Institutional Effectiveness
2024-2025

Program: Biology BS
College and Department: College of Arts & Sciences, Biology
Contact: Steve Hayslette
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):
Attached Files: See Appendix 1

Student Learning 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.

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	*n*	National
2020-2021	74.2	32	74.0
2021-2022	75.3	90	73.3
2022-2023	76.5	59	73.3
2023-2024	76.4	88	72.8
2024-2025	76.6	83	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.

Student Learning 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 also is tracked via enrollment in BIOL 4900, Internship in Biology.

Undergraduate research activity also 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 each of the last three years (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. During 2020-21 and 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 (*n*)	Percent
2020-2021	N/A	N/A
2021-2022	112	3.6
2022-2023	51	13.7
2023-2024	77	23.4
2024-2025	89	19.1

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 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. Over the past two years, our department has established accounts on several social media platforms, and these are likely serving as good outlets for internship information.

Student Learning Outcome 3: Understanding Scientific Reasoning

Define Outcome:
Students majoring in Biology will demonstrate an understanding of scientific reasoning by achieving an average score of at least 90% on the Scientific Method Questionnaire and having at least 50% of students achieving a perfect score on the 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):
We agreed as a department last year to adjust our criteria for success in this outcome. Our criteria for success are now 1) an average score of at least 90% on the Scientific Method Questionnaire, and 2) at least 50% of students achieving a perfect score on the 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 >90% in each of the last five years, and percentage achieving a perfect score has ranged 53-64% (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. Sample sizes are given in parentheses.

Academic Year	Average Score (%)	100% Correct (%)
2020-2021	91.4 (N=133)	52.9
2021-2022	90.7 (N=139)	56.0
2022-2023	92.4 (N=145)	64.3
2023-2024	90.1 (N=164)	54.3
2024-2025	91.1 (N=115)	54.8

Use of Results to Improve Outcomes:
We previously assessed this outcome in both our BIOL 1000 and 3920 classes. Biology 1000 was eliminated several years ago, and we've adjusted this outcome to reflect only performance by our upper-level students.

Also, as a department, we decided last year to adjust our criteria for success in this outcome. Previously, we only used the percentage of students achieving a perfect score on our Scientific Method Questionnaire, targeting 80% of our students as indication of success. In recent years, even students who achieved overall high (90%+) scores on the Questionnaire rarely scored perfectly, indicating that a new set of criteria for success were needed. We now aim for an average score of at least 90% on the Scientific Method Questionnaire and at least 50% of students achieving a perfect score on the Questionnaire.

Additionally, we introduced a new, research component in BIOL 1113, General Biology I, the introductory biology course for Biology and Wildlife and Fisheries Science majors last year. The instructor focused on examples of the scientific process and how each step is important. Using hypothetical examples and published research papers, students practiced identifying the steps in the scientific method and discussed their importance. We've anticipated that this new research focus in our BIOL 1113 course will improve student performance relative to this outcome in future assessments, but that effect wasn't evident this year. Since this new research component was included in a freshman-level class, and this outcome is assessed in upper-division class, expected improvement in upper-division performance on the Scientific Method Questionnaire may not be evident for several years.

Student Learning 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 at least half of the tested categories on the ACAT Exam.

Assessment Methods:
The ACAT exam is given as the department major field exam to all graduating seniors each Fall and Spring semester. Prior to this most recent year, we tested our Biology students in 7 categories - bacteriology, cellular biology, ecology, genetics, botany, zoology, and evolution. Exams were taken online, and scores are reported back to the department by the test providers. Each student received an aggregate score, as well as a score for each of the 7 subject areas.

Beginning in 2024-25, the content areas included in the ACAT Exam for Biology majors varied by concentration. Number of subject areas for each concentration ranged 4-5 and included the following:

- Botany Concentration - Ecology, Plant Physiology, Botany, Evolution
- Cellular and Molecular Biology - Biochemistry, Cell Physiology, Cell Biology, Genetics, Human Anatomy and Physiology
- Environmental Biology - Bacteriology, Ecology, Vascular Botany, Plant and Animal Physiology
- Health Sciences Biology - Bacteriology, Cell Biology, Genetics, Human Anatomy and Physiology, Evolution
- Marine Biology - Cell Biology, Ecology, Genetics, Invertebrate Zoology, Vertebrate Zoology
- Microbiology - Bacteriology, Cell Biology, Genetics, Evolution
- Zoology - Ecology, Invertebrate Zoology, Animal Physiology, Vertebrate Zoology, Evolution

Criteria for Success (Thresholds for Assessment Methods):
Students will meet or exceed the national average in at least half of the subject areas included on their 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. Prior to 2024-25, students majoring in Biology were scored on each of seven content areas, as shown in Table 4A. Scores are scaled so that the national average is a 500, and this score marks the 50th percentile. Prior to 2024-25, our department goal was to have students score at or above the national average in at least 4 of the 7 content areas each year. This goal was not met during 2020-2024 (Table 4A), and during that period the number of content areas in which our students meet or exceed the national average seemed to show a decline. Scores in only two categories - Cell Biology and Ecology - exceeded the national average in more than one year. One possible explanation for these disappointing performances is that we tested a wide variety of concentrations with one standard exam - with a standard set of subject areas for all concentrations. While a student may be expected to do well on the subject areas of the exam most related to their concentration, it seems unreasonable that any concentration could prepare a student to do well on the exam as a whole.

Beginning in 2024-25, the content areas included in the ACAT Exam for Biology majors varied by concentration. This was adopted to better match the exam to concentration coursework. Number of subject areas for each concentration ranged 4-5 and included the following:

- Botany Concentration - **Ecology**, Plant Physiology, **Botany**, **Evolution**
- Cellular and Molecular Biology - Biochemistry, Cell Physiology, **Cell Biology**, **Genetics**, Human Anatomy and Physiology
- Environmental Biology - **Bacteriology, Ecology**, Vascular Botany, Plant and Animal Physiology
- Health Sciences Biology - **Bacteriology**, **Cell Biology**, **Genetics**, Human Anatomy and Physiology, **Evolution**
- Marine Biology - **Cell Biology**, **Ecology**, **Genetics**, Invertebrate Zoology, Vertebrate Zoology
- Microbiology - **Bacteriology**, **Cell Biology**, **Genetics**, **Evolution**
- Zoology - **Ecology**, Invertebrate Zoology, Animal Physiology, Vertebrate Zoology, **Evolution**

All concentrations included some of the subject areas tested previously (bolded above), but only two concentrations - Health Sciences Biology and Zoology - had sample sizes large enough (n=>5 per semester, n=>10 per year) to generate individual subject area group scores for comparison with previous years. These comparisons are shown in Table 4A. In Health Sciences, our goal of scoring higher than the national average was not met in any of the subject areas tested previously or in Human Anatomy and Physiology. Zoology scores exceeded our goal in all subject areas, however, including Ecology and Evolution (Table 4A).

Table 4A. Average scores and average percentiles for content categories from the ACAT Biology exam taken by graduating Biology students 2020-2024, and by Health Sciences and Zoology Concentration students in 2024-25. Sample size (*n*) is given after the academic year and includes both Fall and Spring semester data.

	Bacteriology		Cell Biology		Ecology		Genetics		Botany		Zoology		Evolution	
Year (*n*)	Score	%ile	Score	%ile	Score	%ile	Score	%ile	Score	%ile	Score	%ile	Score	%ile
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
2023-24 (86)	456	33	470	38	522	**59**	451	31	480	42	470	38	458	34
2024-25 (43) Health Sciences	460	35	477	41			447	30					480	42
2024-25 (26) Zoology					587	**81**							513	**55**

Because sample sizes were too small to generate group scores for individual subject area tests for most of our concentrations in 2024-25, we compared overall ACAT scores pooled across subject areas for 2020-2024 to overall scores for individual concentrations in 2024-25, which were calculated despite small sample sizes. These comparisons are shown in Table 4B. As expected, overall scores were poor relative to our goal for 2020-24, but overall scores exceeded our >50%ile goal in four concentrations (bolded %tile) - Botany, Cellular and Molecular Biology, Microbiology, and Zoology.

Table 4B. Overall scores and average percentiles pooled across subject areas for 2020-2024, compared to overall scores by concentration in 2024-25. Both Fall and Spring semester data are included.

		Overall Score	
Year	Concentration	Score	%tile
2020-21	(pooled)	473	39
2021-22	(pooled)	469	38
2022-23	(pooled)	472	39
2023-24	(pooled)	447	30
2024-25	Botany (N=3)	595	**79**
	Cellular and Molecular (N=4)	625	**85**
	Environmental Biology (N=4)	425	27
	Marine Biology (N=8)	434	30
	Health Sciences (N=43)	466	37
	Microbiology (N=8)	503	**51**
	Zoology (N=26)	513	**55**

Use of Results to Improve Outcomes:

Based on available data, our departmental decision to fine-tune our ACAT assessment tool by varying the subject areas by concentration, rather than having a standard set of subject area tests for all concentrations, improved overall performance to some degree. Overall exam performance, considering all included content areas, never reached the 40th percentile in 2020-24. Zoology students achieved our 50th percentile goal in all subject areas in 2024-25, and four concentrations achieved our benchmark in overall score in 2024-25. Overall ACAT scores clearly

were improved in 2024-25 compared to recent years. In 2025-26, we plan to continue to vary the ACAT exam content by concentration. Our Biology faculty plan to discuss the problem of small sample sizes of graduates in some concentrations, as we decide about using this approach going beyond 2025-26.

We're encouraged that students in the Zoology concentration achieved our 50th percentile goal in the subject of Evolution in 2024-25. The advisor of the Zoology concentration has developed a junior-level course in evolution, which was added to the catalog this past year. It will be offered in Fall semesters beginning in 2025, and it has been added as a directed elective to some of our concentration curricula. It may be added as a required course to others in the coming year. This course should boost ACAT scores in the subject of evolution for the concentrations that adopt it.

Summative Evaluation:

Student Learning Outcome 1: We continue to meet our goal here, but we still seek improvement. The Department of Biology is evaluating 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 are being developed by our newer faculty employ active learning approaches that challenge students to develop their critical thinking skills.

Student Learning Outcome 2: We met our goal relative to this outcome, although participation in experiential learning was not as high as last year. The department is working on ways to get known internship opportunities out to a wider audience of Biology majors, including through mass emails, postings on the department website, and/or use of departmental social media sites. We also plan to continue our aggressive efforts to recruit high-quality, research-minded undergraduates in our upper-division classes.

Student Learning Outcome 3: We continue to meet our goal here, but we still seek improvement. In order to improve student knowledge of the scientific method, the department is actively looking at our freshmen Biology sequence to better include ideas related to the scientific method in these courses (as well as carry that through to our upper-level classes). Additionally, we introduced a new, research component in BIOL 1113, General Biology I, the introductory biology course for Biology and Wildlife and Fisheries Science majors last year.

Student Learning Outcome 4: Overall performance on our ACAT exam has improved, but more improvement is possible, and some concentrations still performed poorly. A departmental committee is looking at ways to improve our freshman biology sequence and upper-division courses relative to ACAT performance. We also developed a stand-alone Evolution course, to be offered Fall 2025, which is now a directed elective in some concentrations, and which should improve ACAT performance in that area.

Assessment Plan Changes:

Student Learning Outcome 1: None

Student Learning Outcome 2: We will continue to include undergraduate research in our definition of experiential learning, and we will continue to use our new online student survey to quantify experiential learning, supplemented by faculty activity reports.

Student Learning Outcome 3: We will continue to use our new criteria for success in this outcome.

Student Learning Outcome 4: We will continue to use an ACAT exam that varies content area tests by concentration, although we will discuss problems with small sample sizes in some concentrations.

List of Appendices:

Appendix 1: Biology BS Curriculum Map

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

		Learning Outcomes			
Course No.	Title	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

Appendix 1: Biology BS Curriculum Map, cont.

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