

Andrews University

Department of Biology

Self-Study

Submitted by the
Department of Biology
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Criterion 1: Mission, Impact, History, and Demand

1. How does the program contribute to the mission of Andrews University and the Seventh-day Adventist Church?

The Department of Biology identifies its mission as providing "transformational education in the biological sciences for a diverse student population, set in the context of a Seventh-day Adventist Christian worldview," an education centered on seeking knowledge, affirming faith, and preparing students to "change the world." These commitments closely parallel the University's mission statement, which likewise emphasizes, "seek, affirm, change" as transformational elements of Seventh-day Adventist education at Andrews University.

Three elements of our Department's mission-driven contribution deserve particular comment: transformational education, service to a diverse student population, and a Seventh-day Adventist commitment.

Transformational Education

The historic success of the Department in transforming average students to achieve above-average outcomes was the motivation for two National Science Foundation grants: STEP grant # 0336596 (funded 2003) to "clone" the biology program's success in developing an interdisciplinary Behavioral Neuroscience program; and STEP grant # 0724516 (funded 2007) to evaluate outcomes and elucidate processes responsible for student success.

The data are still being analyzed, but it is already clear that students cited meaningful student-faculty interaction as the most important factor contributing to their success in the biology program (draft of final grant report, Larry Burton et al., in preparation). We are thankful for this recognition, but we realize that such success must not be assumed. Indeed, rapid growth in student numbers from 2000 to 2011 (see Fig. 4.1) made it more challenging to provide this nurturing environment, and student learning may have suffered as a result. The recent addition of a faculty budget has helped address that challenge, but we are concerned about some recent declines in exit test scores of graduating seniors (see Table 9.1).

Serving a Diverse Student Population

Sharp contrasts exist between the distributions of ethnicities of undergraduate Biology majors at Andrews compared with those of all undergraduate biology majors in the United States (Fig. 1.1). At least two trends over the past 10 years are noteworthy: First, far higher proportions of blacks and Asians are represented among Andrews Biology students than at the national undergraduate Biology level. Second, although there has been a modest increase in percentages of Hispanic undergraduates in the U.S., the rise in numbers of Hispanic Biology majors at Andrews has been quite steep.

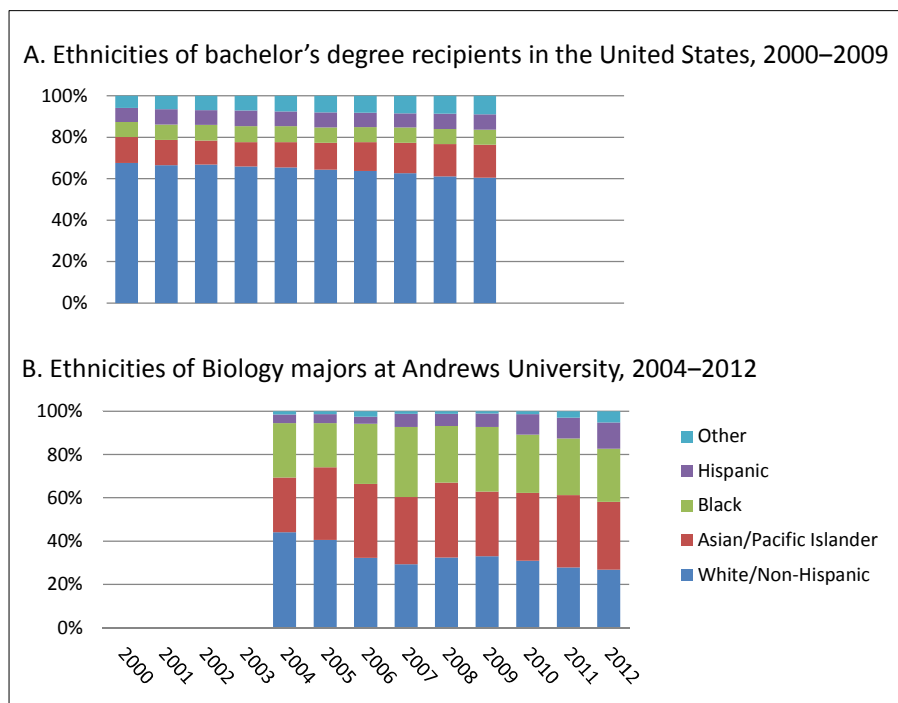


Figure 1.1.—Ethnic composition of undergraduate students in the United States in comparison with that of Andrews University undergraduate Biology majors. National data for 2011 and 2012 not yet available.

The gender composition of Andrews Biology students differs somewhat from national averages. Over the past 10 years the gender composition of our students has fluctuated without exhibiting any particular trend, averaging 52% females and 48% males. By contrast, between 2004 and 2010, 57% of undergraduate students nationally were females and 43% were male. Thus, Andrews' undergraduate Biology student

population is more evenly distributed gender-wise than the national undergraduate distribution.

How can we best serve this diverse student population? We will continue to explore this question. We believe that recent changes in the demographic makeup of biology faculty may assist. In the past two years we have tripled the percentage of female faculty, and added two Hispanic faculty members. Diverse faculty members serve as important role models for students.

Seventh-day Adventist Commitment

We serve the church in multiple ways. First, we actively seek to help our students engage the complex issues at the interface of science and Adventist faith in ways that honor both science and faith. One required course Historical and Philosophical Biology focuses on this interconnection. Beginning with the 2013-14 class, we also will require a religion course that focuses on bioethics from a Christian perspective.

Second, we primarily serve Seventh-day Adventist students. From 2004 to 2011, 95-97% of our students described themselves as Seventh-day Adventist, down to 88% in 2012 (Fig. 1.2). This drop does not reflect a change in proportion of students coming from academies (Fig. 1.3).

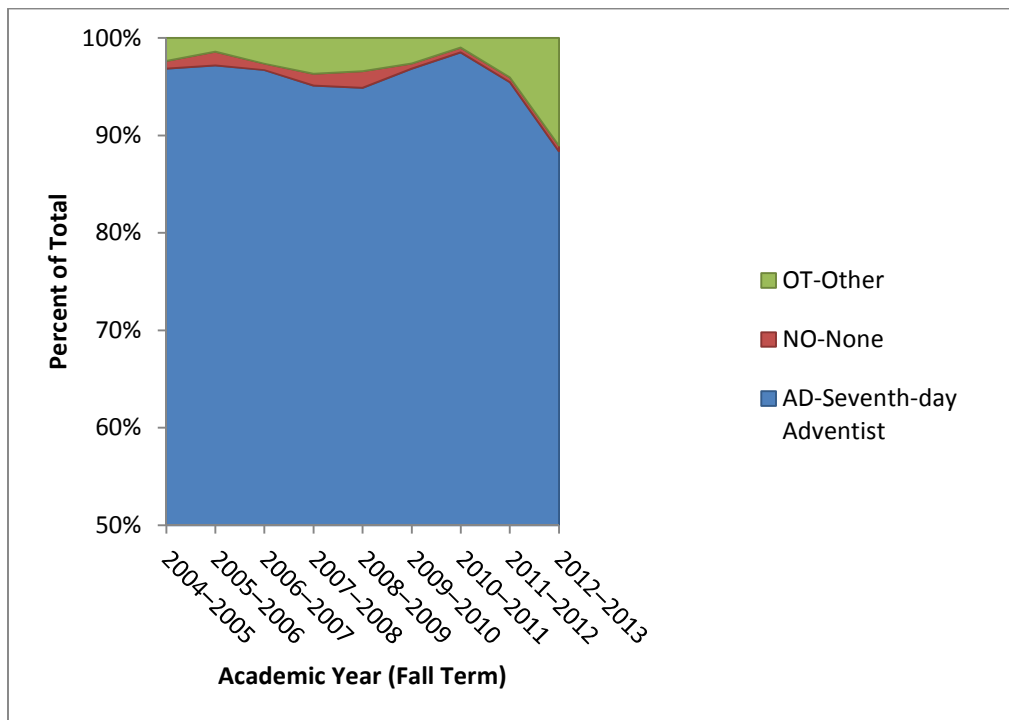


Figure 1.2.—Religious affiliations of Andrews University undergraduate Biology majors.

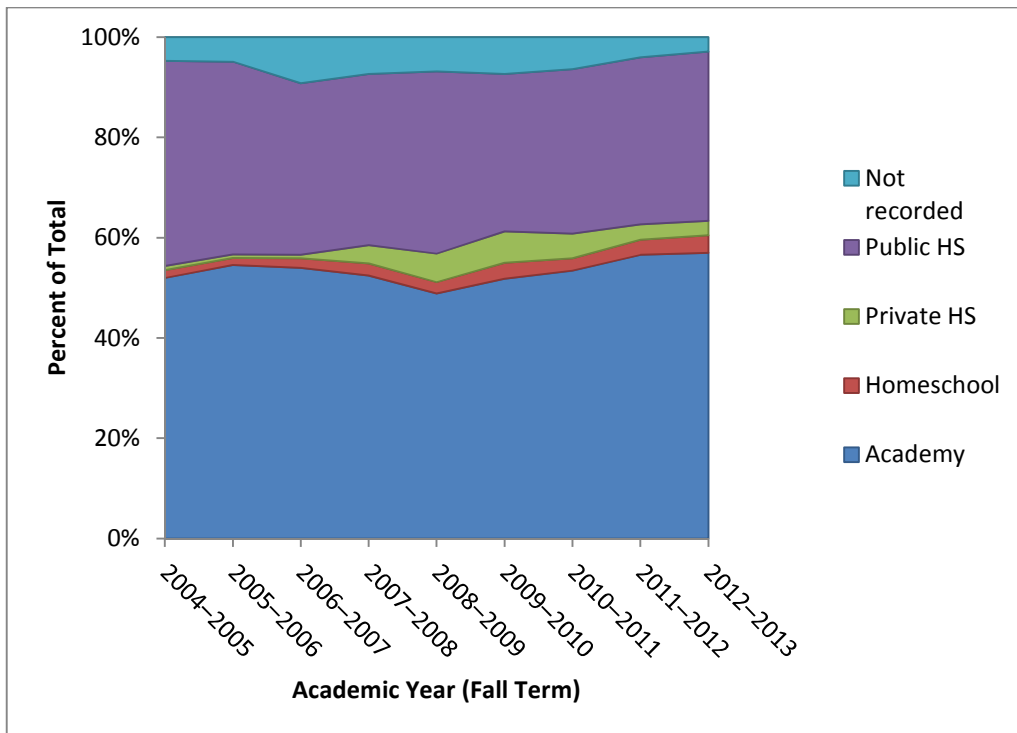


Figure 1.3.—Secondary schools attended by Andrews University undergraduate Biology majors.

Third, we successfully prepare many of our students for academic and health-related careers that serve the church and world. As one example, 74% of our majors who applied for medical school during the last 5 years for whom we have complete data (2008-2012) successfully gained acceptance to a school of their choice, with most of them choosing Loma Linda University.

2. How does the history of the program define the contributions of the program to Andrews University?

The Department of Biology at Emmanuel Missionary College, the precursor of Andrews University, was formed in 1938 with Burton H. Phipps as chair. Prior to 1938, courses such as General Zoology were taught by instructors affiliated with a “Science Department” or other such designations. At all Seventh-day Adventist institutions, coursework in the sciences was offered due to the need for qualified medical personnel, particularly physicians, who graduated from accredited professional schools.

The Department has grown and matured in multiple ways since its establishment more than 75 years ago. The number of faculty has increased from 1 professor with a master's degree to 11 professors, all with Ph.D. degrees. This growth in expertise parallels a growth of course offerings and emphases. Andrews offered a Biology major beginning with a simple curriculum. Undergraduate students majoring in Biology today, however, enjoy a variety of emphases and electives, including courses that provide training in transmission electron microscopy, scanning electron microscopy, genetics, biostatistics, bioinformatics, field ecology, ornithology, mammalogy, and other up-to-date tools, conceptual frameworks, and methodologies.

Growth in numbers of faculty, curriculum diversity, and quality paralleled concomitant increases in numbers of majors. Figure 2.1 illustrates growth in numbers of majors, which more than tripled between 1980 and 2010.

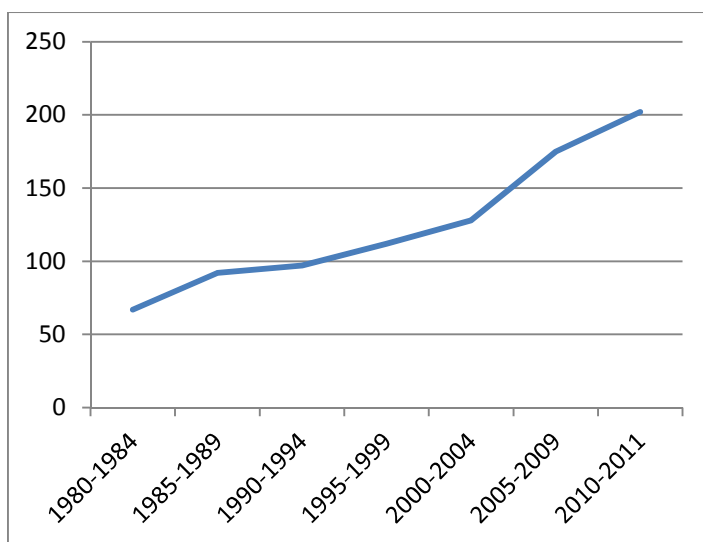


Figure 2.1—Growth in numbers of Andrews University Biology majors, 1980–2010

Foundations of Biology

The Department's entry-level course is titled Foundations of Biology. Unlike many college-level biology courses which constitute 8 semester credits, Foundations of Biology is a two-semester, 10-credit laboratory course. Given the large proportion of students interested in medically-related professions at Andrews, some of whom do not major in Biology, this course provides solid and comprehensive treatment of the biological sciences at the freshman level. Many Andrews University graduates who today are medical professionals look back on this course as pivotal to their learning

experience. This course provided them with excellent preparation for the Medical College Admissions Test (MCAT) and Dental Aptitude Test (DAT).

Harold Heidtke designed Foundations of Biology and taught/co-taught the course for over 30 years. We attribute the course's comprehensiveness and rigor to his foundational planning and implementation. Due to growth in student numbers, currently the course is taught in two sections. The first semester of each section is taught by a professor with expertise at the molecular/cellular scale of biology, whereas the second semester is taught by a professor with expertise at the organismal scale of biology. Laboratories continue to focus on hands-on experiments and observations and have not resorted to computer-based simulations.

Biology Core Curriculum

The Biology Core of 27 credits, taken by all Biology majors, has been modified and honed through the years to track modern trends in biology. It has long included Foundations of Biology, along with Genetics, General Ecology, Cell and Molecular Biology, Historical and Philosophical Biology, courses that emphasize key concepts in contemporary life science. More recently, courses that provide students with tools and perspectives important to their future have been added, including Biostatistics and Research Design and Scientific Communication.

The cognate core has long consisted of full years of General Chemistry, Organic Chemistry, and Physics (either General Physics or Physics for Scientists and Engineers). Beginning in 2014, a required General Education Cognate will include a 3-credit course entitled Bioethics and Christian Faith taught by the Department of Religion.

Programs of Emphasis

Under leadership of John F. Stout in 1985, the Department began to group course offerings into more specific programs than simply Zoology and Botany. Currently, the Department offers Bachelor of Science programs with courses grouped according to specific emphases. These include emphases in Behavior/Mathematics, Biomedical Science, Molecular Biology, Neurobiology, Neuroscience, Secondary Education, Zoology, and Special (tailored to specific interests and needs of interested students). In addition, the Department offers minors in Biology and in Environmental Science.

Designation of programs of emphasis has attracted students to programs designed for specific interests and career goals. The Biomedical Science option (introduced in 1985) is by far the most popular program, which reflects the large proportion of our students interested in pursuing medicine or dentistry. This option has

provided these students with strong preparatory courses prior to entrance to professional school. We commonly hear from former students who have gone to medical and dental programs, that they were better prepared as a result of their program at AU than their peers from other undergraduate programs.

Master of Science in Biology Program and Strong Research Emphasis

In addition to the Bachelor of Science program in Biology, since the mid-1960s the Department has offered a Master of Science in Biology. This program was initiated as part of a larger push by then-president Richard Hamel to expand graduate education at the newly-formed university. This decision made AU an attractive option for newly-minted Ph.D.'s courted by the department.

In addition to strengthening offerings at the undergraduate level, the move to offer a graduate program proved essential to the professional productivity of faculty. The research programs of faculty now could be continued with involvement by graduate students. Moreover, the emphasis on research spilled over quite naturally to the undergraduate level. Vertical integration of research in the Department is common, with faculty mentoring graduate students, and graduate students mentoring undergraduates in lab and field. Masters-level students, for their part, are prepared for acceptance into Ph.D. programs or for successful employment in biology-related industrial or academic positions. (Issues related to the graduate program are discussed under Question 19.)

Overall Contributions to Andrews University

The Department of Biology actively reinforces in students the University's motto of "Seek Knowledge, Affirm Faith, Change the World" in a variety of tangible ways. Learners are presented with current knowledge of the almost bewildering array of sub-disciplines that characterize contemporary life science.

Seek Knowledge.—Students graduate from our program armed with a detailed knowledge of biological "facts", experienced in contemporary biological techniques and concepts, and functioning as intelligent and informed participants in an on-going conversation about the intersection of biological science and society.

Affirm Faith.—Students in our program are continually reminded of God's creatorship, challenged to create for themselves a coherent personal faith, and encouraged to share their faith through commitment to human health, ethical conduct, and creation care.

Change the World.—Virtually all of graduates enter professions which make tangible differences in the lives of others and the well-being of the planet. They accomplish this by enhancing the physical well-being of patients they will attend to in

their practices, and by passing along crucial information and attitudes to future generations of students as teachers.

3. How does the program contribute to the academic success of Andrews University?

Academic success at a university can be measured in a variety of ways. The most important measure of success is the degree of career success achieved by its graduates. The Department of Biology has prepared thousands of its majors for careers in medicine, dentistry, teaching, and research. These alumni have made and continue to make major contributions to society through the provision of health care, the teaching of young people, and the generation of new concepts and information through research productivity. Additionally, through service courses such as Microbiology and Anatomy and Physiology, the Department has contributed significantly to the education of thousands of students majoring in nursing, physical therapy, clinical laboratory sciences, physical education, and other majors. The department's general education courses such as Environmental Science have contributed to the liberal education of non-science majors. Every biology major, in turn, takes courses in other departments, thus boosting the success of the University overall. Finally, participation in the broader scientific community increases the value and visibility of the institution.

Enrollment Numbers and Credit Hours Generated

Biology major enrollment increased steadily from 2004 to a high of 2010. Enrollment has declined from a high of 212 in 2010 to 178 in 2013 (Fig. 3.1). Reasons for the decline are unknown. Subjective impressions among departmental faculty, however, suggest that the average quality of our students has *risen* from 2010.

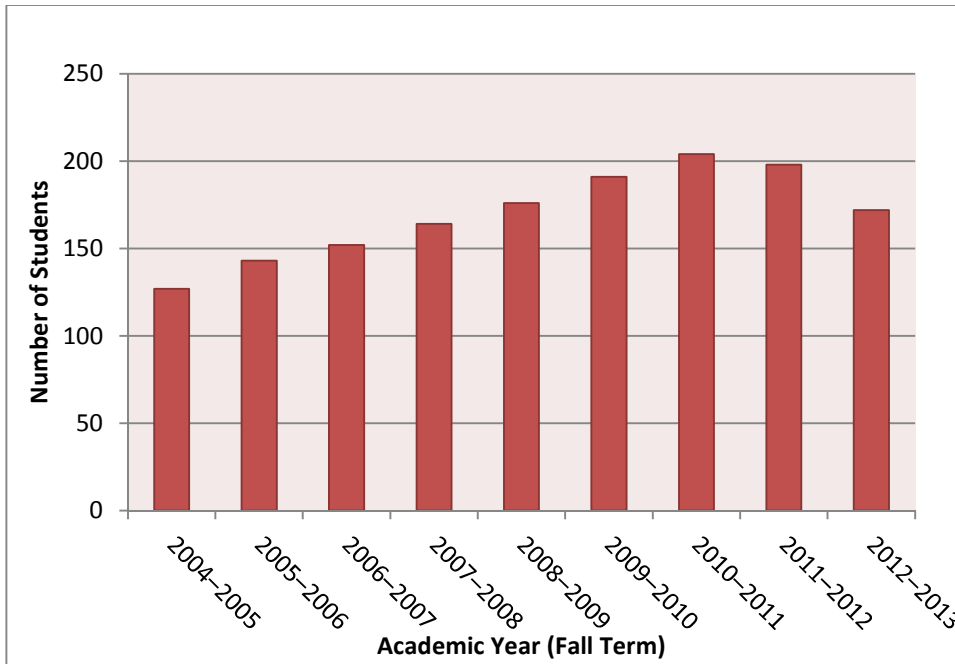


Figure 3.1—Number of students enrolled in the B.S. program in Biology at Andrews University, 2004–2013.

Our primary competitor for students in this major within the Adventist system is Southern Adventist University. But we commonly enroll students from Southern’s “territory” as well, so the net impact of losses to Southern on our program is probably insignificant.

Table 3.1 shows enrollment numbers and credit hours generated by undergraduate Biology majors and non-majors in the Department from 2004 to 2012.

Table 3.1—Undergraduate enrollments and credit hours in the Department of Biology from 2004–2013. Credits rounded to nearest whole numbers.

Year	Majors enrolled	Total UG credits	No. graduated
2004-2005	127	3,154	13
2005-2006	143	3,357	21
2006-2007	152	3,212	23
2007-2008	164	3,465	23
2008-2009	176	3,934	23
2009-2010	191	4,013	25
2010-2011	204	4,278	28
2011-2012	198	4,178	32
2012-2013	172	3,905	28

Enrollment by undergraduates during the last 10 years peaked in 2010-2011. Following 2011, enrollment began to decline. The reason for this decline is unclear. We will monitor any trends closely over the next several years.

Graduate enrollment in the Department from 2003 to 2013 is highlighted in Table 3.2.

Table 3.2—Graduate enrollments and credit hours in the Department of Biology from 2004-2013. Credits rounded to nearest whole numbers.

Year	Grad students enrolled	Total grad credits	No. graduated
2004-2005		83	2
2005-2006	9	91	1
2006-2007	9	91	1
2007-2008	8	94	4
2008-2009	6	58	4
2009-2010	4	61	3
2010-2011		66	1
2011-2012		76	2
2012-2013		90	2

Graduate enrollment has also declined. One reason for this may be the relatively non-competitive financial package our Department could offer prospective graduate students. This package was less attractive than what is offered by Loma Linda University and Walla Walla University, the only two other Seventh-day Adventist institutions that offer graduate programs in biology. In response to the enrollment decline, the Department has voted a new financial package for graduate students which, along with other changes to the graduate program, should make our offering more attractive to prospective students.

Research Visibility

The Department of Biology has a tradition of research that reaches back to the 1960s. Numbers of peer-reviewed publications over the past 10 years by departmental faculty and students are summarized in Figure 3.2. The average yearly output of peer-reviewed publications from 2004 to 2013 was 5.5. Although not high, this value represents a steady involvement of faculty in research output.

New faculty members are hired with an expectation that research productivity will be given high priority. Each of our five new faculty members has an active research

program. Thus, we suspect that the yearly research productivity of the Department will see an increase in future years.

Peer-reviewed publications are important for several reasons including providing 1) an objective measure of departmental contributions to the wealth of human knowledge and understanding, 2) an indication that faculty are subject specialists in their areas of teaching, and 3) visibility of the University as an active participant in the academic community. Each of these services enhances the academic success of Andrews University and increases the value of all degrees from this institution.

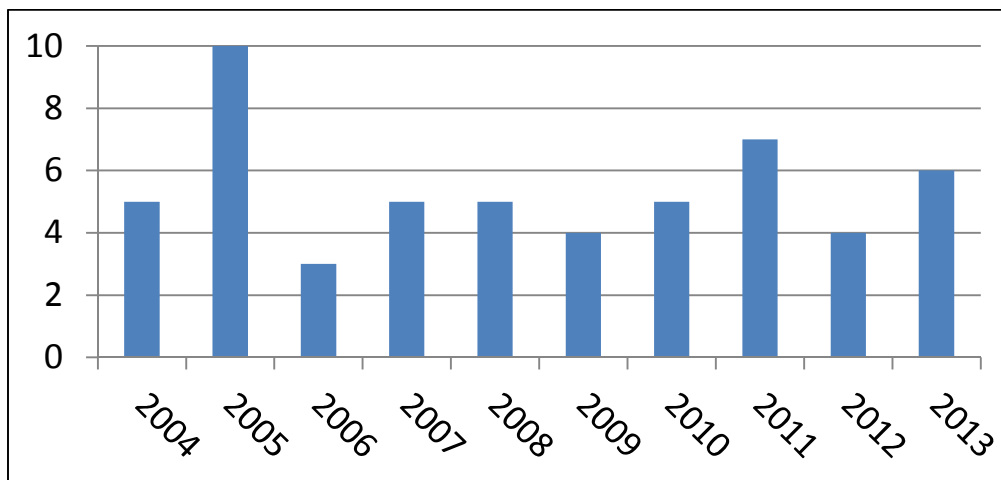


Figure 3.2—Yearly output of peer-reviewed publications by Andrews University Biology faculty and students. Only papers appearing in recognized scholarly journals are listed. Faculty members also publish articles for general audiences in journals which may or may not be peer-reviewed.

Peer-reviewed publications represent only one avenue for communication of research results to the broad scientific community. Figure 3.3 highlights numbers of talks and posters presented by Biology faculty and students at scientific conventions.

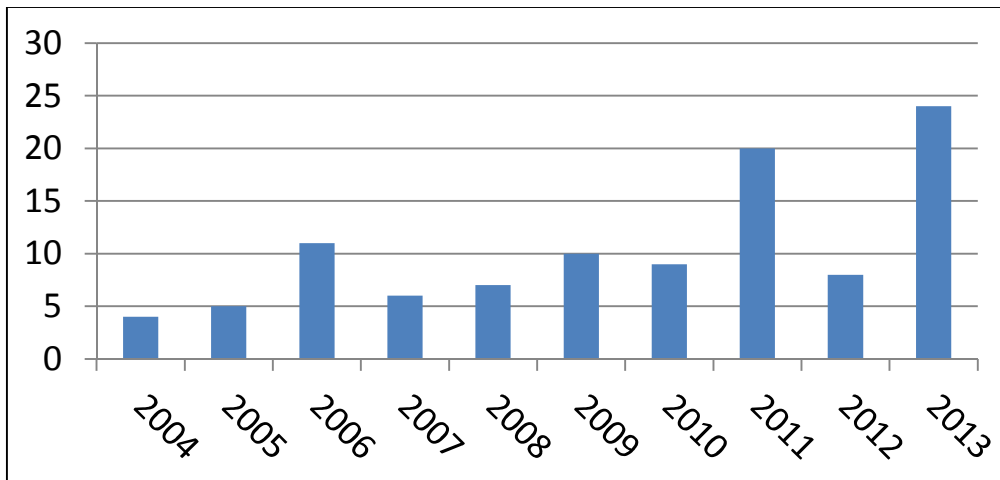


Figure 3.3—Yearly output of posters and oral presentations presented by Andrews University Biology faculty and students at scientific meetings, symposia, and colleges and universities other than Andrews.

Increases in numbers of oral and poster presentations in 2011 and 2013 over previous years are encouraging. Often, oral and poster presentations are developed into manuscripts for submission to peer-reviewed journals. Moreover, our newer faculty members are part of the reason for the increase in presentations. A trend toward more presentations at meetings may suggest an increase in numbers of peer-reviewed publications in the near future.

Alumni Contributions

Alumni of the Department of Biology provide significant financial support for our program (see data under Question 5). This financial support underwrites important aspects of our program, including equipment acquisition, upgrading of facilities, and financial assistance for students. Career success and career satisfaction of our graduates is responsible for this support which strengthens the University as a whole and enhances academic success of all students who take courses offered by the Department, whether they are majors or not.

4. What is the state of demand for graduates of – and employment in – the program?

A high percentage of Biology graduates pursue graduate or professional degrees immediately after earning their bachelor's degree. Seventy-four percent of Andrews

biology graduates who applied to medical school from 2008–2012 were accepted, 1.7 times the national average, and more than 90% of those who apply to graduate programs are admitted.

Employment data for persons trained in the biological sciences is strong and rising. For example, the U.S. Bureau of Labor Statistics Occupational Outlook Handbook (<http://www.bls.gov/ooh>) projects an average growth rate of 11% for all occupations between 2012 and 2022. But the projected percent change in employment during this same period for dentists is 16%, physicians and surgeons 18%, chiropractors 15%, optometrists 24%, podiatrists 23%, and veterinarians 12%. These are the professions that employ most of our graduates, and predicted growth for each these professions through 2022 is higher than the average rate of growth for all occupations.

Table 4.1 summarizes the latest available (May 2012) United States government employment data for professions that employ most of our graduates.

Table 4.1. Employment data for professions chosen by biology graduates in the United States. This table focuses on professions employing Andrews University Biology graduates. These are the latest available data from the U.S. Bureau of Labor Statistics, Occupational and Employment and Wages, May 2012 (www.bls.gov/oes/current/oes_stru.htm#00-0000).

Occupation	No. employed in U.S.	Employment rise (%)	Mean hourly wage (\$\$)	Mean annual wage (\$\$)	Wage Rise (%)
Anesthesiologist	29,930	5.5	111.94	232,830	2.0
Family & General Practitioner	110,050	1.8	86.95	180,850	0.8
Internist	45,210	3.3	92.08	191,520	1.4
Obstetrician	20,880	6.3	104.21	216,760	1.8
Pediatrician	30,560	4.2	80.59	167,640	1.5
Psychiatrist	24,210	3.7	85.35	177,520	1.9
Surgeon	42,410	2.9	110.84	230,540	1.3
Chiropractor	27,740	2.5	38.25	79,550	1.8
General Dentist	93,580	2.2	78.48	163,240	1.2
Oral or Maxillofacial Surgeon	4990	9.1	104.06	216,440	3.9
Orthodontist	5530	10.2	89.58	186,320	5.5
Prosthodontists	310	26.0	80.83	168,120	14.7
Optometrist	29,180	2.8	52.80	109,810	1.4

Physician Assistant	83,640	1.6	44.45	92,460	0.5
Veterinarian	56,020	1.5	44.83	93,250	1.0
Medical Research Scientist	95,420	2.7	42.23	87,830	1.5
Zoologist or Wildlife Scientist	18,650	2.6	30.05	62,500	0.6
Microbiologist	18,550	5.0	35.22	73,250	1.9
Conservation Scientist	18,460	1.7	30.57	63,590	0.5
Postsec. Biol. Science Teacher	50,040	1.6	N/A	87,060	1.7
Secondary Science Teacher	959,770	0.9	N/A	57,770	0.5

As noted above, the demand for graduates from this program will remain robust over the next 10 years. Physicians, dentists, and other health professionals who earn biology degrees will be needed in increasing numbers as the Baby Boomer population ages. Thus, it is doubtful that our recent drop in enrollment is due to decreased market demand for Biology majors overall.

Criterion 2: Program Quality

5. How do available human and physical resources relate to what is necessary to have a strong program of high quality that mentors students to succeed?

Twenty-first-century biological science is highly diverse and technically challenging. Excellent teaching and training in this area requires significant investments in human resources, equipment, supplies, and other resources. With rising costs, it is a continual struggle to maintain a strong program. But with the support of alumni and administrators who value our contributions to the University program, we have been able maintain particularly strong undergraduate and graduate programs in Biology.

Human Resources

We have enjoyed, and we continue to enjoy, excellent, well-trained, and committed faculty. Four long-time faculty members retired in 2012 and another left for another

institution. These five members constituted exactly half of the Department’s teaching and research force – and represented a remarkable 170 accumulated years of service to Andrews University. Indeed, long service by our faculty has been one of the Department’s strengths. Another measure of our stability is the fact that in its 76-year history, the Department has changed chairs only six times.

Figure 5.1 shows cumulative five-year maximums in numbers of Biology faculty at Andrews from 1920 (before a formal department was formed) to 2014 and gains and losses of Biology faculty during the 95-year period. Three trends are apparent.

- Numbers of faculty have grown from only one in the early days to 11.
- The first decade of the 21st century was the most stable period in terms of cumulative numbers of Biology faculty and numbers of gains and losses over the entire period.
- By contrast, in the 4-year interval from 2010-2013, the Department experienced the highest turnover in its history.

Such unprecedented change presents challenges in maintaining the integrity of a program. But a careful search and vetting process enlisted six excellent faculty replacements. Indeed, careful hiring has characterized this Department’s history. Since the 1960s, we have been careful not only to hire good teachers, but to hire good teachers who value research.

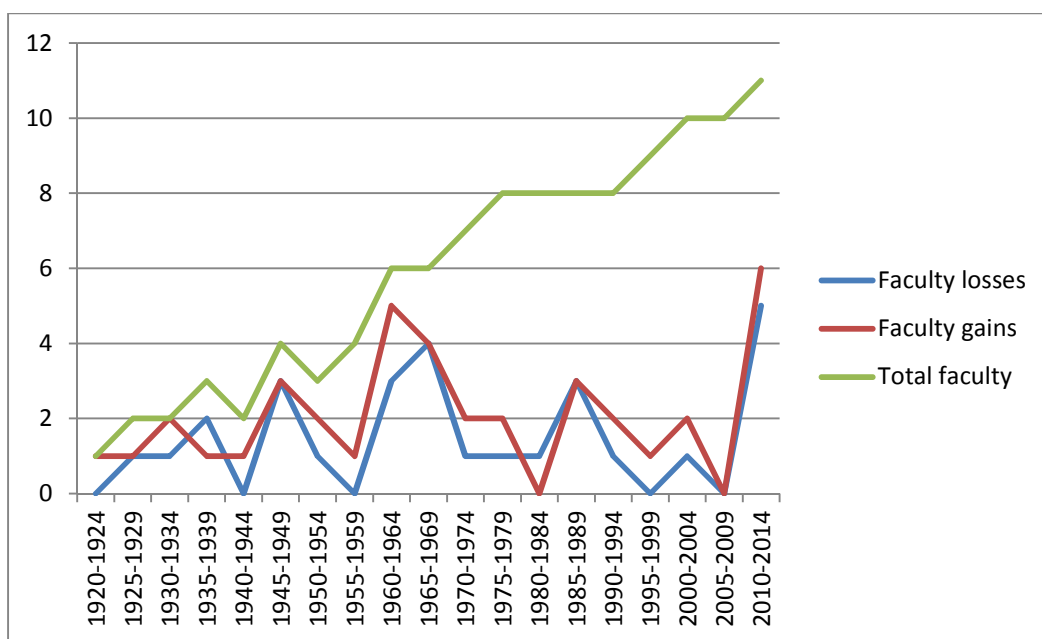


Figure 5.1—Andrews University Biology faculty losses, gains, and net growth from 1920 to 2014.

The research commitment on the part of faculty provides several benefits, not the least of which is the opportunity for students to participate at every level of the research process. For example, of the 55 papers published by Biology faculty in peer-reviewed, scientific journals from 2004 to 2013 (Fig. 3.2), 36 were coauthored by students, several of whom served as first authors. An additional 104 oral and poster presentations presented at scientific meetings (Fig. 3.3) featured 55 student authors and coauthors. Participation in the research process is formative for students and enhances their ability to enter graduate and professional school. A number of our former students are now professors at leading research institutions, including the University of Michigan, Mayo Foundation for Medical Education and Research, Auburn University, Cardiff University, and University of Connecticut. Many others are physicians and dentists with successful practices, and as a result of their experience in the Department of Biology, have learned to understand and value research as providing an important foundation for their careers.

Physical Resources

The Department of Biology is housed in Price Hall, which consists of three floors plus a greenhouse/animal facility penthouse in the University's Science Complex. Price Hall was completed in 1973, and houses offices for the 11 Biology faculty members. In addition to an office, each faculty member is assigned a research laboratory. The building contains seven teaching laboratories, a lecture hall that seats 162 students, and a smaller classroom that holds approximately 40 students. A conference room is used for small seminar-type classes, meetings, and study. A museum contains a wide variety of biological specimens on display as well as scientific study collections. Additional rooms house scanning and transmission electron microscopes, darkroom, and a field equipment storage area.

With funds provided by alumni and the administration, the Department updates its equipment on a regular basis. For example, within the last 28 years the Department has rotated through three scanning electron microscopes and two transmission electron microscopes. Light and dissecting microscopes are relatively new. The Department also owns phase contrast and epifluorescence microscopes. Cell and molecular biology teaching and research is supported by an array of up-to-date equipment, including thermocyclers, laminar flow hoods, a CO₂ incubator, centrifuges, microcentrifuges, electrophoresis apparatus, Powerlab Intermediate Teaching Kits, and miscellaneous software.

A fourth-floor penthouse contains a spacious greenhouse with four large rooms plus a work area. An adjacent animal care facility contains four research labs and a cage-cleaning room. The greenhouse is well-maintained and contains a wide variety of tropical, desert, and temperate plants. Currently, the animal care facility requires new

cage-cleaning apparatus plus a new ventilation system to meet with government requirements before it can be utilized to capacity.

Forty-one-year-old Price Hall is in need of remodeling, including a new mechanical system to maintain better temperature control, new tables in the teaching labs, conversion of one of the labs into a room that can double as a medium-size classroom, new flooring, and dedicated office space for graduate students.

A new research and development wing is being planned for the Science Complex. Preliminary architectural plans have been drawn up. This facility will provide laboratory and office space for faculty and student researchers. Construction of this facility will occur in conjunction with the building of an atrium at the front of the Science Complex. The atrium will serve as an area for exhibit and facilitate social interaction.

Alumni Support

Quality education in the biological sciences costs a great deal of money. Lab equipment is expensive and needs to be updated on a regular basis. Laboratory space sometimes needs to be renovated. Outstanding students must be rewarded with scholarships. The University provides what funds it can, but these funds are limited and insufficient to maintain the quality of education students deserve and have come to expect. Our alumni have provided crucial support in this area. Over the past 10 years, alumni have contributed more than a half million dollars to the Department of Biology (Fig. 5.2).

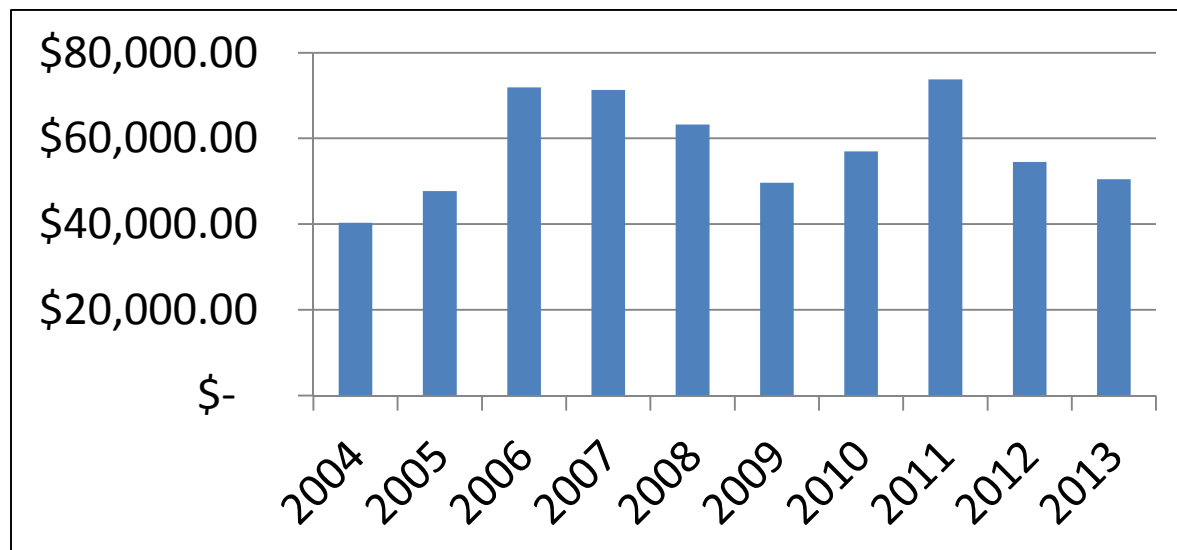


Figure 5.2—Financial contributions provided by Andrews University Biology alumni, 2004–2013.

6. What library resources are necessary for the program, and to what extent are they available and utilized?

Library Resources Necessary for the Program

Biological knowledge is growing extremely fast. For example, if we consider only medical knowledge, the doubling time is estimated to have been 50 years in 1950, seven years in 1980, and 3.5 years in 2010. In 2020, the projected doubling time will be 73 days (Densen, P., Challenges and opportunities facing medical education, *Transactions of the American Clinical and Climatological Association* 122:48–58 (2011)). Clearly the challenge faced by libraries at educational institutions is daunting, to say nothing of the challenge faced by students seeking information on a particular topic. A given library is capable of providing physical access to a mere sliver of information onsite. Fortunately, numbers of online, open-access journals are rapidly expanding. (Although care must be used in which ones to trust; increasing numbers of these e-journals are run by for-profit, overseas, fraudulent organizations). Funding organizations such as the National Institutes of Health mandate open access to information generated from funded research, and many non-open-access journals now publish online enhancing accessibility. Nonetheless, challenges remain. For example, the cost of an institutional online subscription to a major, non-open-access journal like *Science* runs thousands of dollars.

Andrews University is located only 21 miles from the University of Notre Dame which offers a Ph.D. program in biology. Biology journal holdings at Notre Dame are substantial. Other regional research libraries include those at Western Michigan University (60 miles distant) and Michigan State University (135 miles distant). Moreover, James White Library (JWL) at Andrews University, which houses three-quarters of a million volumes, is a member of the Midwest Collaborative for Library Services (MeLCat) which provides access to books, audio recordings, and video recordings owned by 431 libraries, including 51 academic institutions. The interlibrary loan service provided by JWL provides access to nearly journal articles owned by any library.

Table 6.1 highlights JWL expenditures on behalf of the Department of Biology over the past 10 years. Journal print subscriptions have been reduced by 17% over the past 10 years, but increases in online subscriptions, primarily through services such as JSTOR, Wiley-Blackwell Full Collection, and Academic OneFile, have provided students and faculty access to thousands of peer-reviewed journals in all areas of life science. A listing of these journals can be found at the following website:

<http://ug3lf7jn4y.search.serialssolutions.com/?V=1.0&L=UG3LF7JN4Y&S=SC&C=HE>

Table 6.1—James White Library resource expenditures for the Department of Biology over the past 10 years.

Year	# of period-ical titles	Periodical expenditure	Books expenditure	E-journals expenditure	Database expenditure	Total expenditure for Biology	% of total library resources budget
2003-2004	83	\$45,462	\$3,048	\$3,824	\$3,707	\$56,041	8.2
2004-2005	80	\$47,286	\$2,224	\$3,200	\$5,005	\$57,714	7.6
2005-2006	76	\$33,926	\$1,856	\$8,044	\$9,221	\$53,153	7.1
2006-2007	77	\$38,141	\$2,269	\$3,200	\$6,134	\$49,744	6.4
2007-2008	77	\$42,623	\$1,889	\$4,230	\$6,134	\$54,875	6.2
2008-2009	70	\$49,342	\$2,389	\$4,132	\$5,329	\$61,192	6.2
2009-2010	70	\$55,329	\$2,333	\$4,132	\$6,341	\$68,136	7.4
2010-2011	69	\$57,349	\$3,079	\$4,823	\$8,124	\$73,375	6.8
2011-2012	70	\$61,459	\$2,912	\$5,711	\$9,039	\$79,120	6.8
2012-2013	69	\$59,440	\$1,428	\$5,750	\$9,540	\$76,158	6.5

The decrease in print journal subscriptions has coincided with a tendency for students and faculty to use personal computers as primary library research tools. Thus, it can be argued that the access to biological literature by biology students and faculty has markedly increased in recent years as a result of an increase in available online sources.

Although JWL provides online access to many fine journals in the biological sciences, one premier, cross-disciplinary journal remains unavailable online, *Science*. This journal, which is available in print format, highlights some of the most important advances in all of science. Students and faculty would benefit from having this journal available online. Lawrence Onsager, Dean of Libraries, is hoping to add online access to this journal in the near future. Adding online access to this journal not only would benefit the Department of Biology, but it would benefit all the STEM departments and the Department of Behavioral Science.

Comparison with Benchmark Institutions

Comparison of JWL holdings and services with benchmark institutions is complicated now that so much information, once restricted to print holdings, is available online. Thus, it is difficult to know how to compare resources. One simple measure is number

of volumes on the shelves. This number, however, may or may not include bound volumes of journals in addition to regular books. Table 6.2 compares numbers of books and journals reported on the websites of benchmark institution libraries. Numbers of books does not include electronic books.

In comparison with benchmark institutions, the JWL print collection is by far the largest. How the print collection in life sciences compares is impossible to tell from these numbers.

Table 6.2—Library holdings of benchmark institutions. Numbers reported should be taken as rough estimates given that different criteria are used by different institutions, and some of the available data are several years old.

Andrews Univ.	Southern Adv. U.	La Sierra Univ.	Walla Walla U.	Wheaton College	Denison Univ.	Messiah College	Allegheny College	College Wooster	Seattle Pacific U.
Books on shelves (no ebooks): 750,000	165,000	206,000	190,000	370,000	?	253,484	350,000*	361,018	246,937
Journals (print and electronic): ?	20,000	17,400	“thousands”	“thousands”	?	98,644	35,000	?	74,538

*Includes bound journal volumes

Extent to Which Library Facilities Are Utilized

Data provided by Lawrence W. Onsager and Steve Sowder at JWL indicate that in the past 19 months (July 1, 2012–February 13, 2014), 742 items of a total of 11,218 items with call numbers in the range of QH–QR (biology, botany, zoology, human anatomy, physiology, microbiology) were checked out of the library. In addition, 2,427 items of a total of 29,047 items with call numbers in the range of call numbers R–R9999 (medicine) were checked out during this time. It is important to realize that items with these call numbers are utilized by students in Medical Laboratory Sciences, Nursing, Nutrition, Physical Therapy, and other majors. These circulation numbers represent active use of biologically and medically related items, but only a portion of the use would have been by Biology majors and faculty. Moreover, it is important to realize that books typically represent secondary sources of information in the sciences. Utilization of the primary literature by Biology majors and faculty at the University is impossible to track given online access to many of these sources through non-library search engines such as Google Scholar.

As indicated by Table 7.4, literature searches, research papers, poster presentations, and oral presentations are required in a variety of upper division courses in Biology. Moreover, students who present talks and posters or who serve as

coauthors on peer-reviewed papers also must access the literature. Thus, it is fair to say that library facilities and online search engines are heavily used by Biology students and faculty in the course of their educational and research activities.

Standards for Library Literacy

The Association of College and Research Libraries has published a set of five information literacy competency standards for nursing (*College & Research Libraries News*, January 2014, pages 34–41). Lawrence W. Onsager, Dean of Libraries, would like to see these standards adapted for all academic areas of Andrews University, including Biology. These standards, adapted for the Department of Biology, are stated as follows:

- 1. The information literate biologist determines the nature and extent of the information needed.***
- 2. The information literate biologist accesses needed information effectively and efficiently.***
- 3. The information literate biologist critically evaluates the procured information and its sources, and, as a result, decides whether or not to modify the initial query and/or seek additional sources and whether to develop a new research process.***
- 4. The information literate biologist, individually or as a member of a group, uses information effectively to accomplish a specific purpose.***
- 5. The information literate biologist understands many of the economic, legal, and social issues surrounding the use of information and accesses and uses information ethically and legally.***

Given that this set of standards has only recently been published, the Department of Biology has not had an opportunity to assess student competencies against these standards. Our new course in Scientific Communication, however, will provide an opportunity to do so.

Interconnectedness of Library Needs and Use

Library books, journals, and search engines useful to the Department of Biology benefit other departments, in the same way library resources most useful to other departments

benefit Biology. Topical overlap is common and interdisciplinary thinking and activity is *de rigueur* in academe today. Thus, biologists do research and thinking that overlaps with that of physics, chemistry, nursing, physical therapy, medical laboratory science, behavioral science, mathematics, engineering, and other fields. Consequently, library resources ordered by one department will benefit many other departments.

7. How rigorous is the curriculum for the preparation of graduates with skills necessary to adapt to changing environments and technology within their field? How well does the program engage students in collecting, analyzing, and communicating information, and in mastering modes of inquiry or creative work?

Description of Program and Curriculum Rigor

A student who majors in Biology at Andrews can take any one of eight “emphases”, each of which features a specially-designed curriculum. Six of the eight emphases feature a Biology Core, Cognate Core, General Education Cognates, and a set of upper division courses consistent with the chosen emphasis. These first six emphases are Biomedical Science, Molecular Biology, Neurobiology, Secondary Education, Zoology, and Special (for students with unique career goals). The two additional emphases, which have somewhat different core and cognate requirements, are Behavior/Mathematics and Neuroscience.

Biology Core.—The Biology Core features a set of courses that emphasize both theoretical and practical aspects of contemporary life science. Students who complete these courses are prepared to take more specialized, upper-division electives, and they obtain the skills and experience necessary to adapt to the rapidly-changing technologies associated with science and science-related professions.

Theoretical aspects are covered in Foundations of Biology (10 credits), Research Seminar in Biology (features scientists reporting on current research; 0 credits) General Ecology (3 credits), Genetics (3 credits), Cell and Molecular Biology (3 credits), and Historical and Philosophical Biology (3 credits). All these courses except Biology Seminar feature weekly laboratories that provide experience in data collection, data analysis, and careful observation of biological processes. Foundations of Biology features a comprehensive treatment of life, from the molecular to the ecological scale. Many university foundational courses in biology, usually titled “General Biology”, consist of 8-credits. Our 10-credit course provides an exceptionally rigorous introduction to the

discipline. General Ecology, Genetics, Cell and Molecular Biology, and Historical and Philosophical Biology provide more in-depth coverage of the major theoretical ideas in contemporary life science.

More practical aspects of the practice of biology will be emphasized in two additional core courses, Biostatistics and Research Design (3 credits) and Scientific Communication (2 credits). These two courses will provide students with an opportunity to develop the analytic and communication skills important in the practice of modern science.

Cognate Core.—In addition to the Biology Core, majors are required to successfully complete full-year courses in General Chemistry (8 credits), Organic Chemistry (8 credits), and either General Physics (8 credits) or the calculus-based Physics for Scientists and Engineers (10 credits). All cognate core courses feature weekly labs in which students learn basic procedures associated with the practice of each of the sciences addressed. It should be noted that our Department of Chemistry program, in which majors take 16 science cognate credits, is approved by the American Chemical Society, the only chemistry program in the Seventh-day Adventist system that enjoys this approval.

General Education Cognates.—The General Education Cognates have been chosen from a broader slate of possibilities to provide graduates with the ethical, quantitative, and social skills necessary to excel in today's competitive workplace.

Bioethics and Christian Faith (3 credits) is a new course designed to give students an opportunity to wrestle with bioethical issues in the context of Christian faith. The course will be taught by Rahel Shafer, currently a doctoral candidate in Biblical and Theological Studies at Wheaton College and whose dissertation deals with the ethics of creation care. She has both B.S. and M.S. degrees in biology which make her especially well-suited to teach this course.

Biology majors are required to take one 4-credit course in mathematics. They are encouraged to take Calculus I, but they may take Precalculus if they are not prepared for calculus. A facility with mathematics, and particularly calculus, is important and often necessary for contemporary work in the biological sciences ranging from molecular scales to ecosystem scales of complexity.

Premedical students enrolled in the Biomedical Emphasis program are required to take both Introduction to Psychology (3 credits) and Principles of Sociology (3 credits), with the recognition that the successful practice of medicine involves interpersonal skills as much as technical expertise and knowledge.

Upper Division Electives.—The various areas of emphasis feature clusters of upper division courses that round out the biology knowledge and experience base of students. The total course credits for these electives range from 12 to 17, depending on the emphasis. Details can be found in the attached curriculum planners available to students online.

Behavior/Mathematics Emphasis.—The Behavior/Mathematics Emphasis is designed as a hybrid program including focuses in Biology, Behavioral Science, and Mathematics for students pursuing an interdisciplinary career. This option includes three required courses in mathematics: Calculus I (4 credits), Calculus II (4 credits), and Mathematical Modeling in Biology (3 credits).

Neuroscience Emphasis.—The Neuroscience Emphasis is similar to the Behavior/Mathematics Emphasis, except that students are required to take only the mathematics requirements that other Biology majors take, and additional courses in Systems Physiology (3 credits) and Animal Behavior (3 credits).

Comparison of the Andrews B.S. Biology Program with Benchmark Programs

Comparisons in Table 7.1–7.3 are for B.S. in Biology programs. Credit hours for nontraditional programs (such as at College of Wooster) are estimated where possible. Credit hours are shown as semester values (1 quarter credit = 2/3 semester credit).

Table 7.1—Features of benchmark institutions. (No adjuncts, emeriti, or visiting professors reported; school enrollments based on 2014 *U.S. News and World Report* data; numbers of B.S. in biology majors based on data from the respective department chairs).

Data category	Andrews Univ.	Southern Adv. U.	La Sierra Univ.	Walla Walla Univ.	Wheaton College	Denison Univ.	Messiah College	Allegheny College	College of Wooster	Seattle Pacific Univ.
No. of under-grads enrolled	1,917	2,895	2,048	1,710	2,508	2,336	2,798	2,140	2,080	3,238
No. of B.S. majors in Biology	169	100*	290	96	[no data]	230**	85***	[no data]	[no data]	[no data]
Percent of students who are B.S. in Bio majors	8.3%	3.5%	14.2%	5.6%	–	9.8%	3.0%	–	–	–
Master's in Biology program	Yes	No	No	Yes	No	No	No	No	No	No
No. faculty with PhD degree	11	7	9	9	7	16	9	18	9	12
No. faculty with Master's degree	0	2	0	0	0	0	2	1	0	0

No. faculty with MD or DVM degree	0	2	1	0	0	0	0	0	0	1
B.S. Biol student to faculty ratio	14.5:1	9.1:1	29:1	10.7:1	–	14.4:1	7.7:1	–	–	–
Total no. of Biology faculty:	11	11	10	9	7	16	11	19	9	13

*Plus approximately 100 students enrolled in a B.A. in biology program.

** This number includes 130 students enrolled in a B.A. in biology program who likely will switch to a B.S., according to department chair

***Does not include other biology-related majors such as molecular biology

Table 7.2—Comparison of biology core and elective courses among benchmark institutions.

Andrews Univ.	Southern Adv. U.	La Sierra Univ.	Walla Walla U.	Wheaton College	Denison Univ.	Messiah College	Allegheny College	College Wooster	Seattle Pac. U.
Foundation course: 10 credits	General Biology: 8 credits	General Biology: 10 credits	General Biology: 8 credits	Gen Bio equiv: 12 credits	3 intro courses: 12 credit	General Bio equiv: 10 credit	General Bio equiv: 8 credits	General Bio equiv [10 cred]	General Biology: 10 credits
Biostat. And Res. Design: 3 credits		Tools and Methods: _ credits	Biostatistics: 2.7 credits	Modeling Systems of Life: 4 credits			Investig. Appro. In Biology: 4 credits	Research Skills: [4 credit]	Biology Cornerstone Seminar: 0.7 credits
Scientific Communication: 2 credits			Introduction to Biol Research: 1.3 credits						
			Current Topics in Biology: 0.7 credits						Scientific Literature: 0.7 credits
General Ecology: 3 credits			General Ecology: 2.7 credits			Ecology & Adap: 4 credits			
Genetics: 3 credits	Genetics: 4 credits		Cell Biology II: 2.7 credits	Genetics: 4 credits		Genetics & Devel: 3 credits			Genetics: 3.3 credits
Cell & Mol. Bio: 3 credits	Cell & Mol. Bio: 4 credits		Cell Biology I: 2.7. credits						Cell Biology: 3.3 credits
		Develop-mental Biology: 3.3 credits							
Historical & Phil. Bio: 3 credits	Issues in Nat. Sci. & Relig: 3 credits		Phil. of Origins & Speciation: 2 credits						
		Colloquium: 1 credit	Colloquium: 0 credits				Junior Seminar: 4 credits	Junior Ind Study [? credit]	
	Senior capstone: 1 credit	Biology Seminar: 1.3 credits	Senior Seminar: 1.3 credits	Senior capstone: 2 credits		Capstone: 3 credits	Senior Seminar: 6 credits	Senior Ind Study [? credit]	Nat Science Seminar: 1.3 credits
Electives: 12-14 cred	15 credits	_ credits	17.3 credits	14 credits	20-24 credits	17 credits	12 credits	5 courses	10 credits
TOTALS: 39-43 cred	38 credits		41 credits	36 credits	32-36 credits	37 credits	34 credits	[? credit]	29.3 credits

Table 7.3—Comparison of Cognate Core requirements at Andrews University with requirements at benchmark institutions. (Included are mathematics and statistics courses which at Andrews University are considered part of the General Education Core).

Andrews Univ.	Southern Adv. U.	La Sierra Univ.	Walla Walla U.	Wheaton College	Denison College	Messiah College	Allegheny College	College Wooster	Seattle Pac. U.
General Chemistry: 8 credits	General Chemistry: 8 credits	General Chemistry: 10 credits	General Chemistry: 8 credits	Gen & Inorganic: 8 credits	General Chem: 8 credits	General Chem: 8 credits	GenChem Equiv: 8 credits	General Chem: 8 credits	General Chem: 10 credits
Organic Chemistry: 8 credits	Organic Chemistry: 8 credits	Organic Chemistry: 8 credits	Organic Chemistry: 8.7 credits	Organic Chemistry: 8 credits	Organic Chem: 4 credits	Organic Chem: 8 credits	Organic Chem: 4 credits	Organic Chem: 8 credits	Organic Chemistry: 10 credits
Physics: 8 or 12 credits	General Physics: 8 credits	General Physics: 10 credits	General Physics: 8 credits		General Physics: 8 credits	Intro. to Physics: 4 credits		General Physics: 8 credits	Gen Phys (recommended): 10 credits
Precalculus /Calculus: 4 credits	Statistics or Calculus I: 3 credits	Calculus I: 2.64 credit	Pre-calculus: 2.7-3.3 credits	Calculus or Quant. Skills: 4 or 2 cred	2 sem Calculus or Stat: 8 credits	Calculus & Stat: 6-7 credit	Calculus: 4 credits	Calculus: [? credit]	Statistics or Calculus: 3.3 credits
Biochem: 4 credits	Biochem: 4 credits				Biochem: 4 credits		Science electives: 8 credits		
TOTALS: 32-36 cred	31 credits	30.64 cred	27.4-28 credits	18-20 credits	32 credits	26-27 credits	24 credits	[? credit]	33.3 credits

Comments on Features of Institutions.—Of the 10 schools compared, Andrews has next to the smallest overall undergraduate enrollment; undergraduate enrollment at Walla Walla is somewhat smaller. Yet, of the 10 schools, only Andrews and Walla Walla offer master’s degree programs in biology. Total numbers of faculty in the compared schools range from 7 to 19. Thus, the 11 Biology faculty members represent an intermediate-sized department in comparison with benchmark institutions. Moreover, the Biology major/Biology faculty ratio of 14.5 to 1 is also intermediate for the schools compared. Each of the Andrews Biology faculty has an earned Ph.D. degree.

Among the six institutions for which data are available, the percent of all enrolled undergraduates who are B.S. in Biology majors is intermediate; one of every 12 undergraduates at Andrews University is a Biology major.

Comments on Biology Core and Electives.—Comparisons between Andrews University Biology Core with those of other institutions are complicated by considerable variability in course and curriculum structure. Although most of the benchmark institutions feature more traditional programs, Denison, Allegheny, and especially Wooster possess programs that depart significantly from traditional curricula.

Andrews, like Walla Walla, features a core curriculum in which course content and sequence is quite constrained. Indeed, curricula of these two institutions exhibit the most similarities among those compared, an understandable outcome given that eight recent or current Andrews faculty were either students or faculty members at Walla Walla (Chobotar, Hayward, Ritland, Snow, Stout, Thoresen, Woodland, Zdor).

Seven of the 10 institutions compared, including Andrews, offer special coursework in research and/or biostatistics, three require ecology, six require genetics,

four require cell biology, and all but one requires a senior capstone course. (Andrews' current capstone course, Biology Seminar, will be replaced in 2014–2015 with Bioethics and Christian Faith taught by the Department of Religion.) Developmental biology is required only by La Sierra, although Messiah teaches a combined course in genetics and development.

Three of the four Seventh-day Adventist institutions require courses that focus on philosophies related to the history of life. This emphasis arises out of a traditional interest in this topic from a doctrinal position. The non-SDA institutions offer more standard courses in evolutionary biology. This no doubt contributes to the fact that Andrews students perform less well in this area on the Major Field Test than in other areas of the test.

Biology credit requirements for the B.S. degree at the 10 schools range from 29.3 to 43. Andrews, with Walla Walla, is at the high end of this range, whereas Seattle Pacific is at the low end. Denison and Wooster seem to allow the most flexibility in their program, whereas Andrews and Walla Walla are the most rigidly structured.

Comments on Cognate Core, including Mathematics and Statistics.—All 10 programs require 8 to 10 credits of general chemistry in the cognate core. All (including Andrews) but two of the programs require 8 to 10 credits of organic chemistry; the remaining two require only 4 credits of organic. Seven of the 10 programs (including Andrews) require a full academic year of physics; Messiah College requires only one semester of physics. Seven of the 10 programs require a term of either statistics or calculus; three (including Andrews) allow students to take only precalculus or Quantitative Skills (Wheaton only). Three of the 10 programs (including Andrews) require biochemistry. Total cognate core and mathematics requirements range from 18 credits (Wheaton) to highs of 32 to 36 credits at Denison, Andrews, and Seattle Pacific.

Biology majors at Andrews are as well trained as students from any of the other nine schools in general and organic chemistry, physics, and biochemistry. Unless they elect to take calculus, however, they may be less well trained in mathematics than students at La Sierra, Allegheny, and Wooster.

Assessment of Curriculum Rigor.—The Department of Biology offers a rigorous program in contemporary life science. Evidence that graduates leave the department with skills necessary to adapt to changing environments and technologies in their fields is derived from several sources: 1) Our majors perform well above the national average on the Major Fields Test (see Table 9.1); 2) our former majors excel in their professions as is indicated by a high rate of annual financial giving by alumni in support of the department (see Fig. 5.2); and 3) our preprofessional graduates commonly report they are better prepared for their professional programs than most of their peers.

Engagement of Students in Collecting, Analyzing, and Communicating Information, and in Mastering Modes of Inquiry and Creativity

Laboratory Experiences.—Most biology courses at Andrews feature a laboratory component. Many laboratory exercises are designed to engage students in collecting, analyzing, and communicating scientific information. This process begins in Foundations of Biology in which students are required to produce formal laboratory write-ups for several experimental labs during the year. Moreover, first year students gain experience with probability theory and simple statistical testing. Table 7.4 details the types of student experiences featured in Andrews University’s Biology courses.

Table 7.4—Student experiences in courses with data handling and creativity.

Course	Lab reports	Literature searches	Research projects	Research papers	Poster presentations	Oral presentations
Foundations of Biology	X					
Human Biology	X					
Genetics	X		X			
Cell and Molecular Biol	X	X				X
General Ecology	X	X	X	X		
Developmental Biology	X		X			X
Biology of Bacteria	X		X			X
Molecular Genetics						X
Virology	X	X		X		X
Vector Biology and Disease		X		X		X
Immunology	X					
Neurobiology	X		X			
Neuropsychopharmacology	X	X	X	X	X	X
Paleobiology		X	X			
Systems Physiology		X	X	X	X	X
Genomics, Proteomics, & Bioinformatics			X		X	

Biostatistics and Research Design (BIOL 280).—This new 3-credit course will be introduced spring semester 2015. It takes the place of Research Methods I, a 1-credit course. The course will feature probability, basic study design, descriptive

statistics, sampling, contingency tables, t-tests, one- and two-way analysis of variance, correlation, and simple linear regression. Computational exercises will use R and SPSS statistical packages. Students completing this course will use what they have learned to collect and analyze data collected in upper division courses taken during their junior and senior years.

Scientific Communication (BIOL 305).—This new 2-credit course will be introduced spring semester 2015. It takes the place of Research Methods II, a 1-credit course. Prerequisites for Scientific Communication include two semesters of English Composition and one course in Communication Skills. The course will provide a practical introduction to communication in science, including the development of fundamental skills required to convey information in the form of grant proposals, oral and poster presentations, and research articles.

Senior Honors Project (HONS 497).—From 2005 to 2013, 32% of graduating Biology majors graduated as Honors students. One requirement of the Honors program is completion of a research project. The original research project is designed and completed in consultation with a faculty mentor. Undergraduate research stipends of \$1000 in support of this research can be applied for through the University's Office of Research and Creative Scholarship. Honors students communicate the results of their work in three ways: a poster presentation, an oral presentation, and a written report.

Non-Honors Research Projects.—Biology majors not enrolled in the Honors program commonly elect to do a research project. These students are eligible for undergraduate research stipends of \$1000 just like the Honors students. These students are expected to present their results in the form of a written report, and also have an opportunity to present a poster presentation of their work.

Presentations at Scholarly Conferences.—From 2004 to January 2014, Biology faculty presented 104 oral and poster presentations at professional meetings. Students served as coauthors (in some cases as first authors) on 55 (53%) of these presentations.

Coauthorship in Peer-reviewed Publications.—From 2004 to January 2014, Biology faculty published 55 papers in peer-reviewed journals. Students served as coauthors (in some cases as first authors) on 36 (65%) of these publications.

Assessment of Data Handling, Modes of Inquiry, Communication, and Creative Involvement.—Biology majors begin to gain experience collecting, analyzing, and communicating information during their freshman year in Foundations of Biology laboratories. In their sophomore and junior years, majors take two courses specifically designed to give students experience with experimental design, sampling, data analysis, and communication of results. Moreover, laboratories in most upper division courses feature opportunities for students to become involved with data collection, analysis, and communication in which they make use of the skills learned in these sophomore and junior methodology courses.

All Biology majors gain experience in mastering modes of inquiry and creativity in required courses. In addition, a large proportion of our students enroll in the University's Honors program which requires significant creative involvement in original research in collaboration with faculty mentors. At the very least, each resultant project results in an Honors thesis which is permanently housed in the James White Library. In addition, many projects end up as peer-reviewed publications or as components of peer-reviewed publications for which students serve as co-authors with their mentors. Tom Goodwin, the Department chair, actively encourages faculty to include students in their research projects and publications. With the recent addition of six young, energetic, Ph.D.s to our faculty, more opportunities for student research involvement are now available than just two years ago.

In short, our program provides significant opportunities for students to hone their skills in the collection, analysis, and communication of scientific information and the mastering of modes of inquiry and creativity.

8. How do the various measures of outputs and research and teaching productivity contribute to and demonstrate the quality of the program?

Output of Graduates

An important measure of output is the number of undergraduate students enrolled each year in the Biology program and the number of seniors each year who graduate with a Biology degree (Table 3.1). Yearly numbers of majors increased dramatically during the early 2000s, and then experienced a decline following the 2010-2011 academic year. But numbers of majors continue to be more than twice as high as they were during the 1970s and early 1980s.

Graduate student numbers (Table 3.2) have declined in recent years, due in part to a non-competitive financial package offered to prospective students. This problem has been addressed and a new financial package put in place which is considerably more competitive with those of Loma Linda University and Walla Walla University, our chief competitors for graduate students.

From 3.0% to 14.2% of students are B.S. in Biology majors at the six institutions for which data are available. The 8.3% of Andrews University undergraduates who are biology majors represents a mid-point in this distribution. Thus, our productivity in terms of relative numbers of biology majors is respectable and representative, and indicates the attractiveness of our program to students.

Teaching Output

Tables 3.1, 3.2, and 7.1 report measures of teaching output. Of special interest in the context of Question 8 is how our program compares with others in terms of biology student to faculty ratios. Numbers of biology students per faculty member range from 7.7 to 29.0 for the six institutions for which we have data; Andrews has 14.5 biology students per biology faculty member. Compared with Walla Walla University, the only other benchmark institution to offer a master's degree in biology, Andrews is more efficient with a 14.5:1 ratio compared with Walla Walla's 10.7:1 ratio.

Research Output

Figures 3.2 and 3.3 provide data on research output by Andrews University faculty and students from 2004 to 2013. Yearly numbers of peer-reviewed papers published from the department have ranged from three to 11. Yearly numbers of oral and poster presentations at professional meetings ranged from four to 24. Many of these publications and presentations include students as coauthors.

The data reported in the last paragraph represent low to modest levels of research output for a department of 10 or 11 faculty members, all with Ph.D. degrees. These numbers suggest that Andrews Biology faculty members devote considerably more attention to teaching and advising than to research. Certainly this might be expected – perhaps even desired – for a department that serves primarily undergraduate students. However, with the increasing emphasis on the value of research and critical thinking in higher education, our level of research output should be improved. Any increased emphasis in this area, however, should not interfere with the teaching quality for which the Department of Biology is known. But it is important to remember that some of the best teaching occurs in a research setting.

Six new and relatively young scientists with Ph.D. degrees joined our Biology faculty in the past two years. These new faculty members already show signs of active research involvement. Within the past year, Biology faculty members have submitted three major grant proposals to federal agencies. This fresh input bodes well for the research productivity of our Department over the next several years. Most importantly, new research opportunities will provide crucial training for our students.

9. How well are students meeting the program’s learning outcomes? How do your program’s student learning outcomes support the University curricular and co-curricular goals?

Expected Student Learning Outcomes

As part of its Mission Statement, the Department of Biology has developed a series of five expected student learning outcomes for its students. Each of these outcomes is listed below with a response as how the Department is facilitating achievement of the outcome.

1. Demonstrate an integrated understanding of biological science

“As a group in comparison to other institutions, Andrews University Biology students will score: ≥ 80 percentile on the Major Field Test (MFT) composite score, with an aspiration to be $\geq 90^{\text{th}}$ percentile; and $\geq 70^{\text{th}}$ percentile in each of the four subscores of the MFT (Cell Biology, Molecular Biology & Genetics, Organismal Biology, Population Biology and Evolution) – with aspiration to be $\geq 80^{\text{th}}$ percentile.”

The most objective measure of learning outcomes consists of scores by senior biology majors on the Major Field Test for Biology published by the Educational Testing Service (ETS). This 2-hour test consists of 150 multiple-choice questions. Questions are grouped into four sections: 1) cell biology; 2) molecular biology and genetics; 3) organismal biology; and 4) population biology, evolution, and ecology. Questions evaluating analytical skills constitute approximately 25% of the test and are distributed among the four sections.

Table 9.1 provides percentile scores for Andrews University Biology seniors as groups for 17 academic years, 1995–2013. (No scores are available for 2000–2001.)

Table 9.1—Percentile scores for groups of Andrews University Biology seniors, 1995-2013.

Academic Year	Cell Biology	Genetics & Molecular Biology	Organismal Biology	Ecology & Evolution	Analytical Skills	Composite Score
1995-1996	99	97	89	92	97	97
1996-1997	99	95	86	96	97	97
1997-1998	88	67	49	83	88	81

1998-1999	97	86	86	83	92	94
1999-2000	97	73	89	77	97	90
2001-2002	90	80	95	85	75	90
2002-2003	95	70	85	80	75	90
2003-2004	90	85	80	90	90	95
2004-2005	95	95	95	95	90	95
2005-2006	90	85	85	85	90	85
2006-2007	90	85	80	57	85	85
2007-2008	80	65	65	70	65	75
2008-2009	80	75	70	50	50	70
2009-2010	90	75	65	55	40	75
2010-2011	94	84	95	72	86	90
2011-2012	97	96	98	78	92	94
2012-2013	84	80	88	66	81	83

Cell Biology.—Andrews University Biology seniors scored consistently highest in this section of the exam. In no year was the score for this section lower than 80th percentile, and in 13 of the 17 years percentile scores were higher than the 90th percentile (with two years at 99th percentile). These results suggest that our Foundations of Biology and Cell and Molecular Biology courses are doing an outstanding job preparing our students.

Genetics and Molecular Biology.—The lowest percentile achieved in this section of the exam was 65th percentile. During 11 years, however, the group score was at or above the 80th percentile, and reached at least the 90th percentile during four years. Thus, our courses in Genetics and Cell and Molecular Biology have done an above-average job preparing our students.

Organismal Biology.—The lowest score for this section was 49th percentile in 1997–1998. This result seems to have been an anomaly given that in no other year was the score lower than the 65th percentile; during four years students performed at the 90th percentile or above on this section.

Ecology and Evolution.—The lowest score for this section was 50th percentile. Scores on this section of the exam tend to average lower from year to year than for other sections, although during four years the scores reached the 90th percentile or above. There are two possible reasons for the somewhat lackluster performance on this section during some years. First, almost all our students are oriented toward some medically-related field and sometimes fail to see the importance of ecology to their life goals. Second, most of our students come from religiously conservative homes and schools, and as such have been under trained in concepts of evolutionary biology.

Analytical Skills.—Questions related to analytical skills are scattered throughout the other four sections of the exam. During eight of the 17 years, students performed at the 90th percentile or above in this area. However, the score of 40th percentile achieved by students in 2009–2010 is the lowest score for any set of questions for any group of seniors. Thus, this area has exhibited the most variability over the years. With the Department of Mathematics now offering Calculus I for Biology, a new required Biostatistics and Research Design course, and more emphasis on data analysis in other biology courses, this score hopefully will stabilize at a higher level in future years.

Composite Scores.—Composite percentile scores ranged from the 70th to 97th percentiles, with student groups scoring at or above the 90th percentile during 10 of the 17 academic years. These results suggest that, in comparison with students at other schools, Andrews University Biology seniors achieved much better than average learning in Biology for each of the 17 years. Thus, overall, our students are receiving an excellent education and they are meeting Learning Outcome 1 of the Biology Department exceptionally well. Clearly there are places we can improve, particularly in the areas of organismal biology, ecology and evolutionary biology, and analytical ability. We look forward to test results over the next several years.

2. Apply scientific methodology to create and assess scientific knowledge

“On average, students will score above ‘adequate’ in a rubric that assesses application of scientific methodology.”

In summer of 2012, the Department of Biology underwent a significant turnover. In order to leverage this transition time, the Department engaged in a mini-retreat in August 2012 which focused on visioning for the future. We brainstormed about learning outcomes and possible curricular changes that would support these outcomes. Direct consequences of these discussions, which continued into the fall of 2012, were as follows: First, we identified and formalized measurable learning outcomes, which are now the core of our assessment plan in this cycle. Second, we developed and implemented a revised curriculum, which we believe will better leverage these outcomes. Two new core courses were proposed and accepted for implementation: BIOL 280 – Biostatistics and Research Design, and BIOL 305 – Scientific Communication. In this curriculum, the former course must be taken before or concurrent with the latter course, so that our students will first learn how to design and evaluate scientific studies, and then how to communicate their designs and findings effectively. Because these courses are intended to be taken by sophomores and juniors, respectively, they will not be implemented until the 2014–2015 academic year. Thus, we will not have official “findings” until the summer of 2015, when our first students complete BIOL 280 and BIOL 305.

3. Communicate scientific understanding effectively

“On average, students will score above “adequate” on rubrics that assess effectiveness of oral and written communication.”

(See information under last section, “Apply Scientific Methodology to Create and Assess Scientific Knowledge”.

4. Integrate faith and science in light of personal faith commitments

“A final essay, prepared with feedback during the term, in BIOL 449 – Historical and Philosophical Biology, asks students to engage an issue of their choice at the interface of science and faith.”

We will use this essay as a “check point” to assess how well students apply a mature understanding of this relationship to a relevant issue.

5. Practice ethics and professionalism in science

“At least 90% of our graduating seniors will report that the Biology curriculum and program significantly enhanced their understanding of and commitment to Christian ethics and professionalism in the practice of science.”

Assessment of this goal will be made during senior exit interviews, which are carried out with individual majors during their senior year.

How Biology Student Learning Outcomes Support University Curricular and Co-curricular Goals

Andrews University’s curricular and co-curricular goals perhaps are best summarized in its motto of “Seek Knowledge, Affirm Faith, Change the World”.

Seek Knowledge.—The University’s General Education program is designed in line with one of two pillars of American higher education: “broad encounter with varied perspectives and the exposure to knowledge gained from many disciplines.” The second pillar is the chosen major, in which the student focuses on a particular area of study and develops important skills associated with that discipline. The Department of Biology supports both pillars in three ways: 1) It offers General Education credit for several of its courses, including Principles of Biology, Human Biology, Environmental Science, and History of Earth and Life; 2) it offers in-depth education and training in a

wide variety of life science sub-disciplines; and 3) it offers several courses designated as “service learning” courses, such as Vertebrate Zoology, which allow majors to fulfill the General Education Service Learning requirement of the University described in the University Bulletin

(http://bulletin.andrews.edu/content.php?catoid=4&navoid=240#Service-Learning_Requirements).

Thus, direct support for the University’s first goal of “Seek Knowledge” is provided by the Department’s Student Learning Outcomes of “Demonstrate an integrated understanding of biological science”, “Apply scientific methodology to create and assess scientific knowledge”, and “Communicate scientific understanding effectively”.

Affirm Faith.—Biology faculty members proactively promote faith perspectives in their courses. They accomplish this in part by making connections between faith and course content whenever appropriate. Also, faculty members take a personal interest in the spiritual health of their students by talking with students about spiritual issues and showing Christian concern when students are struggling with personal, academic, or spiritual problems. Finally, the Department requires all Biology majors to take Historical and Philosophical Biology and Bioethics and Christian Faith. Both courses focus on religious, spiritual, and ethical issues which are faced, or will be faced, by students in college, post-graduate school, and in their professions.

Thus, support for the University’s second goal of “Affirm Faith” is actively provided by the Department’s Student Learning Outcome 4, “Integrate faith and science in light of personal faith commitments”.

Change the World.—Biology majors most commonly go into medically-related, teaching, and/or research professions. These professions are directly involved with benefiting the health of individuals, teaching important concepts to children and young adults, promoting environmental sustainability in the world, and providing new information benefiting the endeavors of humankind and the quality of the natural world. No professions are more important in changing the lives of people and the enhancing the health of the ecosystem on which all life depends. In addition, while they are still college students, many of our majors choose to serve as student missionaries to begin changing the world in very personal ways before they graduate.

Thus, support for the University’s third goal of “Change the World” is supported by all five of the Department of Biology’s Student Learning Outcomes, but in particular “Practice ethics and professionalism in science”.

10. How successful are program graduates in seeking graduate and professional admission? What is the level of satisfaction among students, alumni, and employers of alumni with the program and its outcomes?

Success of Graduates in Admission to Graduate and Professional Schools

Seventy-four percent of Andrews University biology graduates who applied to medical school from 2008 to 2012 were accepted (Table 10.1). This is 1.7 times the national average. More than 90% of those who apply to graduate programs are accepted.

Table 10.1—Numbers of Biology majors who applied to medical schools, and numbers and percentages of these applicants who were accepted into medical schools from 2008 to 2012.

Year	Biology Med School Applicants	Med School Acceptances	Percent of Applicants Accepted
2008	7	4	57%
2009	12	9	75%
2010	20	9	45%
2011	16	15	94%
2012	18	17	94%
Totals	73	54	74%

Part of this success is due to excellent advising on the part of the Biology faculty. Our faculty members take a deep interest in the success of each of our students. If an advisor does not think a student is prepared for successful admission, the student is advised to take additional courses, participate in a bridge-type program, or do a graduate degree before applying.

Another part of this success derives from the excellent classroom, laboratory, and research preparation students receive. We commonly hear back from alumni who have entered professional school who tell us they feel better prepared than their peers.

Levels of Satisfaction among Students, Alumni, and Employers

Several years ago, the National Science Foundation provided funds to evaluate the Andrews University Biology program. Results of the study were released in a report to NSF entitled “Uncovering Antecedents of STEM Success at Andrews University” in 2012. The study consisted of two parts, one devoted to “processes” leading to student success and satisfaction, and the other devoted to “outcomes”. The processes study

involved one-on-one interviews with 113 Biology alumni and current Biology majors. The sample represented all major ethnic groups, males and females, and preparation levels. A brief summary of the results of the processes study is presented in Table 10.2.

Table 10.2—Percentages of student and alumna interviewees who mentioned seven characteristics of the Andrews University Biology program that impacted student success and experience with the program.

Factor	Total % (n=87)	Female (n=66)	Male (n=37)	African American (n=35)	Asian American (n=16)	European American (n=38)	Latino American (n=13)	Under- prepared (n=42)
Transformational Processes	94.3%	95.5%	91.9%	100%	87.5%	92.1%	92.3%	95.2%
Student-Faculty Relationships	94.3%	97.0%	89.2%	94.3%	93.8%	92.1%	100%	92.9%
University Context	85.1%	84.8%	86.5%	91.4%	100%	71.1%	92.3%	90.5%
Departmental Climate	86.2%	81.8%	89.2%	82.9%	100%	78.9%	84.6%	81.0%
Educational Attitudes Profs	67.8%	66.7%	70.3%	71.4%	75.0%	60.5%	69.2%	69.0%

Transformational Processes.—A high percentage of interviewees believed that the Biology professors focused on student success, served as motivators, and spent time supporting student efforts to achieve success.

Student-Faculty Relationships.—A high percentage of interviewees mentioned the importance of personal attention and holistic support provided by Biology faculty.

University Context.—A high percentage of interviewees mentioned that Biology professors saw students as a priority. Professors made time for students outside of class and took an interest in their personal lives.

Departmental Climate.—A high percentage of interviewees mentioned the importance of the Department of Biology’s supportive environment.

Educational Attitudes of Professors.—More than half of interviewees mentioned that Biology professors were supportive.

In short, results of the study support the view that students enrolled in the Biology program and alumni who graduated from the program who participated in the study were highly satisfied with the support they received from the Biology faculty and with the overall climate of the Department.

Evaluating the level of satisfaction on the part of employers with our graduates is problematic given that most of our students end up as self-employed professionals or as members of professional practice groups.

11. How have the above data contributed to decisions for program improvement? What impacts have the evidence-based changes had on student learning and student success?

How Learning Outcomes Have Contributed to Program Improvement

Learning outcomes as indicated by the results of the Major Field Test in Biology suggest that we are doing many things right. Our graduating seniors as a yearly group have consistently scored in the 70th to 97th percentile since the 1995–1996 academic year. Thus, in terms of basic transmission of biological knowledge and understanding, we seem to be functioning well above most institutions involved in the training of biology majors. This is not to say improvements are unnecessary, and as the MFT results indicate, we have accomplished our task better with some subdisciplines than with others.

Program Improvement with New Departmental Faculty.—One of the biggest challenges in maintaining quality we faced over the past two years has been the replacement of 50% of our Biology faculty, who either retired or moved elsewhere, and the filling of a new faculty position. In a matter of 24 months we lost five long-term faculty and gained six new faculty. In hiring new individuals, we wanted to maintain the strengths we have built through the years. We also wanted to enhance areas that needed improvement.

One area of strength, as indicated by the MFT scores, has been cell and molecular biology. Some of the more important advances in life science are happening in this subdiscipline and we intended to maintain strength in this area. After a careful search, we hired Peter Lyons and Denise Smith, both of whom recently earned Ph.D. degrees in molecular biology and both of whom are active researchers.

A second area of strength has been neurobiology. We offer two areas of emphasis in this area, Neurobiology and Neuroscience. We also cooperate with the Department of Behavioral Sciences in offering a major in Behavioral Neuroscience. Given that one of our neuroscientist faculty members retired and another moved to other employment, we hired two neurobiologists as replacements: Dr. Pamela Coburn-Litvak and Dr. Benjamin Navia. Both Dr. Coburn-Litvak and Dr. Navia have long-term experience with the Department as former students and research collaborators. They join Dr. David Mbungu, also a neurobiologist, in maintaining strength in this area.

Major Field Test scores in Organismal Biology and in Ecology and Evolutionary Biology have tended to be weaker than scores for other subdisciplines. Thus, we were keen to enhance student performance in this area. To this end, we hired two faculty with specialties in these areas: Dr. Kanya Long and Dr. Daniel Gonzalez. Dr. Long is a

virologist with expertise in the ecology of disease and disease vectors, and Dr. Gonzalez is an expert in vertebrate field ecology.

Program Improvement by Increasing Faculty Diversity.—Until 2001, all faculty in the Department of Biology were non-Hispanic, white males. In that year we were able to hire a black female, Dr. Marlene Murray, and a black male, Dr. David Mbungu. The recent addition of six new faculty has increased our Departmental diversity even more. We now enjoy the expertise of four females and seven males, including two blacks, two Hispanics, and seven non-Hispanic whites. We view this increase in diversity as a very positive improvement in our program, diversity which is more reflective of our student body.

Program Improvement through Enhancement of Student Analytical Skills.—Major Field Test scores in Analytical Skills by groups of Biology seniors have exhibited a large range – 40th to 97th percentile. Given the importance of analytical skills in all areas of science, we have found low-scoring years to be disappointing. In response, several years ago we instituted a two-semester Research Methods sequence, the first semester of which focused on data gathering, description, and analysis. Although this course was an improvement over the complete lack of formal biostatistics training (except as part of an occasional lab exercise) in previous years, a one-credit course could provide only a cursory introduction to statistical analysis. Beginning in the 2014–2015 academic year, we will offer a three-credit Research Design and Biostatistics course in the Biology core which will provide our majors with a much better background in processes of data gathering and analysis.

In addition, two years ago the Department of Mathematics began offering Calculus I for Biology. This course, taught by biomathematician Dr. Shandelle Henson, is taught at the same level as the regular Calculus I course except that example problems and applications are from the life sciences. This course, recommended but not required of our majors, attracts many of our better students, and provides important analytical training.

Impacts of Program Changes on Student Learning and Success

It is too early to assess the impact our new faculty will have on student learning and success. We are optimistic, however, that the energy and expertise they have brought to the program will be very positive. Given that all the new faculty members maintain active research programs, new opportunities for student research have opened up. Also, there has been a noticeable increase in use of statistics by our students.

Criterion 3: Financial Analysis

12. What is the relationship between the cost of the program and its income and how has that been changing over time?

The Department of Biology is an income generator for the College of Arts and Sciences. Table 12.1 provides cost and income data for the department over the past eight years.

Table 12.1—Numbers of full time equivalent (FTE) faculty, total undergraduate and graduate credits generated, undergraduate student to faculty ratio, income, expense, contribution to bottom line, and percent contributed by the Department of Biology of the STEM contribution to the School of Arts and Sciences bottom line, 2005-2013.

Year	Dept FTE	Total credits	UG Fac:student	Income	Cost	Contribution to bottom line	% of STEM contribution to bottom line
2005-2006	8.5	3,519	13.4 : 1	\$ 1,386,404	\$ 871,409	\$ 514,995	26%
2006-2007	8.5	3,538	13.4 : 1	\$ 1,523,140	\$ 870,438	\$ 652,702	31%
2007-2008	9.0	3,650	13.1 : 1	\$ 1,651,978	\$ 986,879	\$ 665,099	27%
2008-2009	9.0	4,140	14.8 : 1	\$ 2,096,702	\$ 875,739	\$ 1,220,963	41%
2009-2010	9.0	4,223	15.1 : 1	\$ 2,145,077	\$ 1,074,818	\$ 1,070,259	37%
2010-2011	9.0	4,290	15.4 : 1	\$ 2,282,310	\$ 1,121,210	\$ 1,161,100	37%
2011-2012	9.0	4,104	15.6 : 1	\$ 2,212,886	\$ 1,101,678	\$ 1,111,208	39%
2012-2013	10.0	3,990	11.2 : 1	\$ 2,266,357	\$ 1,128,972	\$ 1,137,386	35%

Income exceeded costs during all years by a large margin. During the past five years, more than 50% of the income generated by the Department contributed to the bottom line of the College of Arts and Sciences, in most years more than 30% of the entire STEM contribution. The data include information through spring 2013, but the Department picked up an additional faculty FTE during 2013–2014. Thus, income generated will have declined somewhat during 2013–2014.

In addition to income generated by tuition, over the past 12 years approximately 1.1 million dollars in extramural grant funds have benefited Biology students and faculty. These funds have been used primarily to support costs associated with research and to support a study of factors enhancing the academic success of Biology majors.

Finally, alumni make significant yearly contributions to the department. From 2004 to 2013, alumni contributed \$579,752 to the department, an average of \$57,975

per year (see Fig. 5.2). These funds are used for student scholarships, special equipment items, and facilities upgrade.

13. What is the (financial and other) impact of the program on the University and, based on trends, how is that likely to change in the future? How adequate is University support to maintaining the health of the program?

As noted under Question 12, income generated by the Department of Biology during each of the past eight years always exceeded costs by a large margin; between 37% and 58% of the income generated was “profit” and contributed to the bottom line of the College of Arts and Sciences, and thus to the University. The profit margin will decline somewhat during 2013–2014, however, due to the addition of one faculty FTE to the Department and a decline in student credits generated. Although these trends would be worrisome if they continued for years into the future, their impact will not be serious in the short term.

In addition to serving Biology majors, the Department of Biology functions as a service department for students majoring in nursing, physical therapy, clinical laboratory science, nutrition, and other majors that require biology credits. Moreover, many pre-medical and pre-dental students major in fields other than Biology but must take Foundations of Biology offered by our Department. Enrollment by non-majors in these courses is large, especially in Anatomy and Physiology and in Microbiology. Finally, non-majors take courses such as Principles of Environmental Science and Human Biology to fulfill general education science credits. If the Department of Biology were to disappear from campus, the reduction in enrollment would be significant.

We have appreciated university support of our program, especially the addition of a faculty budget in the recent time of turnover. Although this is essentially revenue neutral initially (full professors were replaced with assistant and associate professors), it is a long-term financial commitment given that new faculty advance in rank.

Adequacy of budgetary support for departmental expenses is essential for maintaining program quality (e.g., student wages, professional development of faculty, supplies, and small equipment [under \$2,500]), is depicted in Fig. 13.1 for 2010–2011 through 2013–2014. Support has been adequate or nearly so for student wages and professional development, but always underfunds supply purchases – and usually underfunds (three of four years) small equipment purchases. Recent underfunding in these areas relates in part to startup costs for new faculty; we have made up for this underfunding through use of restricted funds.

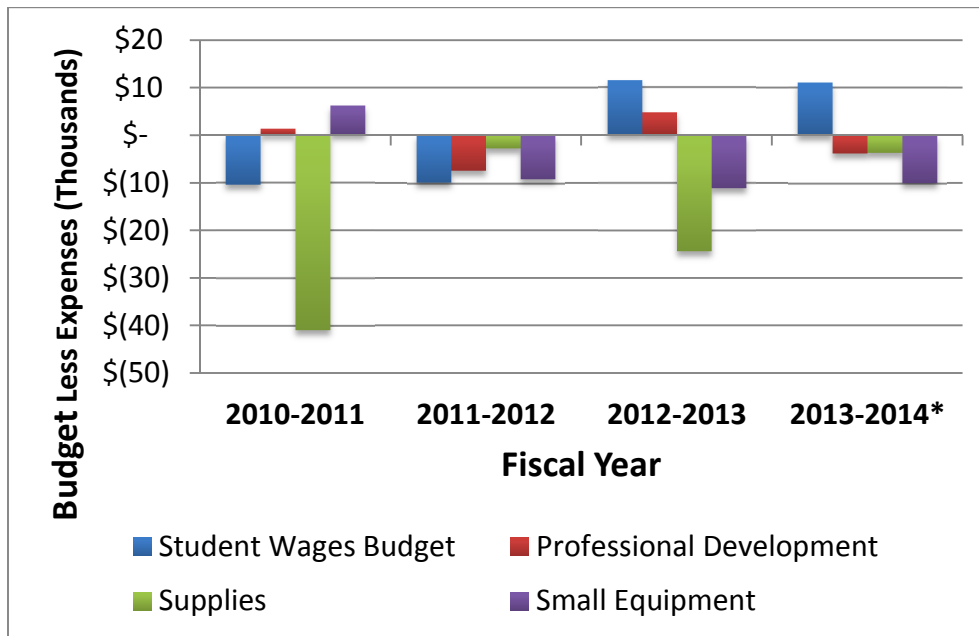


Figure 13.1–Budget less expenses over the last four budget years. Data for 2013–2014 are through January 31, 2014. Values at or above 0 were adequately funded; those below 0 were underfunded (expenses greater than budget)

A graver cause for concern is lack of adequate support for capital improvement and facility upgrades. For example, we requested funding for \$35,000 in teaching equipment (individual costs >\$2,500) as well as support to renovate three rooms for new faculty offices and labs in the 2013–2014 budget. We thankfully received support for \$19,000 of teaching equipment (54% of equipment request) but no support for this time-critical renovation, which we have had to cover from restricted funds (\$26,000). For the 2014–2015 fiscal year, we requested funds (\$19,400) to begin rehabilitating our two most heavily used teaching labs, PH 229 and 240. These labs are badly deteriorating and the subject of negative senior exit comments. However, financial administration has indicated that rehabilitation of these labs will not be covered with capital funds in the coming year, and has intimated that we should cover them using biology restricted funds. We are concerned by this trend, especially given that restricted funds are *not* intended to cover rehabilitation of worn-out teaching space. Fortunately, the Dean of CAS fully supports our case, and we hope this issue will be rectified.

The tendency to severely underfund capital expenses and facility rehabilitation and upgrade will likely impact our ability to attract quality students and future faculty, if not rectified. Over the next few years, we will be requesting support to refurbish or replace badly worn furnishings in most of our teaching labs. In addition, carpet in public spaces in the building has deteriorated badly and compares unfavorably with new carpet in the rest of the Science Complex. Fortunately, this is slated for replacement

during the summer of 2014. Finally, some department research space, notably the Animal Care Facility, is no longer functional. Estimates of upgrade costs for this facility are around \$200,000.

In summary, without alumni support, University support in maintaining the health of the Biology program would prove insufficient. As noted earlier, alumni support has allowed the Department to maintain quality lab equipment in face of rising costs and changing technology, and has provided start-up funds and space renovation for new faculty. We do not believe, however, that it is proper to apply these funds for maintaining decent quality laboratory and other mission-critical space.

Criterion 4: Strategic Analysis

14. What are the strengths of the Biology program?

Faculty Strengths

Aside from having an earned Ph.D. degree and a commitment to a Seventh-day Adventist faith perspective, at least two criteria are applied to every candidate for a permanent faculty position in the Department of Biology: 1) The candidate must be able to communicate well and express a strong commitment to teaching undergraduate and graduate students. 2) The candidate must demonstrate an established research record and a passion for doing research. Application of these hiring criteria over the past several decades has led to development of a remarkably stable faculty of excellent teacher/scholars.

As evidence of the stability of the Biology faculty, the following statistics tell a lot. In the 94 years since 1920, Andrews University has employed only 39 biology faculty, including the six faculty hired in the past two years. The Department was formed in 1938. In the 76 years since that time, only seven chairs have led the Department, including Dr. Tom Goodwin, who assumed the responsibility two years ago. The five individuals who retired or left the Department in the past two years served the Department a cumulative 170 years. All four retirees continued to teach and serve the department following retirement.

Currently, the Biology faculty consists of 11 Ph.D.s trained in diverse areas of life science. As noted following Question 11, the current faculty includes women, along with black and Hispanic minorities (Table 14.1). Each faculty member has published in the peer-reviewed literature, although currently not all faculty members are active in research (see "Faculty Weaknesses" below).

Table 14.1—Gender, ethnicity, teaching expertise, and research expertise of faculty members in the Department of Biology. This table illustrates the diversity of the current faculty which suggests the future, broad-based direction of the Department. Faculty members hired within the past two years are indicated by an asterisk.

Name	Sex	Ethnicity	Teaching Areas	Research Areas
*Coburn-Litvak, Pamela	F	White	Vertebrate physiology	Physiology of stress
*Gonzalez-Socoloske, Daniel	M	Hispanic	Mammalogy, Biostatistics	Marine mammalogy
Goodwin, Thomas	M	White	Paleontology, Phil. of Science	Paleontology
Hayward, James	M	White	Ecology, Animal Behavior	Behavioral ecology
*Long, Kanya	F	White	Virology, Immunology	Tropical virology
*Lyons, Peter	M	White	Cell and Molecular Biology	Enzyme biochemistry
Mbungu, David	M	Black	Neurobiology, Entomology	Synaptic transmission
Murray-Nseula, Marlene	F	Black	Genetics	Molecular genetics of yeast
*Navia, Benjamin	M	Hispanic	Neurobiology	Neural processing
*Smith, Denise	F	White	Anatomy and Physiology	Cancer cell biology
Zdor, Robert	M	White	Bacteriology, Development	Plant pathology

Student Strengths

A significant strength of our Biology student body is the ethnic diversity they represent (see Figure 1.1). This diversity provides a rich learning environment for all our students who benefit from close interactions with students of other backgrounds and races.

Our students represent a wide range of scholastic abilities. One of the strengths of the program has been its capacity to improve the academic skills of marginal students to competitive levels. This was part of the motivation for National Science Foundation support of the study designed to evaluate student success and satisfaction in our program (see response to Question 10). This study found that personal attention on the part of faculty constitutes one of the most important influences to bring students to higher levels of achievement.

The Department also attracts significant numbers of students who enter our program with highly developed academic skills. It can be a challenge to reach the needs of students both with weak and strong backgrounds in science, but the departmental record suggest this is what happens.

Opportunity for research involvement plays a significant role in the scholastic development of both initially weak and strong students. Successful completion of a research project builds confidence and draws students into deep engagement with science. Each year, several of our students present the results of their work at professional meetings and serve as coauthors on peer-reviewed publications.

Curriculum Strengths

As noted in the response to Question 7, our curriculum is strong and compares well with benchmark institutions. Our cognate core includes two years of coursework in chemistry, taught by faculty in the only Seventh-day Adventist department of chemistry that enjoys American Chemical Society accreditation. Cognate core courses in physics are taught by excellent teachers with substantial track records in research. The Foundations of Biology course provides a more comprehensive treatment of life science than many first-year biology courses. New courses in Research Design and Biostatistics and Scientific Communication will provide students with skills crucial for success in today's high tech, competitive world. Historical and Philosophical Biology teaches students to wrestle with tough ethical and philosophy of science issues in the context of faith. Yearly Major Field Test results for our seniors reported in Table 9.1 provide objective evidence of the strength of our curriculum. Our seniors as a group have scored between the 70th and 97th percentile each year since 1995.

Facility and Equipment Strengths

The Department of Biology enjoys fairly adequate research equipment and space. As noted below, however, teaching facilities need to be significantly upgraded.

Alumni Strengths

Department of Biology alumni provide strong support for our program. Not only do alumni provide significant financial support (see Fig. 5.2), they also provide moral support in the form of letters of appreciation, and frequent comments applauding the quality of education they received from the Department.

15. What are the weaknesses of the Biology program and what plans are in place to address them?

Faculty Weaknesses

For the most part, all major areas of biology except botany can be covered adequately by our faculty. Dr. David Steen, who recently retired, is a plant physiologist and Dr. Dennis Woodland, also recently retired, is a plant systematist. Their retirements left a significant deficit to our ability to cover courses in botany. Dr. Rob Zdor was trained in plant pathology, but his focus centers more around microbial interactions with plants

than with plant anatomy, physiology, development, and systematics. As we look to the future, we are cognizant of a need to hire a botanist, hopefully with ecological training. Most likely this will happen following the retirement of behavioral ecologist Dr. James Hayward in 2015 or 2016.

Although each faculty member exhibits research interests and expresses a desire for involvement in research, teaching and personal responsibilities have occupied the primary focus of several individuals. Over the next few years, we hope to see more research output, particularly in the form of refereed publications. An increase in the number of graduate students will help to facilitate this process, but faculty members also need to work toward publication with undergraduates, with fellow faculty members, and with colleagues at other institutions to fulfill this responsibility. Peer-reviewed publications serve as the most important evidence that faculty members at a graduate institution are productive and effective mentors.

Student Weaknesses

Andrews University does not have an “open admission” policy, but we do admit students with diverse academic backgrounds and abilities. As a result, some of our beginning courses exhibit bimodal grade distributions: We always have some exceptionally talented students but we also work to improve the skills of students who are less well prepared. Over the years, we have exhibited significant success in helping students with lower achievement early on in their programs improve their success as they proceed to their senior year. It was this success that was of interest to the National Science Foundation, which led to its support of a study designed to find out how our program achieved this accomplishment.

Curriculum Weaknesses

As indicated by comparative curriculum data presented following Questions 7, and by learning outcome data presented following Question 9, the Department of Biology appears to offer a strong curriculum. The Biology faculty would like to see our Major Field Test (MFT) scores in Organismal Biology and in Ecology and Evolution improve. Over the past couple of years an ad hoc Biology curriculum subcommittee has been studying our curriculum to make sure all areas of life science are covered adequately and in an integrated fashion. Moreover, our recent hire of Dr. Dan Gonzalez, whose research focuses on whole organisms, will strengthen our program.

We also have been concerned about low scores in MFT in Analytical Skills during some but not all years. We have made a concerted effort to help our students realize the importance of developing their analytical skills. This effort has included 1) implementing a 3-credit course in Biostatistics and Research Design, 2) encouraging

more Biology majors to take Calculus I for Biology, and 3) incorporating more opportunity for formal data analysis in labs and research projects.

Facility and Equipment Weaknesses

Research equipment in the Department is adequate. Teaching facilities, however, including classroom and laboratory spaces are in serious need of upgrade. As one new faculty member notes, “The first impression one might get walking through our department is that of a 1970s second-hand store.” Laboratory tables need to be replaced and audiovisual teaching equipment need attention. The Department needs an intermediate-sized classroom. The floors throughout Price Hall need to be resurfaced (re-carpeted or tiled). Drop ceilings need to be installed in some rooms to reduce noise and echoes. The amphitheater looks shabby when compared with those in the spaces occupied by the Mathematics and Physics Departments and the Chemistry Department.

First impressions are important. There is little esthetic appeal to Department of Biology facilities at the present time. High school students who visit the university with an interest in pursuing a degree in Biology see an unimpressive, run-down, out-of-date facility.

Enrollment Weaknesses

As noted in Figure 3.1, the number of students enrolled in the B.S. in Biology program at Andrews University has been on the decline since fall 2010, when enrollment peaked at 204. Enrollment has dropped nearly 25% since that time. College of Arts and Sciences enrollment as a whole has declined as well, but at a lower rate. The reason for the decline in majors is unclear. The rise and fall around the 2010 peak may have been a fluke. More aggressive recruiting efforts could have accounted for this. It does appear that student caliber has risen since the peak, but this is only a subjective impression. In short, until we see enrollment data for a few more years, the long-term significance of this trend will remain unclear.

Regardless of the reason for the downturn in numbers of Biology majors, the entire STEM unit of the College of Arts and Sciences is attempting to do a better job at recruiting qualified students. We have hired a full-time STEM recruiter, Rachel Boothby, who is enthusiastically involved in promoting our Department. In conjunction with Dan Gonzalez, our new faculty member with experience at producing promotional videos, she is making a short video for recruiters to present to area schools and post of social media and YouTube. Our faculty members are committed to recruiting potential students through phone calls and by giving talks at surrounding secondary schools.

Financial Weaknesses

Due to the large number of labs associated with our courses, our Department has significant need for student laboratory assistants, laboratory equipment, and supplies. All this costs a great deal of money. Some of this is offset by laboratory fees collected from each student for each lab course. As noted following Question 5, our alumni have partnered with our administration in providing necessary funds for high quality equipment and facilities.

In some ways we are more fortunate than many departments in that significant numbers of our alumni are health professionals who are well positioned financially. Their support has been crucial for maintenance of a top-quality program. Financial support from the University, however, is subject to the vagaries of enrollment and the economy. We are somewhat buffered from these vagaries thanks to financial support from our alumni, but we would be unable to continue our program without significant and continued support from the financial administration of the University.

16. What opportunities are likely to present themselves to the program in the coming years, and what changes and resources are necessary to take advantage of them?

Opportunities for Growth and Expansion

Most of our Biology majors are headed into a medically related field. As the Baby-boomer generation ages and as population continues to increase, more and more opportunities will be available for medical specialists. As the data in Table 4.1 suggest, all professions which attract biology majors and are monitored by the federal government are expected to show modest to large gains in job openings over the next decade.

This projected growth in opportunities for Biology majors, however, must be considered in relation to trends in attendance at Seventh-day Adventist institutions of higher education. Regardless of an increase in rate of job opportunities, if enrollment at Adventist schools drops as it is predicted to do, we may experience a continued drop in students enrolled as Biology majors. In short, it is important for the Department of Biology to remain flexible in the face of financial uncertainty.

The physical resources available to the Department must be maintained and seriously upgraded, regardless of future trends. The Department has occupied Price Hall for the past 41 years. The building shows multiple signs serious wear, especially of laboratory teaching space and, more generally, of mechanical systems. The

Department needs significant, ongoing University support to address these challenges. A planned new research and development wing could alleviate some of the crowding now experienced by the Department and open up opportunities for research and office space, but will not substitute for upgrading our current space.

Roles for Restructuring and Technological Innovation

As noted above, the Department of Biology must remain nimble in face of oncoming change. And given that the practice of life science is increasingly dependent on technology, the Department must find ways to keep up. Alumni support is crucial, but so is support from the administration.

Relation to Distance Education

By its very nature, biological education is difficult to carry out effectively at a distance. Biological education consists of a great deal of hands-on work in the lab. It is possible that some such lab work could be administered long-distance, but nothing can substitute for teacher involvement during lab activity. Moreover, research is a crucial component of our program. Without the involvement of on-site mentors and necessary equipment, it is unlikely that research projects would be very effective if mentoring occurred long distance. Life science departments across the United States and around the world are grappling with these real and substantial challenges to implementing distance education. No one to our knowledge has yet found an adequate solution. Currently, we can only continue to monitor progress for this educational trend.

Relation to Cooperative and Collaborative Relationships with Other Institutions

Cooperative and collaborative relationships with other institutions are important to biologists, particularly for expanded research opportunities, but also for extended learning environment opportunities.

The Department of Biology has enjoyed a long-term relationship with Walla Walla University's Rosario Beach Marine Laboratory. Each summer Andrews supplies one teacher for the summer program at Rosario Beach, and some of our Biology majors take coursework there for Andrews University credit. This is a win-win-win situation for our students, Andrews University, and Walla Walla University. Other schools offer summer research internships for undergraduates, which involve our students.

Most of the Department's faculty members enjoy research collaborations with faculty at other institutions. These collaborations have the benefit of establishing the

reputation of Andrews University as an institution involved in significant research. Often Andrews students are involved in these research endeavors which provides a broadening opportunity for them as well.

The Department is in negotiations with Spicer Memorial College in Pune, Maharashtra, India. The Department of Biology at Spicer is hoping to offer an Andrews University Bachelor's degree in Biology to students. This plan would bring significant advantages to Spicer, but it presents important challenges to both Spicer and Andrews. Specifically, we are concerned that Spicer offer students the same level of training in life science as occurs in Michigan. Given limited human and facilities resources at Spicer, it may be difficult to achieve equivalence between the two programs. Dr. John Stout, with other Andrews University representatives, has made two visits to Spicer to discuss arrangements. Currently, it appears that some type of provisional approval of the Spicer program may occur.

Resources Needed to Leverage Opportunities

Space is an important resource: both quantity and quality. We are enthusiastic about the proposal for a new STEM wing as a means of leveraging opportunities for expanded research and creative teaching, but we must also receive support for upgrading our heavily worn current facility. Money is always necessary and always in short supply. Gifts and extramural grants can provide significant help in this regard. Time for creative work must also be available. Extramural grants, Faculty Research Grants, and the University's sabbatical policy are helpful in providing release time.

17. What threats may negatively impact the program in the coming years, and what changes and resources are necessary to mitigate them?

Description of Threats

Financial Threats.—Currently, all institutions of higher learning are faced with financial threats. These threats are rooted in the vagaries of the American market-based economy, disproportionate levels of inflation associated with higher education costs, changing values on the part of potential students, and the increasing popularity of online courses and for-profit institutions. Changing demographic patterns of the Seventh-day Adventist Church present an added challenge.

The increasing popularity of online courses and for-profit institutions may be less a problem for the sciences than other disciplines, although this remains to be seen. Students, perhaps out of necessity, have become progressively more pragmatic and are looking for ways to streamline their education so as to reach career goals more directly. Non-traditional forms of higher education may be appealing to students who may view these educational venues as more efficient and less expensive means of achieving career goals.

The demographic characteristics of the Seventh-day Adventist Church in North America are undergoing significant change. Today, Adventist converts are more likely to come from less educated and lower socioeconomic groups for which Adventist higher education is not a priority nor financially feasible. Moreover, as Seventh-day Adventists become more assimilated into the broader culture, it is becoming more acceptable to attend institutions which provide less costly access to education or which are deemed educationally superior to Adventist institutions.

Philosophical and Cultural Threats.—Driven by certain popular media, political forces, and religious entities, anti-intellectualism has achieved almost sacred status among elements of American culture. Science generally and biological science in particular are seen as especially threatening. GMOs, vaccinations, evolutionary biology, DNA testing, environmentalism, and a variety of other concepts, products, and procedures emerging out of biological laboratories and thinking are perceived as detrimental to human physical, moral, and spiritual well-being.

Biology – indeed all of higher education – holds significant stake in the outcome of the “culture wars” that swirl around and within these issues. How these issues are addressed in the classroom feeds back into the general culture of North America and constituencies of the University.

Changes and Resources to Mitigate Threats

Financial threats.—Vagaries of the American economy and inflationary forces must be dealt with by careful spending and use of resources on the part of the Department. Purchase of quality equipment during good times, and proper maintenance of this equipment at all times is one defense against economic downturns. Careful hiring is another defense.

In face of the threat of online courses and courses from for-profit institutions, the Department must market itself in such a way as to convince prospective students that they will obtain a superior education in a more traditional university setting with personalized, face-to-face instruction, lab-based instruction with professors who operate at the cutting edge of their disciplines. The opportunity to carry out research in our Department is a benefit that cannot be duplicated in a non-traditional setting and must be highlighted in our marketing to both Adventist and non-Adventist students.

The demographic-shift threat is serious. Enrollment at feeder institutions (primarily Adventist academies) is on a decline. Marketing our services to non-SDA Christian students in our region could help mitigate these negative trends.

Philosophical and Cultural Threats.—Philosophical threats are somewhat intangible and difficult to control, given the powerful influence of popular culture. Our Department should make every effort to educate constituencies on how to distinguish fact from theory and theory from conjecture. We should continually work to help our constituencies recognize benefits derived from careful thinking and science-based decision-making within a Christian context.

18. What should be the future direction of your program and what steps and resources are necessary to take your program in that direction? How might changes and trends in technology, student demographics, and enrollment impact this direction?

Future Direction of Program

In the future, the Department of Biology should continue to offer a strong, broad-based education in the life sciences to prepare students for post-graduate professional programs such as medicine and dentistry, and for graduate programs in biology. It is important for the Department to remain broad-based without narrowing its focus on, say, either field biology or molecular biology. Moreover, the Department should continue to exhibit strengths in both teaching and research; both processes are important for fostering student excellence.

The selection over the past two years of faculty members for the six openings to complement the expertise of remaining faculty members has demonstrated our commitment to maintaining both human and subject matter diversity. Table 14.1 lists the gender, ethnicity, teaching expertise, and research expertise of Biology faculty members. The contents of this table are suggestive of the future, broad-based direction of the Department.

A significant issue concerns the future of the Department's graduate program. Resources are available to continue with a strong graduate program, but an increase in enrollment in the program is a crucial need. To that end, Pamela Coburn-Litvak, the Biology graduate coordinator, has led the Department through a review of the existing program resulting in recommendations for change. These recommendations are highlighted under Question 19.

Resources Necessary to Achieve Goals for Future

To maintain the strength and diversity of our program, it is important that we retain our strong faculty. In order to retain our strong faculty, we must maintain strong student enrollments. The recent decline in numbers of majors is of concern to us. We are pleased that we now have Rachel Boothby as a STEM recruiter. We hope her work and our increased efforts at reaching out to prospective students and surrounding schools will pay off. The hiring of Denise Smith as a laboratory coordinator was an important move and is a huge help in keeping things going smoothly in the Department. Obviously, continued good funding is important for retaining faculty and for supporting recruitment efforts.

Impact of Various Changes on Future of Department

Probably our biggest concern at present is enrollment, both at the undergraduate and graduate levels. If enrollment drops too far, we will be unable to defend replacements for future retirements. Although we are ramping up our recruiting efforts, we are somewhat at the mercy of demographic trends in the Seventh-day Adventist Church, particularly in Adventist academies which traditionally have served as our primary feeder institutions.

Refurbishing existing facilities and the addition of a new research and development wing to the Science Complex will greatly enhance our need for added space and enhance the research capabilities of our students and faculty. Moreover, plans are in place to upgrade the Biology website make it more appealing, accurate, and informative.

19. What is the status of the Master of Science in Biology degree program at Andrews University?

Master of Science Program in Biology

The Department of Biology has offered a Master of Science Degree in Biology since the mid-1960s. In the nearly half century of its existence, well over 100 students have completed this program. Many of these individuals completed Ph.D. degrees at leading research universities. Others earned medical degrees. Still others went on to secondary teaching and other careers.

The Master of Science program entails three major components: coursework, comprehensive exams, and thesis research. The coursework may involve some 400-level “swing” courses with 500-level “graduate-level” courses. Graduate students who take 400-level courses may have to complete work for these courses beyond what is required for undergraduate students. Comprehensive exams involve testing students for their knowledge of biology and their capacity to reason with biological concepts. The thesis research involves doing original research under the mentorship of a thesis advisor and guidance committee.

The Master of Science in Biology typically takes a minimum of two years to complete. The first year is devoted primarily to coursework, whereas the second year involves more focus on research and thesis completion. Comprehensive exams usually are taken after completion of the second semester of coursework.

Financial support for graduate students is offered through tuition waivers and pay for work either as teaching assistants or research assistants. Teaching assistantships are offered by the Department of Biology whereas research assistantships may be offered to the student by a thesis advisor with access to extramural grant funds.

Under the leadership of Dr. Pam Coburn-Litvak, the Biology graduate program coordinator, the Department is reexamining and restructuring its graduate program to make it more attractive to potential students and to bring it more into line with current standards. The next section summarizes changes the Department plans to make in the program.

Graduate Program Restructuring

Most of the program restructuring concerns entrance requirements, comprehensive examinations, and financial support.

Entrance requirements.—The Department has voted a motion to change the wording in the bulletin for admission to the program:

Current wording:

(http://bulletin.andrews.edu/preview_program.php?catoid=4&poid=1572&returnto=256)

In addition to the general requirements for admission to and enrollment in graduate degree programs outlined in this bulletin on pp. 44–54, students must meet the following departmental requirements.

Admission Requirements

- A bachelor’s degree with major in biology or an approved, related discipline, including courses in cell/molecular biology, organismal physiology, developmental biology, genetics, and ecology.
- A minimum GPA of 3.00 (B) in the undergraduate major for admission to regular student status.
- Cognate sciences, including full-year courses in general chemistry, organic chemistry, and physics. Mathematics through calculus level is encouraged.

New wording:

In addition to the general admission requirements under the School of Graduate Studies & Research, note also the Department of Biology requirements listed below.

Admission Requirements

- A bachelor's degree with major in biology or an approved, related discipline, with appropriate upper division courses. The following are recommended: cell/molecular biology, organismal physiology, developmental biology, genetics, and ecology.
- A minimum GPA of 3.00 (B) in the undergraduate major for admission.
- GRE scores are required in order to review the application (for more information, see required tests I under School of Graduate Studies).

Cognate sciences, including full-year courses in general chemistry, organic chemistry, and physics. Mathematics through calculus and a course in biostatistics are strongly recommended.

This revision is currently under review by the ___ committee.

Comprehensive examinations.—Until this academic year comprehensive exams consisted of six sections: 1) Cell and Molecular Biology, 2) Genetics, 3) Developmental Biology, 4) Physiology, 5) Ecology, and 6) General Biology. The Department is proposing a new four-part examination, which is described below along with procedural and evaluative criteria, along with expectations for exam preparation:

The comprehensive exam is organized into four core subjects in the biological sciences listed below. Underneath each core subject are “potential” subtopics – these are intended to be helpful, but are not all-inclusive.

Cellular and Molecular Biology

Molecular genetics and genomics
Immunobiology
Cell biology
Recombinant DNA methodology
Molecular development
Microbiology

Organismal Biology

Plant form and function
Animal form and function
Reproduction and development
Animal behavior and sociobiology

Population Biology

Population genetics
Environment/organism interaction
Communities and ecosystems Behavioral ecology
Evolutionary processes and consequences

Philosophical Biology

Ethical issues surrounding biotechnology
Origins and speciation
Ethics and the practice of science

The comprehensive exam consists of two essay questions in each core subject area written by different faculty examiners. The questions are submitted to the Graduate Program Coordinator who compiles the exam.

Procedure

You will write the comprehensive exam over a six-day period. All of the questions will be given to you on Sunday morning, and you may answer the questions in any order. It is generally expected that you will need 30-60 hours to complete this exam. All narrative answers must be computer generated and checked for scientific accuracy as well as grammar, spelling, and general readability. References should be cited appropriately.

All responses are due on Friday afternoon (a more precise time will be published for each exam – must be before sundown). Submit your completed exam to the Graduate Program Coordinator.

The following policies apply:

1. An appropriate answer is in the form of an essay rather than a term paper, therefore extensive references are not required. However, certain references may be suitable depending on the nature of the question. Acceptable references include primary literature, textbooks, review journals and *Annual Reviews*. Web pages, interviews with other students or faculty (either on this campus or other campuses) are not appropriate.
2. You may work in your office or residence. However, to minimize distractions during the exam, you should plan not to travel for social reasons, medical appointments, interviews, etc. for the duration of the exam.
3. In consideration for fellow students, you should not check reference material out of the library during the exam. Using the material on site or making photocopies will allow all students access to needed information.

Evaluation

Completed exams are distributed to the examiners. Each question is scored separately on a 0-100 point scale and the scores are communicated to the graduate program coordinator. The two scores for each core subject are averaged. Passing a core subject requires an average score of 70 and a minimum score of 50 on each question. Students who pass each core area are given an "overall pass" for the exam.

Students who pass at least two of the core subjects but not all subjects will be allowed to retake the exam in just the core subjects they did not pass. Students who pass fewer than two core subjects will be required to retake the entire comprehensive exam. An individual section of the exam may not be taken more than three times and the entire comprehensive exam may not be taken more than twice. Students who do not meet this requirement are subject to dismissal.

Evaluation: Each of the six sections of the comprehensive exam is graded according to the following scale: "pass," "provisional pass" or "no pass."

If you receive...	Then your exam results are...	What to do next
A "pass" on all questions on all four sections	Pass	Congratulate yourself on passing this hurdle in your academic career!
A "pass" on at least 2 sections	Provisional Pass	You will be allowed to retake these sections at the next scheduled comprehensive exam.
A "pass on fewer than 2 sections	No Pass	You will be allowed to repeat the entire exam only once after at least one semester has elapsed. All six sections of the exam must be passed on this second try.

After they are graded, comprehensive exam papers may be examined by you but are not returned to you. They are kept on file and become part of the record of the student's performance in the graduate program.

How to prepare for and successfully pass the comprehensive exam

Preparing for a comprehensive exam is a long-term investment and students have already been preparing for this exam as they completed courses in their undergraduate program. In addition, students should probably have some sort of systematic reading program whereby they maintain consistent contact with primary and secondary scientific literature. Students cannot actually study for this exam in the same sense that one studies for a course exam since it is much more comprehensive in scope.

Financial package.—Table 19.1 contains information related to the proposed new financial package for Biology graduate students.

Table 19.1. M.S. in Biology scholarship package

	Description & Purpose	Funding Terms	Qualifications & Application process	Renewal Criteria
1. Teaching Assistantship	<ul style="list-style-type: none"> All MS in Biology students receive a teaching assistantship. These funds come with an obligation to provide teaching services in the department (e.g. lab preparation & supervision, grading, student mentoring, etc.) Purpose: living and/or tuition expenses 	<ul style="list-style-type: none"> Up to \$2500/semester For up to 4 semesters (excluding summers) Paid as hourly wage 	<ul style="list-style-type: none"> Qualifications: A bachelor's degree with major in biology (or related discipline) Application process: Complete the AU Department of Biology Scholarships Application (for placement purposes only) 	<p>Automatically renewed' each semester for up to 4 semesters</p> <p>*Subject to review by work supervisor</p>

<p>2. Tuition Reduction Scholarships</p>	<ul style="list-style-type: none"> MS students may receive an Andrews Graduate Scholarship from the School of Graduate Studies & Research (SGSR), based on GRE scores. The SGSR award is matched with Department of Biology funds Purpose: tuition expenses 	<ul style="list-style-type: none"> Up to 100% tuition reduction/semester For up to 4 semesters Paid to student account 	<ul style="list-style-type: none"> Qualifications: Tuition reduction percentages are awarded as follows: <ul style="list-style-type: none"> GRE score \geq 300: 50% GRE score \geq 320: 100% Application process: None required (part of admission requirements) 	<p>Automatically renewed* each semester for up to 4 semesters</p> <p>*Must maintain degree requirements as stated in the AU Bulletin, including:</p> <ul style="list-style-type: none"> Minimum GPA of 3.0 Adequate degree progress
<p>3. (a) Biology Graduate Scholarships</p> <p>(b) Biology Scholarship for Academic Excellence</p>	<ul style="list-style-type: none"> MS in Biology students may also receive additional, merit-based scholarships based on GPA and other qualifications Purpose: living and/or tuition expenses ONE incoming student per year is chosen for this merit-based scholarship Purpose: living and/or tuition expenses 	<ul style="list-style-type: none"> \$1000/semester For up to 5 semesters (including summers) Paid to student account \$2000/semester For up to 5 semesters (including summers) 	<ul style="list-style-type: none"> Qualifications: GPA, other criteria as specified Application process: Complete the AU Department of Biology Scholarships Application, including personal statement on professional goals 	<p>Automatically renewed* each semester for up to 5 semesters</p> <p>*Must maintain degree requirements as stated in the AU Bulletin, including:</p> <ul style="list-style-type: none"> Minimum GPA of 3.0 Adequate degree progress
<p>4. Research & Conference Travel Awards</p>	<ul style="list-style-type: none"> MS in Biology students may apply for funds to attend research conferences at which they are presenting, or to travel to field research sites 	<ul style="list-style-type: none"> Up to \$500 Limit of one trip per year 	<ul style="list-style-type: none"> Qualifications: As specified in application Application process: Complete the AU Department of Biology Scholarships Application, including a personal statement on the goals for the trip 	<p>Renewable upon application; limit of 1 application per year</p>

20. What recommendations are suggested by this program review?

1. Improve the learning of our students, particularly in areas of organismal biology, ecology, and evolutionary biology.
2. Increase recruitment and retention efforts to maintain strong enrollment.
3. Maintain excellent relations with alumni, students, and prospective students.
4. Maintain current faculty numbers to provide excellent coverage of biological science and training in research.
5. Hire a botanist with ecological training.
6. Maintain strong alumni support.
7. Increase financial support by University administration, especially for supplies, small equipment, capital improvement, and facility upgrades which are severely underfunded.
8. Implement standards for library literacy among Biology majors.
9. Increase the research output and publication of faculty and students.
10. Continue to contribute to the financial bottom line of the College of Arts and Sciences and University as a whole.
11. Deal creatively with a proposed collaboration with Spicer Memorial College.
12. Encourage Biology faculty to seek extramural funding for research.
13. Educate all constituencies of the University on how to distinguish fact from theory and theory from conjecture in face of contemporary cultural threats.
14. Upgrade the Departmental website.
15. Strengthen the M.S. in Biology program offered by the Department, and increase the numbers of students in that program.