

Institutional Effectiveness
2023-2024

Program: Biology BS

College and Department: Department of Biology

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Mission:

The primary mission of the Department of Biology at Tennessee Tech is to promote biological education in, and advance biological knowledge for, the region, state, and nation, through teaching, research, and public service.

Attach Curriculum Map (Educational Programs Only):

See attached file.

Attached Files: See Appendix 1

Outcome 1: Improved Critical Thinking

Define Outcome:

Graduating seniors in the Department of Biology will demonstrate critical thinking skills by meeting or exceeding the national average score on the California Critical Thinking Skills Test.

Assessment Methods:

The California Critical Thinking Skills Test (CCTST) will be used. This test is administered as a senior exit exam for all graduating TTU seniors, and the results reported to the Department of Biology

Criteria for Success (Thresholds for Assessment Methods):

Average score for all graduating Biology seniors will meet or exceed the national average on the CCTST.

Link to 'Tech Tomorrow' Strategic Plan:

2.B Research, Scholar, Intellect, and Creativity

Results and Analysis:

Graduating Biology majors have consistently exceeded the national average in the California Critical Thinking Skills Test (CCTST; Table 1), which meets our criterion for success for this learning outcome. The average score of Biology majors was lowest during the first year of the COVID pandemic (2020-21), but scores have rebounded since, exceeding the pre-pandemic level in each of the last two years.

Table 1. Average score for Biology majors, along with sample size (n), on the California Critical Thinking Skills Test during the past 5 academic years.

| Academic Year | TTU Biology | <i>n</i> | National |
|---------------|-------------|----------|----------|
| 2019-2020 | 75.0 | 41 | 74.0 |
| 2020-2021 | 74.2 | 32 | 74.0 |
| 2021-2022 | 75.3 | 90 | 73.3 |
| 2021-2022 | 76.5 | 59 | 73.3 |
| 2023-2024 | 76.4 | 88 | 72.8 |

Use of Results to Improve Outcomes:

We are pleased that our Biology students have consistently scored above the national average with respect to critical thinking, but clearly there is room for improvement. The Department of Biology has a committee in place to evaluate our introductory (General Biology) courses, with an eye toward improving the skill sets of our students, including critical thinking/active learning. Also, new upper-division courses recently developed by our newer faculty employ active learning approaches that challenge students to develop their critical thinking skills.

Outcome 2: Experiential Learning

Define Outcome:

Students majoring in Biology will gain real-world experience in their chosen fields by participating in some type of experiential learning (co-ops, internships, research), with 10% of our students involved in some type of experiential learning during their time at TTU.

Assessment Methods:

On the department senior questionnaire, students are asked to indicate whether they have had any type of experiential learning: co-ops, internships, undergraduate research, job shadowing, or other related activities.

Student involvement in internships is traced via enrollment in BIOL 4900, Internship in Biology.

Undergraduate research activity is tracked via Faculty annual reports, where faculty are asked to include a list of undergraduates who have worked in their research lab over the preceding year.

Criteria for Success (Thresholds for Assessment Methods):

Combining data from all three assessment methods, a minimum of 10% of graduating seniors will show evidence of some type of experiential learning during their time at Tennessee Tech.

Link to 'Tech Tomorrow' Strategic Plan:

1.A Experiential Learning, 2.B Research, Scholar, Intellect, and Creativity

Results and Analysis:

Participation in internships and co-op assignments has traditionally been examined using our departmental senior questionnaire, given at the time of the major field exam. In 2020-2021, due to the COVID pandemic, this test was moved online, and no questionnaires were given. In 2021-2022, few seniors returned their questionnaire, so we used information from enrollment in our Internship in Biology course (BIOL 4900). Throughout this period, participation in these types of experiential learning fell short of our goal of 10% of graduating seniors engaging in these activities (Table 2).

In 2022-2023 we were once again able to get good response rates using our senior questionnaires, and we expanded our definition of experiential learning to include students engaged in undergraduate research. This information was obtained from faculty annual reports in 2022-23 and from our senior questionnaire in 2023-24. This change stemmed from discussions that indicated that many faculty consider research as another type of experiential learning, and an important one at that. Using this updated measure, greater than 10% of graduating seniors engaged in one of the three types of experiential learning in 2022-23, and far greater than 10% did so in 2023-24 (Table 2). Clearly, undergraduate research, in particular, has been an important component of the education of our Biology majors.

Table 2. Percent of Biology graduating seniors indicating participation in an experiential learning opportunity. From 2019-20 through 2021-22, an experiential learning opportunity was defined as an internship or a coop assignment; starting in 2022-23, this was expanded to include undergraduate research participation.

| Academic Year | Sample Size (<i>n</i>) | Percent |
|---------------|--------------------------|---------|
| 2019-2020 | 18 | 5.5 |
| 2020-2021 | N/A | N/A |
| 2021-2022 | 112 | 3.6 |
| 2022-2023 | 51 | 13.7 |
| 2023-2024 | 77 | 23.4 |

Use of Results to Improve Outcomes:

Since adding undergraduate research experience to our list of included experiential learning options, our estimate of the percentage of Biology students engaged in experiential learning has jumped tremendously. We attribute this to aggressive efforts to recruit high-quality, research-minded undergraduates in our upper-division classes. These efforts will continue, along with more concerted efforts to make these students aware of internship opportunities through mass emails, postings on the department website, and/or use of departmental social media sites. In the past year, our department has established accounts on several social media platforms, which should serve as good outlets for internship information.

Outcome 3: Understanding Scientific Reasoning

Define Outcome:

Students majoring in Biology will demonstrate an understanding of scientific reasoning by having 80% (or more) of students obtaining a perfect score on the departmental Scientific Method Questionnaire.

Assessment Methods:

Scientific Method Questionnaire, developed internally by the Department of Biology. This is administered to graduating seniors either during BIOL 3920 (Biological Communication Skills) or at the time they take the ACAT major field exam.

Criteria for Success (Thresholds for Assessment Methods):

A minimum of 80% of students will achieve a perfect score on the Scientific Method Questionnaire.

Link to 'Tech Tomorrow' Strategic Plan:

2.B Research, Scholar, Intellect, and Creativity

Results and Analysis:

Biological Communication Skills (BIOL 3920) is a course taken by all Biology and Wildlife and Fisheries Science majors, typically during their junior or senior year. Average scores on the departmental scientific method quiz have been in the high 80s - low 90s over the past five years (Table 3). The percentage of students who score a perfect 100% has continually been below the department's goal of 80% but has shown some improvement over the past five years (Table 3).

Table 3. Student performance on the scientific method quiz administered to Biology department students in BIOL 3920 (Biological Communication Skills). All data are given as percentages.

| Academic Year | Average Score (%) | 100% Correct (%) |
|---------------|-------------------|------------------|
| 2019-2020 | 88.5 | 46.2 |
| 2020-2021 | 91.4 | 52.9 |
| 2021-2022 | 90.7 | 56.0 |
| 2022-2023 | 92.4 | 64.3 |
| 2023-2024 | 90.1 | 54.3 |

Use of Results to Improve Outcomes:

With the demise of our BIOL 1000 course, we've adjusted this outcome to reflect only performance by our upper-level students.

We are in the process of looking at our freshmen Biology sequence, and part of that process will likely include discussions of how to better include ideas related to the scientific method in these courses (as well as carry that through to our upper-level classes).

Also, as a department, we decided this year to adjust our criteria for success in this outcome. Rather than use the percentage of students achieving a perfect score on our scientific method questionnaire alone, we added an overall performance criterion of 90% on the Questionnaire. We also lowered our perfect-score criterion to 50%, which we feel is more realistic. In recent years, even students who achieved overall high (90%+) scores on the Questionnaire rarely scored perfectly. We will assess our progress with this outcome using these new criteria in future years.

Outcome 4: Command of General Biology Concepts

Define Outcome:

Students majoring in Biology will demonstrate a command of general biological information in selected fundamental areas of study by having all graduating seniors score at or above the national average in a minimum of 4 of the 7 tested categories.

Assessment Methods:

The ACAT exam is given as the department major field exam to all graduating seniors each Fall and Spring semester. We test our students in 7 categories: bacteriology; cellular biology; ecology; genetics; botany; zoology; and evolution. Exams are taken online, and scores are reported back to the department by the test providers. Each student has an aggregate score, as well as a score for each of the 7 subject areas.

Criteria for Success (Thresholds for Assessment Methods):

Students will meet or exceed the national average in at least 4 of the 7 subject areas on the ACAT exam.

Link to 'Tech Tomorrow' Strategic Plan:

2.B Research, Scholar, Intellect, and Creativity

Results and Analysis:

The ACAT exam is our departmental major field exam, given to students during their final semester before graduation. For Biology majors, students are scored on each of seven content areas, as shown in Table 4. Scores are scaled so that the national average is a 500, and this score marks the 50th percentile. Our department goal is to have students score at or above the national average in at least 4 of the 7 content areas each year. This goal has yet to be met in the past 5 years, and the number of content areas in which our students meet or exceed the national average seems to show a decline over the last 5 years, ranging from three in 2019-20 to one (Ecology) in each of the last two years (Table 4).

The specific content areas in which our students perform above the national average has not been consistent over the years. The Ecology subject area has been the most consistent, with scores exceeding the national average in three of the five reported years. Two subject areas, Cell Biology and Botany, have scores that exceeded the national average in two of the five reported years. Scores in Genetics and Evolution exceed the national average in only a single year, and scores in Bacteriology and Zoology have never exceeded the national average.

Table 4. Average scores and average percentiles from the past five academic years for each of the seven content categories from the ACAT Biology exam taken by graduating Biology students. Sample size (*n*) is given after the academic year, and includes both Fall and Spring semester data. Percentiles meeting our NOTE: Data from the Spring 2020 semester is not included; due to the COVID pandemic, very few students were able to take the exam that semester.

| Year (<i>n</i>) | Bacteriology | | Cell Biology | | Ecology | | Genetics | | Botany | | Zoology | | Evolution | |
|----------------------|--------------|------|--------------|-----------|---------|-----------|----------|-----------|--------|-----------|---------|------|-----------|-----------|
| | Score | %ile | Score | %ile | Score | %ile | Score | %ile | Score | %ile | Score | %ile | Score | %ile |
| 2019 | | | | | | | | | | | | | | |
| -20 (22) | 480 | 42 | 495 | 48 | 502 | 51 | 465 | 36 | 508 | 53 | 492 | 47 | 499 | 50 |
| 2020 | | | | | | | | | | | | | | |
| -21 (35) | 497 | 49 | 513 | 55 | 490 | 46 | 502 | 51 | 494 | 48 | 476 | 41 | 447 | 30 |
| 2021 | | | | | | | | | | | | | | |
| -22 (43) | 471 | 39 | 507 | 53 | 489 | 46 | 486 | 44 | 510 | 54 | 486 | 44 | 454 | 32 |
| 2022 | | | | | | | | | | | | | | |
| -23 (51) | 492 | 47 | 492 | 47 | 525 | 60 | 486 | 44 | 476 | 41 | 485 | 44 | 458 | 34 |
| 2023 | | | | | | | | | | | | | | |
| 3-24 (86) | 456 | 33 | 470 | 38 | 522 | 59 | 451 | 31 | 480 | 42 | 470 | 38 | 458 | 34 |

Use of Results to Improve Outcomes:

Our Biology students have struggled to meet our desired outcome with respect to ACAT Exam results and associated subject matter knowledge over the last five years. The exception has been in Ecology, which is consistent with a major emphasis on field ecology in our department and the fact that all of our students are required to take our General Ecology (BIOL 3120/3130) class. The Department of Biology has created a committee this academic year to examine our introductory (General Biology) courses. Improvements in the content and/or delivery of these

courses could better prepare students for learning more complicated material in upper-division courses, which may be reflected in future improvements in ACAT exam performance. Specific efforts to target improvements in Zoology instruction (e.g., our General Zoology - BIOL 1113 and Invertebrate Zoology - BIOL 4610 courses) are also planned for 2024-25. Finally, the department is planning the development of a course in Evolution, the lack of which has been a major deficit in our department in recent years. Such a course should improve performance in the Evolution subject area of the ACAT.

Additionally, we decided this year as a department to fine-tune our ACAT assessment tool by varying the subject areas tested by concentration, rather than by major alone. This will allow us to better test students in the subject areas covered by coursework in their concentrations, as course content varies considerably among the concentrations in our Biology degree program. This ACAT adjustment will be implemented in the coming year.

List of Appendices:

Appendix 1: Biology BS Curriculum Map

Appendix 1: Biology BS Curriculum Map

Curriculum support for learning outcomes of the undergraduate programs in the Department of Biology.

| Course No. | Title | Learning Outcomes | | | |
|-----------------|---------------------------|-------------------|-----------------------|-------------------|------------------------|
| | | Critical Thinking | Experiential Learning | Scientific Method | Demonstrated Knowledge |
| BIOL 1010 | Introduction to Biology | X | | X | X |
| BIOL 1020 | Diversity of Life | X | | X | X |
| BIOL 1080 | Concepts of Biology | X | X | X | X |
| BIOL 1113 | General Biology I | X | | X | X |
| BIOL 1123 | General Biology II | X | | | X |
| BIOL 2000 | Biological Terminology | | | | X |
| BIOL 2010 | Human Anat. & Phys. I | X | | X | X |
| BIOL 2020 | Human Anat. & Phys. II | X | | X | X |
| BIOL 2310 | General Botany | X | X | | X |
| BIOL 2350 | Intro. Anat. & Phys. | X | | | X |
| BIOL/WFS 2991-4 | Topics | | | | X |
| BIOL 3040 | Comparative Vert. Anat. | X | | | X |
| BIOL 3120 | General Ecology (no lab) | X | | X | X |
| BIOL/WFS 3130 | General Ecology | X | | X | X |
| BIOL 3140 | Cellular Biology | X | X | X | X |
| BIOL 3200 | General Microbiology | X | | X | X |
| BIOL 3230 | Health Science Microbiol. | X | | X | X |
| BIOL 3240 | Field Botany | X | | X | X |
| BIOL 3330 | Entomology | | | | X |
| WFS/CJ 3500 | Wildlife Law Enforcement | | X | | X |
| BIOL 3530 | Animal Physiology | X | | | X |
| WFS 3550 | Wildlife Damage Manage. | X | X | | X |
| BIOL 3700 | Humanism in Medicine | X | | | X |
| BIOL 3810 | General Genetics | X | | X | X |
| BIOL 3920 | Biol. Comm. Skills | X | X | X | X |
| BIOL 4000 | General Parasitology | X | | | X |
| BIOL 4040 | Immunology | X | | | X |
| BIOL 4060 | Hormones/Chem. Comm. | X | | | X |
| BIOL 4070 | Vertebrate Development | X | | | X |
| BIOL 4100 | Evolutionary Biology | X | X | X | X |
| BIOL 4110 | Microbial Evolution | X | | | X |
| BIOL 4130 | Enviro. Microbiology | X | | X | X |
| BIOL 4140 | Pathogenic Bacteriology | X | | | X |
| BIOL 4150 | Molecular Genetics | X | | | X |
| BIOL 4160 | Genetic Engineering Lab | | | | X |
| BIOL/WFS 4220 | Biostatistics | X | | X | X |
| BIOL/WFS 4230 | Animal Behavior | X | | | X |
| BIOL 4240 | Systematic Botany | X | | | X |
| BIOL 4250 | Economic Botany | X | | | X |

| | | | | | |
|-----------------|----------------------------|---|---|---|---|
| BIOL 4300 | Plant Speciation and Evol. | X | | | X |
| BIOL 4310 | Plant Anatomy | X | | | X |
| BIOL 4320 | Plant Physiology | X | X | X | X |
| BIOL 4330 | Plant Ecology | X | | X | X |
| BIOL 4340 | Plant-Animal Interactions | X | | | X |
| WFS 4500 | National Wildlife Policy | X | X | | X |
| BIOL 4610 | Invertebrate Zoology | X | | X | X |
| BIOL/WFS 4630 | Ornithology | X | | | X |
| WFS 4640 | Waterfowl Ecology & Mgt. | X | | | X |
| BIOL/WFS 4650 | Marine Biology | X | | X | X |
| WFS 4660 | Wild Bird Ecology | | | | X |
| WFS 4670 | Wild Mammal Ecology | | | | X |
| WFS 4700 | Habitat Management | X | | X | X |
| WFS 4710 | Fisheries Management | X | | X | X |
| WFS 4711 | Fisheries Mgmt. (no lab) | X | | | X |
| WFS 4730 | Conservation Biology | X | X | X | X |
| WFS 4740 | Wildlife Principles | X | | X | X |
| BIOL 4750 | Medical Microbiology | X | | | X |
| WFS 4760 | Fish Culture | X | X | | X |
| WFS 4770 | Nongame Species Mgmt. | X | X | | X |
| BIOL 4780 | Phycology | X | | X | X |
| WFS 4790 | Wildlife Techniques | X | X | X | X |
| WFS 4800 | Conservation Techniques | X | X | X | X |
| BIOL/WFS 4810 | Ichthyology | X | X | | X |
| BIOL/WFS 4820 | Mammalogy | X | X | | X |
| BIOL/WFS 4830 | Herpetology | X | X | | X |
| BIOL/WFS 4840 | Limnology | X | | X | X |
| BIOL 4850 | Applied Microbiology | X | | X | X |
| BIOL 4860 | Disease Prevention | X | | | |
| BIOL 4870 | Microbiomes | X | | | |
| WFS 4870 | GIS For Wildlife & Fish. | | | | X |
| BIOL 4880 | Bioethics | X | | | X |
| BIOL 4890 | Histology | | | | X |
| BIOL/WFS 4900 | Internship | | X | | X |
| BIOL/WFS 4991-4 | Advanced Topics | X | X | | X |