

**Institutional Effectiveness
2022-2023**

Program: Biology BS

College and Department: College of Arts & Sciences

Contact: Chris Brown

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 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.

Results and Analysis:

Department of Biology graduating seniors 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. Looking at scores within the major, there was a decline during the two primary years of the COVID pandemic, but scores have rebounded somewhat and increased over the past two academic years, although not quite to the level they showed in 2018-2019.

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
2018-2019	79.0	48	74.0
2019-2020	75.0	41	74.0
2020-2021	74.2	32	74.0
2021-2022	75.3	90	73.3
2022-2023	76.5	59	73.3

Use of Results to Improve Outcomes:

No actions needed at this time.

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 (coops, 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: coops, 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.

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. This was done following discussion that indicated that many faculty consider research as another type of experiential learning, and an important one at that. Using this updated measure, we found that greater than 10% of graduating seniors engaged in one of the three types of experiential learning (Table 2). (As a comparison to previous years, 6% engaged in internships/coop assignments).

Table 2. Percent of Biology graduating seniors indicating participation in an experiential learning opportunity. From 2018-19 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
2018-2019	33	3.0
2019-2020	18	5.5
2020-2021	NA	NA
2021-2022	112	3.6
2022-2023	51	13.7

Use of Results to Improve Outcomes:

This past year we added undergraduate research experience to our list of included experiential learning options, since faculty agree that this is also an important kind of experiential learning. We also went back to proctoring the major field exam after several years of having it be unproctored (and online), in order to get better response rates on our senior questionnaires.

We are 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.

STUDENT LEARNING 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.

Results and Analysis:

Biological Communication Skills (BIOL 3920) is a course taken by all Biology and WFS 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 also continuously improved over each of 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 (%)
2018-2019	86.9	40.7
2019-2020	88.5	46.2
2020-2021	91.4	52.9
2021-2022	90.7	56.0
2022-2023	92.4	64.3

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 beginning (in 2023-24) 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).

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 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.

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, and this goal has yet to be met in the past 5 years. The number of content areas in which our students meet or exceed the national average has ranged from zero (in 2018-2019) to three (in 2020-2021). During 2022-2023, our students exceeded the national average in just a single category (Ecology), although they were close in two others (Bacteriology and Cell Biology).

The specific content areas in which our students perform above the national average has not been consistent over the years. In 2022-2023 the only such area was Ecology, the scores in which have exceeded once before (2019-2020). Bacteriology, Cell Biology, Genetics, and Botany show similar trends, with scores above the national average in 1 or 2 years. On the other hand, both Zoology and Evolution have failed to reach an average score of 500 in any of the past 5 years (although each was close in a single year).

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. 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.

	Bacteriology		Cell Biology		Ecology		Genetics		Botany		Zoology		Evolution	
Year (<i>n</i>)	Score	%ile	Score	%ile	Score	%ile	Score	%ile	Score	%ile	Score	%ile	Score	%ile
2018-19 (16)	470	38	455	46	453	32	442	28	480	42	499	50	462	35
2019-20 (22)	480	42	495	44	502	51	465	36	508	53	492	47	499	50
2020-21 (32)	501	50	513	55	493	47	509	54	494	48	471	39	450	31
2021-22 (43)	471	38	507	53	489	46	486	45	510	54	486	44	454	32
2022-23 (50)	496	48	496	48	522	59	490	46	480	42	489	46	459	34

Use of Results to Improve Outcomes:

We have a department committee looking at ways to improve our freshman biology sequence, with the goal of seeing which areas we need to focus on to better prepare students for our upper-division courses.

We are in the process of developing a stand-alone Evolution course, which would then be considered for inclusion in some or all of our Biology concentrations.

Finally, we are considering creating a 1-credit upper-division course for graduating seniors, during which students would take the major field exam (along with having some other assignments). The hope is that this would (A) have more students take the major field exam and, more importantly, (B) create more incentive in the students to take the exam seriously (and thus perform better).

PROGRAM OUTCOME 1: DIVERSITY IN BIOLOGY

Define Outcome:

The Department of Biology will seek diversity amongst students majoring in Biology by having a minimum of 15% of Biology majors be from underrepresented groups as determined by department enrollment information.

Assessment Methods:

Percentage of students in underrepresented groups (e.g., minority students) will be obtained from enrollment data provided by the Office of Institutional Assessment, Research, and Effectiveness (IARE).

Criteria for Success (Thresholds for Assessment Methods):

A minimum of 15% of students majoring in Biology will come from underrepresented groups, as determined by data from IARE.

Results and Analysis:

For the purposes of this outcome, minority students were defined using the sum of the percentages of all non-White racial/ethnic categories from the TTU Institutional Dashboard. The Biology department has exceeded its goal of 15% underrepresented group enrollment in four of the past five years; the only exception was 2020, when we were slightly below this goal (Table 5). For the first time in at least the past 10 years, minority enrollment in the department exceeded 20% as of Fall 2022.

Female enrollment continues to outpace male enrollment, as has been the case in the department for at least the past decade (Table 5). The percentage of female students has remained fairly constant over the past 5 years, at approximately 63-66%.

Table 5. Percent of Biology majors identifying as a minority student or as a female student. Data are based on enrollments at the start of the Fall semester of the corresponding year.

Year	Minority Students (%)	Female Students (%)
2018	17.0	66.3
2019	15.3	62.7
2020	14.4	64.9
2021	15.6	63.5
2022	20.2	63.1

Use of Results to Improve Outcomes:

The department will continue to monitor progress on this outcome.

Summative Evaluation:

Student Learning Outcome 2: 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.

Student Learning Outcome 3: In order to improve student knowledge of the scientific method, the dept is beginning (in 2023-24) 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).

Student Learning Outcome 4: A departmental committee looking at ways to improve our freshman biology sequence, including the development of a stand-alone Evolution course and a 1-credit hour upper-division course for graduation seniors to increase major field exam participation and motivation.

Assessment Plan Changes:

NONE

List of Appendices:

Appendix 1: Curriculum support for learning outcomes of the undergraduate programs in the Department of Biology.

Appendix 2: Scientific Method Questionnaire

**Appendix 1. Curriculum support for learning outcomes of the undergraduate programs of the
Department of Biology.**

Course No.	Title	Learning Outcomes			
		Critical Thinking	Extra-curricular Activities	Scientific Method	Demonstrated Knowledge
BIOL 1000	Intro. to Biol. Methods	X	X	X	
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 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
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	X
BIOL 4100	Evolutionary Biology	X	X	X	X
BIOL 4110	Microbial Evolution	X		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 4170	Pop. & Conserv. Genetics	X			X
BIOL/WFS 4220	Biostatistics	X		X	X
BIOL/WFS 4230	Animal Behavior	X			X
BIOL 4310	Plant Anatomy	X			X
BIOL 4320	Plant Physiology	X	X	X	X
BIOL 4330	Plant Ecology	X		X	X

Appendix 1 (continued)

BIOL 4340	Plant-Animal Interactions	X		X	X
WFS 4500	National Wildlife Policy	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
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	
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			X
WFS 4870	GIS for Wildlife & Fish.				X
BIOL/WFS 4900	Internship				X
BIOL/WFS 4991-4	Advanced Topics	X	X		X

Appendix 2: Scientific Method Questionnaire

Scientific Method Questionnaire

Please select the response that best completes the sentence or answers the question.

_____ 1. _____, in which the experimental variable has been omitted, are used in research as standards of comparison against which experimental data are compared.

- A. Theories B. Controls C. Hypotheses D. Observations E. Replicates

_____ 2. A _____ is a tentative answer to a research question, which will be evaluated using an experiment.

- A. Theory B. Control C. Hypothesis D. Experiment E. Law

_____ 3. _____ is the use of multiple observations in a study.

- A. Hypothesis B. Control C. Theory D. Experiment E. Replication

_____ 4. True (A) or False (B): Science is knowledge obtained by observation.

_____ 5. True (A) or False (B): A theory is a very tentative idea with little or no scientific evidence to support it.

_____ 6. True (A) or False (B): Publishing results in a peer-reviewed journal is an important part of the scientific process.

Does oatmeal really reduce bad cholesterol? You decide to try to answer this question. You predict that people who eat oatmeal 5 times a week for a month will have lower cholesterol than those who don't. You select 10 people, 5 of whom you put on this oatmeal diet, and 5 of whom you don't. At the end of the month, you measure cholesterol in all 10 people.

_____ 7. The statement "Oatmeal reduces bad cholesterol levels" is the _____ of this research.

_____ 8. Using more than 1 person in each group illustrates the concept of _____.

_____ 9. Using a group of people who do not eat oatmeal illustrates the concept of _____.

- A. Observation B. Control C. Hypothesis D. Experiment E. Replication

Please arrange the following steps of the scientific method in the correct order.

_____ design an experiment

_____ make observations

_____ publish results

_____ formulate research hypothesis

_____ draw conclusions

_____ collect data