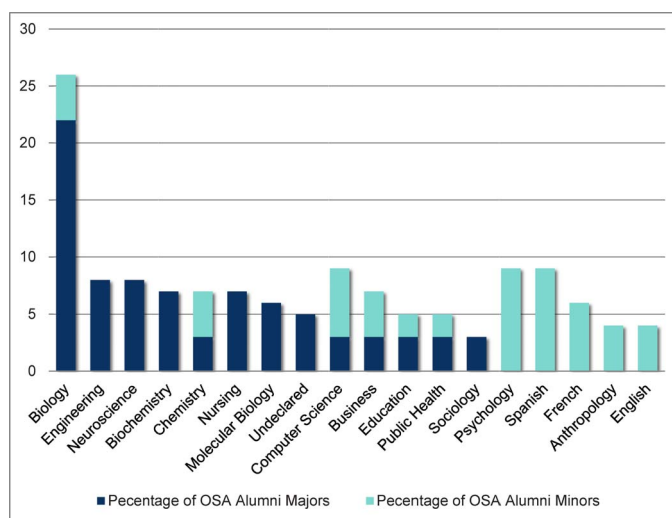


FIG. 1. A survey was administered to OSA alumni to determine the breadth of college majors the alumni are currently pursuing. Majors reported in  $\leq 2\%$  of alumni: advertising, animal health technology, anthropology, biological basis of behavior, communications, creative writing, criminal justice, gender and sexuality studies, geography, health-care management, international relations, kinesiology, mathematics, medical laboratory science, molecular toxicology, occupational therapy, pharmacy, photography, physiology, public policy, social work, sports medicine, statistics, and wildlife conservation. Minors reported in  $\leq 2\%$  of alumni: accounting, African American studies, classical studies, criminal justice, education, emergency medical technician, geo-spatial information systems, health and medicine, health policy, human rights, Latin American studies, marine biology, music, public health, public policy, and religion

competitive academic credentials (Table 1). Over 36% of respondents identify racially as American Indian, Alaska Native, Black, African American, Hispanic, or Latino, thus showing that the programs reach students from a wide variety of racial and ethnic backgrounds and can be classified as underrepresented minorities.

Respondents were asked, depending on their reported educational level, whether they intend to major in science, have declared a major in science, or graduated with a degree in a science field. Of the alumni who participated in the survey, 33.5% are currently still in high school, 55.2% are currently in college, 5.9% have graduated from college, and 1.8% answered as other. Importantly, 78.4% of respondents currently in high school plan to major in a STEM field in college, 73% of respondents currently in college are pursuing a degree in STEM, and 64% of respondents have graduated with a degree in a STEM field. Figure 1 demonstrates the top 98% of college majors and minors the alumni are currently pursuing both in STEM and non-STEM fields.

TABLE 1. OSA racial and ethnic diversity.<sup>a</sup>

University	Total alumni	Survey responses	% URM (American Indian, Alaska Native, Black, or African American)	% Hispanic/Latino	Avg. H.S. GPA	Avg. college GPA	% who plan to attend college
Northwestern University	247	96	41.9%	27%	3.92	3.22	100%
Oregon National Primate Research Center	58	17	3.4%	8.6%	3.71	3.42	100%
The University of Pennsylvania	133	48	26.2	12.5%	3.95	3.55	100%
The University of California, San Diego	107	60	30%	18%	4.12	3.45	100%
Aggregate	545	221	22.5%	14.4%	3.93	3.41	100%

<sup>a</sup> GPA, grade point average, H.S., high school, OSA, Oncofertility Summer Academy, URM, underrepresented minority.

Beyond college, 92% of respondents indicated that they plan on attending graduate school. Seventy-two percent of respondents who plan on going to graduate school indicated that they intend to pursue a degree in a STEM field, including a master, Ph.D., or MD degree (Fig. 2). Looking further ahead into the future, over 88% of respondents reported that they are pursuing a career in research and/or medicine. Respondents were also asked if they have shadowed, volunteered, or had an internship in a hospital, laboratory, or other STEM-related institution in order to learn more about potential careers: 76% reported that they had participated in one of these precareer preparation positions.

Collectively, 78% of respondents indicated this reproductive science program had a definite to major influence on the STEM courses they have chosen to pursue in high school and/or college. Another 72% reported their program also influenced their participation in both extracurricular activities related to STEM and their participation in other science or research programs. Approximately 91% responded that this experience had an (slight, definite, or major) influence on their confidence in STEM classes. Broken out, 24% indicated this experience had a slight influence on their confidence in STEM classes, 30.7% indicated this experience had a definite influence on their confidence in STEM classes, and 36.5% indicated this experience had a major influence on their confidence in STEM classes.

One Penn Academy for Reproductive Sciences (PARS) alumna reported,

I have always been extremely interested in regenerative medicine. However, most high schools do not teach the subject in depth. Yearning to expand my knowledge, I decided that the PARS program would be a perfect place for me to learn more about regenerative medicine. By the end of the program, I learned about regenerative medicine in a unique way and found that I had learned more about the science than I had been expecting. It was quite a stimulating experience that allowed me to realize my true interests in science.

This student and many alumni involved in these programs at the various sites attribute much of their current academic career paths and success to their participation in the program. This curriculum model has been well established for over 10 years and is continually revised to keep up with the latest developments in scientific research and knowledge. The up-to-date curriculum includes instructional packets, laboratory modules, and supplemental activities, making it easy for any institution to implement the program. Additionally, the curriculum is flexible, allowing institutions to make appropriate changes depending on the populations they serve and the resources at their disposal.

This research demonstrates the lasting impacts and benefits of reproductive science programs and suggests continued programs targeting women and minorities in high school are essential for the saturation and retention of students in the science and medicine pipeline. It is clear there is a need for precollegiate programs targeting underserved populations, particularly women and minorities, who express interest in these fields. Given the patterns of lasting impact on participants, this reproductive science curriculum is a useful framework for the implementation of similar programs at universities and institutions across the country, especially ones that are located in areas with stratified socioeconomic diversity, racial diversity, and underfunded secondary schools. In addition to the national dissemination of this oncofertility curriculum, Northwestern University and its partner sites have actively established other means to propagate reproductive education in impactful ways. In 2012, the Women's Health

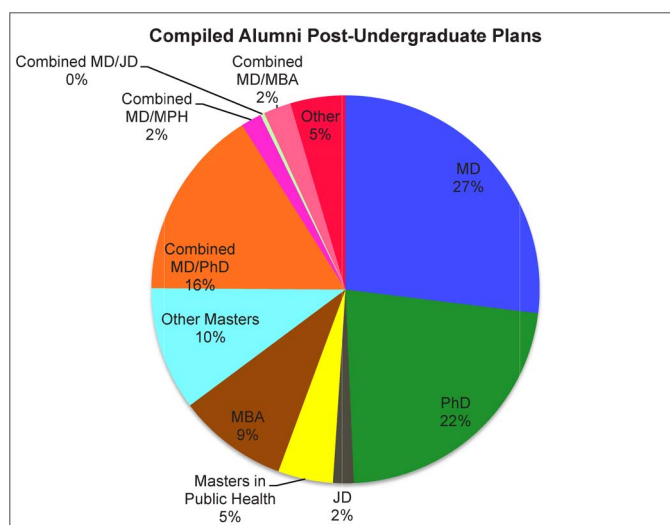


FIG. 2. A survey was administered to OSA alumni to determine the participant's plans for further education after receiving an undergraduate degree.

Research Institute at Northwestern University developed Repopedia, an online lexicon of reproductive health terms and definitions written by experts in the field to help make reproductive jargon more accessible to the general population [8]. Recently, in 2015, Northwestern University created a massive open online course, Introduction to Reproduction, which provides pithy online lectures and assessments in reproductive health and are accessible to anyone anywhere [9]. Also in this past year, Oregon Health & Science University digitized the oncofertility curriculum and made it publically available online (<http://www.ohsu.edu/xd/research/centers-institutes/onprc/public-outreach/oncofertility-curriculum.cfm>) to better equip online learners with learning modules covering the complex topic of oncofertility. The development of Repopedia, Introduction to Reproduction, the digitization of our oncofertility curriculum, and our high school reproductive health academies represent the numerous ways the reproductive science community is building content for kindergarten to gray learners here in the United States and around the globe. More effort is needed to bring additional educational resources to the public, and we hope that many universities will utilize the OSA model and these other tools to improve access to accurate reproductive health information.

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