Abilene Christian University

Application for a New Course v9

Course ID *Subject and Number*	BIOL 399
Date APPROVED	
Date DENIED	

I. Systems and Catalog Information Complete each item.

1	Course Developer	Joshua M. Brokaw
2	Course Teacher	Biology Department Faculty
3	Course Title	Biology Research
4	Course Abbreviation (if title is over 30 characters)	
5	College	College of Arts & Sciences
6	Department	Department of Biology
7	Number of Credit Hours	1 - 3
8	Is the course Fixed Credit or Variable Credit?	Variable Credit
9	Is the course repeatable?	yes
10	Maximum number of times course may be repeated	up to 3 total credits
11	Maximum number of hours credit	3
12	Explanation for variable credit	Up to 3 hours of research course credit can be gained during one bachelor's degree.
13a	Course contact hours - LEC	
13b	Course contact hours - Lab	
13c	Course contact hours - Practicum	
13d	Course contact hours - Seminar	
13e	Course contact hours - Studio	
13f	Course contact hours - Online	
13g	Course contact hours - Colloquium	
13h	Course contact hours – Field Experience	
13j	Course contact hours - Internship	
13k	Course contact hours - Research	1 - 3
13m	Course contact hours - Workshop	
13n	Course contact hours – Other (specify)	
14	Instructor Workload	1 - 3 contact hours per week
15	Grade Mode (check all appropriate):	✓ Standard ___Credit/No Credit (undergrad only)
16	Maximum Enrollment	Determined by instructor
17	**Catalog Description** (50 words or less)	Students perform biological research under the supervision of a faculty member for 1-3 credit hours. A poster or presentation suitable for presentation at a scientific meeting or paper

		incorporating results of the research, written in the format of scientific publications, is required for completion of the course. Special laboratory fee.
18	List any prerequisites (course/s, test scores, class standing, major, etc.)	Instructor approval
19	List any co-requisites	
20	If the course is cross listed, specify the Course ID(s) MUST have signature in Section V off all Department Chairs	
21	Does this course have any special student costs? Yes/No *Attach a completed "Request to Add or Change Course Fees" form. Describe in section IV-F.*	Yes
22	How often will it be offered? **Fall**	
23a	How often will it be offered? **Spring**	
23b	How often will it be offered? **Summer**	
23c	How often will it be offered? **Fall**	
24	Frequency?	All semesters
25	First semester this course will be offered *New courses may not be taught under their approved course ID until they appear in the catalog, therefore, no earlier than the coming fall.*	Fall, 2014
26	List course/s that should be deleted, include the last semester for course/s being deleted *A course cannot be deleted when it is a requirement in a degree plan in any department.*	
27	Is this course required for a degree/s? Yes/No *If "Yes," attach a revised degree plan(s) reflecting the placement of the new course.*	No
28	Has this course been offered as a Special Topics course? Yes/No *If "Yes," specify the Course ID and enrollment for each term it was taught.*	No However, research has been offered as a special topic in the Biology Department under unique names for many years.
29	List any courses in which content overlaps the proposed course. (Course ID and Name) *Attach statement from instructor/dept chair of existing course justifying the new offering in Section IV-D.*	No substantial overlap

II. Curriculum

1	**Degree Plan** Explanation of how	It fulfills requirements for advanced biology credits

	this course affects degree requirements.	required by the Biology BS.
2	**Justification** State the justification for adding this course to the current curriculum. Represent the need.	The Biology Department at ACU is uniquely positioned to provide quality research experiences for undergraduate students. Expansion of these abilities will be vital to our continuing relevance in the changing landscape of higher education. This course has been intentionally designed to strengthen the visibility of undergraduate research at ACU. All students in this course are expected to present some form of research product that will serve to promote both the student and university. Three pdf files of student poster presentations have been attached to document student research facilitated by recent special topics courses that this course has been modeled after.

III. Course Design

1. Audience and Course Goal

1	Describe the intended audience, including prerequisite skills.	This course is intended for science majors interested in the application of modern techniques to biological research questions. Students are expected to have basic aptitude for independent research. Eligibility will be determined on a case by case basis by the instructor.
2	State the overarching course goal(s) in performance terms.	This course is an opportunity to formally incorporate original research as a fundamental component of the curriculum. Students must learn to think critically and develop ways to test their ideas by collecting new data and/or performing new analyses. Students must learn to clearly distinguish original research from the process of literature review.

2. Competencies and Measurements

	Competency	**Measurement**
1	Students will gain experience in the design of experiments.	Graded written research report or presentation
2	Students will learn proper record keeping.	Lab notebook graded for completion and clarity
3	Students will analyze/evaluate data (applying statistics when appropriate).	Graded written research report or presentation
4	Students will develop independent thinking skills.	Graded written research report or presentation
5	Students will gain experience in technical writing and oral communication.	Graded written research report or presentation
6	Students will make a research conference presentation and/or journal submission.	Graded written research report or presentation
7		
8		
9		

3. Text and Resources

1. Give the full publication information of the textbook/s and other required resources and outside readings.

Textbook: A Short Guide to Writing about Biology, 8th edition, by Pechenik (2012)

Because each offering of this course covers original research in a rapidly changing field of science, text resources primarily come from the original literature and will be subject to change from year to year. Journal articles are assigned on a student-by-student basis according to the topics of their research, and students will be trained to search for additional references.

2. For **combined undergraduate/graduate** courses, make two lists:
   a. full publication information; label **Undergraduate**.
   b. full publication information; label **Graduate**. Indicate number of pages required.

IV. Supporting Documentation

Supporting documents must accompany proposal prior to preliminary approval by chair and dean.

	1	**Library** — Submit new course application and syllabus to the Director of the Library. Consult with the director and establish a deadline for completion of the library report. **Attach** the signed copy of the library director's report.
	2	**Instructional Design** — The application and syllabus must be reviewed by the Adams Center. **Attach** a copy of the Adams Center Review Letter.
	3	**Degree Plan** — The impact of the course must be reviewed by the Director of Curriculum. **Attach** degree plan signed by the Director of Curriculum.
	4	**Content Overlap** — Include one document for each course you listed in Section I-I. **Attach** statement from instructor/dept chair of existing course justifying the new offering.
	5	**Departmental Resources** — List the resources that support the course and are available only through the department, if applicable. **Attach** the list of the holdings and the location/s.
	6	**Resources** — List resources (other than library or departmental resources) that are needed to support this course (computers, lab equipment, other technology, etc.). **Attach** a complete list of all items and indicate possible sources or estimated cost of each. List the sources of any needed funds.
	7	**Expenses** — List additional expenses needed to implement this course (full-time or part-time faculty, graduate or lab assistants, student employees, travel, special student costs, room renovation, storage facility, etc.). **Attach** a complete list of all items, the estimated cost of each and the source of the funds.
	8	**Justification** — **Attach** all documents referred to in Section II-2
	9	Syllabus — **Attach** the syllabus for the course based upon the anticipated first-semester offering.
	10	Provide documentation for all additional attachments here

VI. Approvals *Place all approvals on one page.*

A. Course ID: BIOL 399

Course Title: Biology Research

1. **College Academic Council Action**: (for all courses)
   Note: Insert additional lines for College Academic Council action for each college involved in cross-listed courses.

Approved X Denied ___ _____ 1-28-14
College Dean or Director Date

Approved X Denied ___ _____ 1/29/14
College Dean or Director Date

2. **Graduate Council Action**: (for graduate level courses)

Approved ___ Denied ___ _____ _____
Dean of Graduate School Date

3. **University Undergraduate Academic Council Action**:
   For undergraduate level courses only

Approved ___ Denied ___ _____ _____
Associate Provost Date

4. **University General Education Council Action**: (when applicable)

Approved ___ Denied ___ _____ _____
Provost or designee Date

5. **University Budget Committee Action**: (when applicable)
When applicable – see New Course Application Instructions

Approved ___ Denied ___ _____ _____
Chair, University Budget Committee Date

6. **Academic Provost Action**: (for all courses)

Approved ___ Denied ___ _____ _____
Provost Date

7. **President of the University Action**: (for all courses)

Approved ___ Denied ___ _____ _____
President Date

Attach notes, comments, or conditions from appropriate councils:

Course Syllabus for Biology Research

BIOL 399.01 Fall 2014

Foster Science Building Room 375

Mission Statements:

ACU: The mission of Abilene Christian University is to educate students for Christian service and leadership throughout the world.

College of Arts and Sciences: The mission of the College of Arts and Sciences is to educate students for worldwide Christian service and leadership through programs of study and other learning experiences that blend a liberal arts education with professional and career education.

Biology Department: The Department of Biology educates students for Christian service and leadership by preparing them to become biological scientists, pre-college teachers, and health care professionals.

Instructor: Dr. Joshua Brokaw
Office: Foster Science 479D
Office Hours: TBA or appointment
Phone: 674-2168 E-mail: josh.brokaw@acu.edu
*E-mails are welcome at any time and can be used to schedule appointments outside office hours.

Course Description:

BIOL 399 Biology Research (0-3-3),* fall, spring, summer. Students perform biological research under the supervision of a faculty member for 1-3 credit hours. Students must report results of the research by completing a poster or presentation suitable for a scientific meeting or a paper written in the format of scientific publications to obtain credit for the course. Special laboratory fee.

Textbook: A Short Guide to Writing about Biology, 8th edition, by Pechenik (2012)

Prerequisites: consent of instructor.

Purpose: The purpose of this course is to provide students with experience in biology-related research. It is also intended to develop independent thinking and action by students. It is designed for undergraduate science majors who plan to join the work force in a research and development position or go to graduate school, and others, such as health professional students, who are interested in research.

Format: This course is primarily a field/laboratory experience with students working as independently (not alone) as they are capable. The instructor/mentor will be actively involved in the student's project, including training and periodic meetings with the student. Students should devote to the research project a minimum of three field/lab hours per week for each hour of credit for which she or he has registered.

Anticipated Outcomes and Competency Measures: The objective of this course is to provide training and experience in field and/or laboratory investigative work while at the same time contributing a tangible research product to the student's research portfolio or curriculum vitae. Students will 1) gain experience in the **design of experiments**; 2) learn proper **record keeping**; 3) **analyze**/evaluate **data** (applying statistics when appropriate); 4) develop **independent thinking** skills; 5) gain experience in **technical writing** and **oral communication**; 6) prepare to make a **research conference presentation and/or journal submission**. Competency in these areas will be assessed by the degree to which the objectives of the unique research project are met. Instructors will do their best to have fair and reasonable expectations with the understanding that the application of the scientific method is seldom straightforward and results are not always easily realized. Grades based on competencies will be assigned as described below.

Grade Assessment:

The grade in this course will be determined by the average grade (A=4, B=3, C=2, D=1, or F=0) of the following two components ("Process" and "Product").

1. **Research Process** (1 point for each part; 4 points total):
   A. The level of **enthusiasm** and **commitment** to the research project. The student must take responsibility for the project. Full credit will be awarded for a level of commitment to the research appropriate to the student's experience and background. Students must fulfill the minimum requirement of 3 field/lab hours per week per credit hour (i.e. at least 45 hours field/lab work per credit hour) of to achieve a full credit score (1 point). The timing of field and/or laboratory work is flexible and will be determined on an individual basis by an agreement between the student and research mentor.
   B. The degree of **independence of thought** and **effort**. This is balanced against the need to seek help from the mentor for problems that cannot be solved by independent study. In addition to data collection in the field/lab, the student will be expected to search the scientific literature for information as needed and to seek out the advice of his/her mentor and other faculty and students as appropriate. Full credit will be awarded for a level of independence of action and self-motivation appropriate to the student's experience and background. Appropriate literature review is necessary for the "Research Product" below and is necessary to achieve a full credit score (1 point).
   C. The degree to which the **objectives** of the research project are met. Mentors will do their best to have fair and reasonable expectations with the understanding that the application of the scientific method is seldom straightforward and results are not always easily realized. Full credit will be awarded for project completion. Results (even if they are negative results) must be reported to achieve a full credit score (1 point).
   D. The quality of the **laboratory notebook** and/or **research blog**. All aspects of the research procedures and results should be recorded in the lab notebook. Depending on the research program, the notebook may be handwritten, computer based, or blog based (with adequate backup). Notebooks are the property of the mentor and should always be kept in a safe place in the lab and/or stored on the laboratory computers. Photocopies or electronic copies may be given to the student at the end of the semester. The scores (0 to 1 point) will reflect the completeness and clarity of the lab notebook.

2. **Research Product** (4 points total, average of 3 components): The quality of the written research report or presentation document (**paper, poster, or PowerPoint file**). **This final product must be completed with approval of instructor in order to receive a passing grade for the entire course.** However, the grade will reflect adherence to the following rubric.

	4-A	3-B	2-C	1-D	0-F
Clarity and Completion	Product is well-written, void of mistakes, and makes purpose, relevance, and methods clear. Product contains and appropriately distinguishes introduction, methods, results, and discussion. Sources are appropriately cited.	Product is mostly well written, leaving only minimal lack of clarity. Product contains and usually distinguishes introduction, methods, results, and discussion appropriately. Sources are cited.	Product is poorly written, leaving questions about the purpose, relevance, and methods of the research. Product lacks or fails to appropriately distinguish one or two of the following: introduction, methods, results, and discussion. Most sources are cited.	Poor writing quality and clarity make it difficult to judge the product at all. Product lacks or fails to appropriately distinguish three or all of the following: introduction, methods, results, and discussion. Most/all sources are not appropriately cited.	No product/ plagiarism
Results and Analysis	Research is innovative and original* with obvious relevance to the field. Analysis is appropriate and complete, given the data.	Research is original* with clear relevance to the field. Analysis is appropriate, given the data, but more thorough analysis would be preferable.	Review of literature or previous research with inadequate originality* of findings, or research is original but lacks analysis of data.	Review of literature or previous research: does not appear relevant and/or the findings are merely a summary of previous work.	No product/ plagiarism
Review and Discussion	Review of preexisting knowledge is thorough and demonstrates context and relevance of the research. Discussion appropriately interprets the results while fully considering caveats without making claims not supported by the data.	Review of preexisting knowledge is satisfactory to demonstrate context and relevance of the research. Discussion interprets the results but does not fully consider caveats or makes some claims not clearly supported by the data.	There is some review of preexisting knowledge but does not demonstrate context and relevance of the research. Discussion merely restates the results and does not consider caveats or makes claims not supported by the data.	Review and discussion are merely a summary of previous work and/or unsupported claims.	No product/ plagiarism

*Originality: When new data has been collected, this is unambiguously original research. However, different or improved analyses of previously reported data also represent original work. Finally, a literature review can also be considered original research if the author of the review brings new perspectives to the questions considered by combining the findings of many studies. However, this course is intended to consist primarily of original research involving the collection of new data.

This course is not completed until the written description of the semester's work (paper, poster, or PowerPoint file*) is submitted to and accepted by the faculty mentor. The written product must be submitted before Finals Week in order for the mentor read and approve the report by the end of Finals Week.
*PowerPoint files must have sufficient text in the "notes" to explain the slides as they will be presented to an audience.

Late Project Assignments: Late work is always problematic. Because scientific conferences and journals must have submission deadlines, assignments for this course will also be graded based on the level of completion at the due date. Any research endeavor that is undertaken must (and always will) have some kind of results even if those results do not answer the original research questions. Failure to submit any product documenting the research must result in a grade of "F." **There will be NO course incompletes given for failure to complete assignments.** However, students can make an appeal to the department chair for an exception. This appeal must be submitted in writing during the semester of the course. The appeal must include a written detailed plan of action to complete the research that outlines how each task will be completed. After the final day of the semester, no appeal can be made. Assignments can be turned in early for opportunities for review and revision in order obtain a higher grade.

Attendance: Attendance/research activity is vital for success in this class. The attendance schedule may be flexible with approval of instructor, but students should attend a minimum of three field/lab hours per week for each hour of credit registered (i.e. at least 45 hours field/lab work per credit hour).

Academic Integrity: Plagiarism or dishonesty in research will automatically result in a grade of "F." It will be reported to the department chair and the dean according to the procedures established by the university.

Learning Disabilities: If you have a documented disability and wish to discuss accommodations, you must contact the *ACU Student Disability Services Office* (part of *Alpha Academic Service*) at (325) 674-2667 to make an appointment with the Director of Disability Services. In order to receive accommodations, you must be registered with them for each class in which you need accommodations. They will make necessary arrangements in cooperation with instructors.

Behavior/Dress Code: Any behavior or dress that is deemed by the instructor to endanger the student or others will result in warning. If there is continued infringement, the student will be asked to discontinue the research activities.

Policy Regarding Questionable Materials: As with all worthy areas of academic inquiry, scientific research may challenge your understanding of the world (i.e. challenge worldviews). It is our objective to provide support for your questions and your personal development during this process because "Without any doubt, the mystery of our religion is great" (I Timothy 3:16a).

November 5, 2013
Drs Brokaw, Diana Flanagan, Patricia Hernandez, Jennifer Huddleston, Rebecca Hunter, Tom Lee, James Nichols, Qiang Xu
Abilene Christian University

Dear Dr. Brokaw,

Thank you for the submission of the application for the new course BIOL399: Biology Research that you, as well as Drs. Daniel Brannan, Diana Flanagan, Patricia Hernandez, Jennifer Huddleston, Rebecca Hunter, Tom Lee, James Nichols, Qiang Xu will be teaching. We reviewed the syllabus based on the ACU Syllabus Guidelines. We found that the syllabus present the following issues/questions that should be addressed to be fully compliant with the guidelines:

- A brief catalogue description is not available;
- A list of textbooks and/or reading materials is not available;
- In the course format section, would be possible to provide more detail on how the field/lab requirements can be met? For instance, do students schedule their own lab/field time, or is there a set time for labs?
- Would you be more specific about time for semester's work? Description like "remember that the mentor needs time to read and approve the report by the end of Finals Week" may not be most helpful compared to a more specific deadline. Or are such deadlines set by individual instructors?
- As an independent study course, the course does not specify a list of topics to cover or a schedule to go by, but are there some basic research topics to cover or skills students will need to develop in any particular sequence or combination? Right now, everything is vague and that may not help students to understand what kind of outcomes they will be expected to achieve.

Please consider revising these items if making the recommended changes will help your potential students. If there are reasons that would justify not making the changes, please prepare to share them with the council when your course is submitted for approval.

If there is any aspect of the application or syllabus you would like to discuss further, please let me know and we can schedule a time. Please know the Adams Center is here to serve you in any aspect of your course development, implementation, and/or ongoing teaching of the course.

Again, thank you for allowing the Adams Center team to review your course application and if there is any way we can serve you, please know we are here to serve you.

Berlin Fang
Director, Instructional Design, Adams Center

Degreeplan Examples

BS: Biology
BIOG: General Track

Name _____ Banner ID _____

Entering Term/Catalog Year _____ ACT/SAT Score _____

Transfer Hours/Dual Credit/AP _____ Math Placement _____

	Required Biology (21 hours)			Term	Grade
_____	BIOL 112/114	General Biology I and Lab	4 hrs	_____	
_____	BIOL 113/115	General Biology II and Lab	4 hrs	_____	
_____	BIOL 221/223	Animal Biology and Lab			
	OR BIOL 222/224	Plant Biology and Lab	4 hrs	_____	
_____	BIOL 312	Cell Biology	3 hrs	_____	
_____	BIOL 362	Ecology	3 hrs	_____	
_____	BIOL 497	Seminar in Biology (Sr Yr)	3 hrs	_____	

Other Biology (21 hours) Any 300 or 400 Level Biology Course

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Chemistry (16 hours)

_____	CHEM 133/131	General Chemistry I and Lab	4 hrs	_____	
_____	CHEM 134/132	General Chemistry II and Lab	4 hrs	_____	
_____	CHEM 223/221	Organic Chemistry I and Lab	4 hrs	_____	
_____	CHEM 324/322	Organic Chemistry II and Lab	4 hrs	_____	

Physics (8 hours)

_____	PHYS 110/111	General Physics I and Lab	4 hrs	_____	
_____	PHYS 112/113	General Physics II and Lab	4 hrs	_____	

Electives (9 hours)

_____	_____	3 hrs	_____	
_____	_____	3 hrs	_____	
_____	_____	3 hrs	_____	

CORE (12 hours)

_____	CORE 110	The Question of Truth	3 hrs	_____
_____	CORE 120	The Question of Identity	3 hrs	_____
_____	CORE 220	The Question of Community	3 hrs	_____
_____	CORE 320	The Question of Transcendence	3 hrs	_____

Speech (3 hours)

_____	COMS 211	Foundations of Communication	3 hrs	_____

Mathematics (3 hours)

_____	MATH 124	Precalculus II	3 hrs	_____
	OR			
_____	MATH 185	Calculus		

Bible (14 hours)

_____	BIBL 101	Life and Teachings of Jesus	3 hrs	_____
_____	BIBL 102	Acts – Revelation	3 hrs	_____
_____	BIBL 211	Message of the Old Testament	3 hrs	_____
_____	Adv. course (300-499) from BIBL, BIBD, BIBH, BMIS		3 hrs	_____
_____	BIBL 440	Christian Vocation & Mission (Sr. Yr.)	2 hrs	_____

English (12 hours)

_____	ENGL 111	Composition and Rhetoric	3 hrs	_____
_____	ENGL 112	Composition and Literature	3 hrs	_____
_____	ENGL ____	Literature (not including Engl 351)	3 hrs	_____
_____	ENGL ____	Literature (not including Engl 351)	3 hrs	_____

Exercise Science (3 hours)

_____	EXSC 100	Lifetime Wellness	1 hr	_____
_____	EXSC ____	Activity of your choice	1 hr	_____
_____	EXSC ____	Activity of your choice	1 hr	_____

Social Science (3 hours)

_____ 3 hrs (100-299) of social science from Anthropology, Economics (incl. AGRB 261), Geography, History, Political Science, Psychology, Sociology — 3 hrs _____

Social Science/Humanities/Fine Arts (3 hours)

_____ 3 hours (100-299) of social science from a different area from the list above **OR** 3 hours from the following list: ART 101, ART 221, ART 222, MUSM 230, MUSM 231, MUSM 232, MUSM 233, THEA 220, THEA 250 — 3 hrs _____

Total Hours: 128

BS: Biology (BIOG: General Biology Track)

For Students Entering Fall 2011

iis is a sample schedule to illustrate how long it will take to complete this degree plan. Additional semesters may be necessary if you are required to complete courses listed in the right-hand column or if you repeat courses. Consult ith your academic advisor before changing the sequence of courses. Some courses are not offered every semester and some courses have prerequisites. Check the course description in the current catalog for details. Failure to mplete courses in the recommended sequence may delay graduation.

FR Fall 17 hrs	† BIBL 101 Life & Teachings of Jesus 3 hrs	† ENGL 111 Composition & Rhetoric 3 hrs	BIOL 112/114 General Biology I/Lab 4 hrs	CHEM 131/133 General Chemistry I/Lab 4 hrs	† CORE 110 3 hrs		
FR Spring 17 hrs	† BIBL 102 Acts – Revelation 3 hrs	† ENGL 112 Composition & Literature 3 hrs	BIOL 113/115 General Biology II/Lab 4 hrs	CHEM 132/134 General Chemistry II/Lab 4 hrs	CORE 120 3 hrs		
Summer							
SO Fall 17 hrs	• BIBL 211 Message of the Old Testament 3 hrs	• ENGL Literature 3 hrs	BIOL 221 /223 – Animal Biology/Lab OR BIOL 222/224 – Plant Biology/Lab 4 hrs		CHEM 221/223 Organic Chemistry I/Lab 4 hrs	MATH 124 Pre-Calculus II Or MATH 185 3 hrs	
SO Spring 16 or 17 hrs	CORE 220 3 hrs	CHEM 322/324 Organic Chemistry II/Lab 4 hrs	BIOL 312 – Cell Biology 3 hrs		• ENGL Literature 3 hrs	COMS 240 3 hrs	EXSC 100 1 hr
Summer	Recommend Summer Study Abroad						
JR Fall 16 hrs	PHYS 110 / 111 General Physics I/Lab 4 hrs	BIOLOGY Advanced Elective 3 hrs	BIOL 362 – Ecology 3 hrs		•SOCIAL SCIENCE 3 hrs	CORE 320 3 hrs	
JR Spring 17 hrs	Advanced Bible 3 hrs	BIOLOGY Advanced Elective 3 hrs	BIOLOGY Advanced Elective 3 hrs	PHYS 112/113 General Physics II/Lab 4 hrs	•SOCIAL SCIENCE 3 hrs	EXSC (Activity) 1 hr	
Summer							
SR Fall 14 hrs	BIOLOGY Advanced Elective 3 hrs	BIOLOGY Advanced Elective 3 hrs	*Elective/Foreign Language 3 hrs	BIBL 440 2 hrs	ELECTIVE 3 hrs		
SR Spring 13 hrs	*Elective/Foreign Language 3 hrs	BIOL 497 Biology Seminar 3 hrs	BIOLOGY Advanced Elective 3 hrs	BIOLOGY Advanced Elective 3 hrs	EXSC (Activity) 1 hr		

Required if condition of Admission:

UNIV 011
Learning Strategies

May be required based on COMPASS tests.
MATH:
MATW 019
MATH 109

May be required based on ACT or SAT scores.
ENGLISH:
ENGL 003
ENGL 004
ENGL 106
ENGL 006
ENGL 107
ENGL 007

*FOREIGN LANGUAGE
Two semesters required if proficiency is not demonstrated by testing.

ADVANCED MATH COMPASS REQUIRED FOR FINAL MATH PLACEMENT

Total Hours = 128
March 2011

ach block represents 3 hours unless otherwise noted. † Freshman Requirement. • This course or its equivalent is offered at one of ACU's semester-long Study Abroad sites. Those planning to study abroad should save these ourses. See www.acu.edu/study-abroad for updated courses.

University Requirements for all Bachelor's Degrees

University Requirements, except advanced courses, should be completed by the end of the sophomore year.

University Requirements*

Some courses may not be taken for university requirements credit (see course description)	Required Credit
The Core CORE 110 – Cornerstone CORE 120 – Human Person and Identity CORE 220 – The Question of Community CORE 320 – The Question of Transcendence Capstone Course – (hours counted in the major)	12
Bible BIBL 101 - Life and Teachings of Jesus BIBL 102 - Acts-Revelations BIBL 211 - Message of the Old Testament Adv. course (300-499): BIBD, BIBH, BIBL, BMIS** BIBL 440 - Christian Vocation and Mission	14
English ENGL 111 - Composition and Rhetoric (*or* ENGL 106/006 *and* 107/007) ENGL 112 – Composition and Literature Sophomore (200-299) Literature (includes literature in foreign language)	9
Communication COMS 211 Speaking Well: Foundations of Rhetoric	3
Science Select two courses in different department areas from the following list: *Agriculture/Environmental Sciences* AENV 130 - Environmental and Technological Science ANSC 111 - General Animal Science ANSC 235 - Companion Animal Management ENVR 112 - Plant Science *Biology* BIOL 101 – Biology: Human Perspective *Chemistry* CHEM 101 – Consumer Chemistry *Geology* GEOL 111 - Introduction to Geology *Nutrition* NUTR 120 - Nutrition and Wellness *Physics* PHYS 101 – Astronomy PHYS 102 – Physical Science PHYS 378 – History and Philosophy of Science PHYS 379 – Philosophy, Religion, and Science Or select courses from a two semester sequence below: BIOL 112/113 – General Biology I & II BIOL 291/291 – Anatomy & Physiology I & II CHEM 113/114 – Introductory Chemistry/ Introductory Organic and Biological Chemistry CHEM 133/134 – General Chemistry I & II PHYS 110/112 – General Physics I & II PHYS 120/122 – Engineering Physics I & II	6
Mathematics MATW 120/020, MATH 120 or higher	3
Social Science 3 hours from the following list: *Economics* AGRB 261 – Principles of Agriculture and Applied Economics ECON 260 – Macroeconomics ECON 261 – Microeconomics *History* HIST 117 - Civilization I HIST 118 – Civilization II HIST 221 – American History I HIST 222 – American History II *Political Science* POLS 221 – Government and Business POLS 225 – National Government *Sociology* SOCI 111 – Introduction to Sociology	3
Social Science/Humanities/Fine Arts 3 hours of social science from a different area from the list above or from the following list: ART 101 – Introduction to Art ART 221 – Art History: General Survey I ART 222 – Art History: General Survey II HUM 212 – Oxford Through the Ages HUM 217 – Latin America and the Arts MUSM 230 – Survey of Music in Western Culture MUSM 231 – Survey of Jazz MUSM 232 – Survey of Popular Music MUSM 233 – Survey of World Music THEA 220 – Introduction to Theatre THEA 250 – Film Appreciation	3
Exercise Science EXSC 100 - Lifetime Wellness EXSC activity - 2 different activities	3
Foreign Language If lacking two years of high school language (one language): 6 hours of college foreign language required (one language)	0-6
Total University Requirements Hours	56-62

BS: Biology
BIOO: Organismal Track

Name _____ Banner ID _____

Entering Term/Catalog Year _____ ACT/SAT Score _____

Transfer Hours/Dual Credit/AP _____ Math Placement _____

	Required Biology (21 hours)			Term	Grade
_____	BIOL 112/114	General Biology I and Lab	4 hrs	_____	
_____	BIOL 113/115	General Biology II and Lab	4 hrs	_____	
_____	BIOL 221/223	Animal Biology and Lab			
	OR BIOL 222/224	Plant Biology and Lab	4 hrs	_____	
_____	BIOL 312	Cell Biology	3 hrs	_____	
_____	BIOL 362	Ecology	3 hrs	_____	
_____	BIOL 497	Seminar in Biology (Sr Yr)	3 hrs	_____	

Other Biology (21 hours) 12 hrs. listed below plus 9 advanced hours of your choice

Choose two of the following courses:

Biol 370 – Field, BIOL 380 – Mammalogy, BIOL 403 – Marine, BIOL 425 - Behavior

_____	BIOL	_____	4 hrs	_____	
_____	BIOL	_____	4 hrs	_____	
_____	BIOL 492/495	Physiology & Lab	4 hrs	_____	
_____	_____		____	_____	
_____	_____		____	_____	
_____	_____		____	_____	

	Chemistry (16 hours)			
_____	CHEM 133/131	General Chemistry I and Lab	4 hrs	_____
_____	CHEM 134/132	General Chemistry II and Lab	4 hrs	_____
_____	CHEM 223/221	Organic Chemistry I and Lab	4 hrs	_____
_____	CHEM 324/322	Organic Chemistry II and Lab	4 hrs	_____

	Physics (8 hours)			
_____	PHYS 110/111	General Physics I and Lab	4 hrs	_____
_____	PHYS 112/113	General Physics II and Lab	4 hrs	_____

Electives (9 hours)

_____	_____	3 hrs	_____
_____	_____	3 hrs	_____
_____	_____	3 hrs	_____

CORE (12 hours)

_____	CORE 110	The Question of Truth	3 hrs	_____
_____	CORE 120	The Question of Identity	3 hrs	_____
_____	CORE 220	The Question of Community	3 hrs	_____
_____	CORE 320	The Question of Transcendence	3 hrs	_____

Speech (3 hours)

_____	COMS 211	Foundations of Communication	3 hrs	_____

Mathematics (3 hours)

_____	MATH 124	Precalculus II	3 hrs	_____
	OR			
_____	MATH 185	Calculus		

Bible (14 hours)

_____	BIBL 101	Life and Teachings of Jesus	3 hrs	_____
_____	BIBL 102	Acts – Revelation	3 hrs	_____
_____	BIBL 211	Message of the Old Testament	3 hrs	_____
_____	Adv. course (300-499) from BIBL, BIBD, BIBH, BMIS		3 hrs	_____
_____	BIBL 440	Christian Vocation & Mission (Sr. Yr.)	2 hrs	_____

English (12 hours)

_____	ENGL 111	Composition and Rhetoric	3 hrs	_____
_____	ENGL 112	Composition and Literature	3 hrs	_____
_____	ENGL ____	Literature (not including Engl 351)	3 hrs	_____
_____	ENGL ____	Literature (not including Engl 351)	3 hrs	_____

Exercise Science (3 hours)

_____	EXSC 100	Lifetime Wellness	1 hr	_____
_____	EXSC ____	Activity of your choice	1 hr	_____
_____	EXSC ____	Activity of your choice	1 hr	_____

Social Science (3 hours)

_____	3 hrs (100-299) of social science from Anthropology, Economics (incl. AGRB 261), Geography, History, Political Science, Psychology, Sociology	3 hrs	_____

Social Science/Humanities/Fine Arts (3 hours)

_____	3 hours (100-299) of social science from a different area from the list above **OR** 3 hours from the following list: ART 101, ART 221, ART 222, MUSM 230, MUSM 231, MUSM 232, MUSM 233, THEA 220, THEA 250	3 hrs	_____

Total Hours: 128

BS: Biology (BIOO: Organismal Biology Track)

For Students Entering Fall 2011

This is a sample schedule to illustrate how long it will take to complete this degree plan. Additional semesters may be necessary if you are required to complete courses listed in the right-hand column or if you repeat courses. Consult with your academic advisor before changing the sequence of courses. Some courses are not offered every semester and some courses have prerequisites. Check the course description in the current catalog for details. Failure to complete courses in the recommended sequence may delay graduation.

FR Fall 17 hrs	† BIBL 101 Life & Teachings of Jesus 3 hrs	† ENGL 111 Composition & Rhetoric 3 hrs	BIOL 112/114 General Biology I/Lab 4 hrs	CHEM 131/133 General Chemistry I/Lab 4 hrs	† CORE 110 Cornerstone 3 hrs			**Required if condition of Admission:** UNIV 011 Learning Strategies
FR Spring 17 hrs	† BIBL 102 Acts – Revelation 3 hrs	† ENGL 112 Composition & Literature 3 hrs	BIOL 113/115 General Biology II/Lab 4 hrs	CHEM 132/134 General Chemistry II/Lab 4 hrs	CORE 120 Human Person and Identity 3 hrs			
Summer								May be required based on COMPASS tests: MATH: MATW 019 MATH 109 May be required based on ACT or SAT scores ENGLISH: ENGL 003 ENGL 004 ENGL 106 ENGL 006 ENGL 107 ENGL 007
SO Fall 17 hrs	• BIBL 211 Message of the Old Testament 3 hrs	• ENGL Literature 3 hrs	BIOL 221 /223 – Animal Biology/Lab OR BIOL 222/224 – Plant Biology/Lab 4 hrs		CHEM 221/223 Organic Chemistry I/Lab 4 hrs	MATH 124 Pre-Calculus II Or MATH 185 Calculus I 3 hrs		
SO Spring 17 hrs	CORE 220 Community 3 hrs	CHEM 322/324 Organic Chemistry II/Lab 4 hrs	BIOL 312 – Cell Biology 3 hrs		• ENGL Literature 3 hrs	EXSC 100 1 hr	COMS 211 Speech and Rhetoric 3 hrs	
Summer	Recommend Summer Study Abroad							
JR Fall 17 hrs	PHYS 110 / 111 General Physics I/Lab 4 hrs	BIOL 492/495 Physiology/Lab 4 hrs	BIOL 362 – Ecology 3 hrs		•SOCIAL SCIENCE 3 hrs	CORE 320 Transcendence 3 hrs		***FOREIGN LANGUAGE** Two semesters required if proficiency is not demonstrated by testing.
JR Spring 17 hrs	Advanced Bible 3 hrs	* BIOLOGY Advanced Elective 4 hrs	BIOLOGY Advanced Elective 3 hrs	PHYS 112/113 General Physics II/Lab 4 hrs	•SOCIAL SCIENCE 3 hrs			
Summer								
SR Fall 13 hrs	BIOLOGY Advanced Elective 3 hrs	BIOLOGY Advanced Elective 3 hrs	*Elective/Foreign Language 3 hrs	ELECTIVE 3 hrs	EXSC (Activity) 1 hr			**ADVANCED MATH COMPASS REQUIRED FOR FINAL MATH PLACEMENT**
SR Spring 13 hrs	*Elective/Foreign Language 3 hrs	BIOL 497 Biology Seminar 3 hrs	* BIOLOGY Advanced Elective 4 hrs	BIBL 440 2 hrs	EXSC (Activity) 1 hr			Total Hours = 128 **April 2011**

Each block represents3 hours unless otherwise noted. † Freshman Requirement. • This course or its equivalent is offered at one of ACU's semester-long Study Abroad sites. Those planning to study abroad should save these courses. See www.acu.edu/study-abroad for updated courses. *8hrs from BIOL 370 – Field Biology, BIOL 380 – Mammalogy, BIOL 403 – Marine Biology, BIOL 425 – Behavioral Biology

Departmental Resources Used by Biology Research (BIOL 399)

The ACU Herbarium: a research collection of preserved plant specimens
-Foster Science, Room 485

The ACU Natural History Collection: a research collection of preserved animal specimens
-Foster Science, Room 379

The Clark Stevens Research Laboratory (Foster Science, Room 375) and Biology Research Laboratory B (Foster Science, Room 419) and equipment therein
Thermal cyclers
Centrifuges
Pipettes
Freezers and refrigerators
Electrophoresis equipment
Incubators

ABILENE CHRISTIAN UNIVERSITY

LIBRARY

M E M O R A N D U M

DATE: November 11, 2013

TO: Dr. Josh Brokaw

FROM: Mark McCallon, Associate Dean for Library Services

RE: Course Application for BIOL 399 – Biology Research

After reviewing the course application, the library should be able to support the proposed course, depending on the projects chosen by students. If you require additional library resources in support of the course, please contact Jana Davis, Librarian Liaison for the Department of Biology, at davisj@acu.edu . Thank you for letting the library review the course application.

Research Product Examples

Genetic barcodes in *Mentzelia*: *Mentzelia albicaulis* and relatives

Christian H. Hofsommer, Tina A. Johnson, and Joshua M. Brokaw
Department of Biology, Abilene Christian University, Abilene, Texas 79699

Biology Research

Introduction

Mentzelia section *Trachyphytum* is a monophyletic group composed of approximately 20-30 annual plant species (Darlington 1934; Zavortink 1966; Hufford et al. 2003; Brokaw and Hufford 2010a; Brokaw and Hufford 2010b). This group includes common, widespread species and rare, narrow endemics, many of which are polyploids that can be hard to distinguish (Darlington 1934; Zavortink 1966). Because of its commonness, most ambiguous specimens are identified as *M. albicaulis* (Fig. 1; octoploid). However, hexaploid populations of *M. monoensis* (Fig. 6) occur pumice soils and disturbed sites near the Mono Craters (Figs. 5) of Mono Co., California (Brokaw and Hufford 2011). Although evolutionarily distinct (Brokaw 2009), *M. monoensis* is difficult to identify, especially when young.

Fig 1. *M. albicaulis.*

Due to the complexity of identifying *M. monoensis* and its status as a narrow endemic, additional effort is needed to provide reliable characteristics for identification. This investigation involved comparative studies of molecular data that we collected from *M. monoensis* and the similar, widespread species, *M. albicaulis* and *M. montana* (Fig. 2; tetraploid). The primary objective of this work was to identify a molecular marker that can be used as a genetic 'barcode' to distinguish *M. monoensis* from *M. albicaulis* and *M. montana* so that land managers can accurately determine the conservation status of this plant even when sufficient material for identification based on morphology is not available.

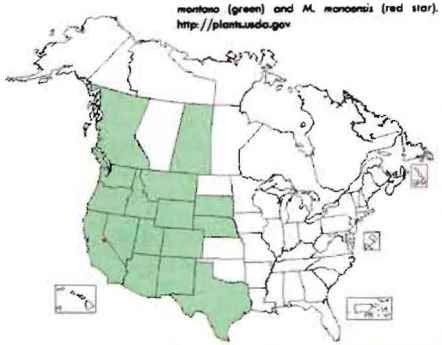
Fig 2. *M. montana.*

Methods

During a recent inventory, populations of *M. monoensis* were located throughout a range of approximately 1000 sq km in the vicinity of Mono Lake and other portions of the Mono Craters volcanic chain (Fig. 5), often intermixed with those of *M. montana*. *M. albicaulis* and *M. montana* cover both this region and much of the western United States and southwestern Canada (Fig. 3). We took samples from 58 total populations, including 15 from *M. albicaulis*, 21 from *M. monoensis*, and 22 from *M. montana*. We performed DNA extraction and amplification for the cpDNA spacer (*ndhF-rpL32*) using standard protocols (Marlowe 2007); amplified DNA was cycle sequenced and sequenced by the DNA Analysis Facility at Yale University.

Sequences were edited and aligned manually using SE-AL (v2.0a11; Rambaut 1996-2002). Haplotype networks were constructed using TCS version 1.21 (Clement et al. 2000) under the criterion of a parsimony network in which connections have a probability of at least 95%.

Fig 3. Combined ranges of *M. albicaulis* and *M. montana* (green) and *M. monoensis* (red star). http://plants.usda.gov



Results

Molecular comparisons. The most common haplotype occurred in most specimens of both *M. albicaulis* and *M. montana* but not *M. monoensis*. With *ndhF-rpL32* sequences, all *M. monoensis* specimens had identical haplotypes, but none were shared with *M. albicaulis* or *M. montana* (Fig. 4). *Mentzelia albicaulis* had one unique sequence found in *F4427*. *Mentzelia montana* specimens exhibited five unique sequences found in *B245, B291, B425, B568,* and *B575*. Also one sequence was shared by two *M. montana* populations (*B564* and *B565*).

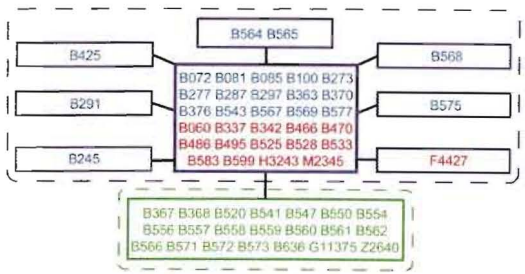


Fig. 4. Unrooted parsimony network of haplotypes (boxes) from *M. albicaulis* (red numbers), *M. montana* (blue numbers), and *M. monoensis* (green numbers) based *ndhF–rpL32* sequences. Numbers in boxes represent collections exhibiting the haplotype. Black lines represent single mutational steps. Dashed lines represent *M. monoensis* (green) and *M. albicaulis and M. montana* (purple).

Discussion

Through the use of molecular data, we will be able to further clarify the range of *M. monoensis* by identifying samples from herbaria in the surrounding counties. When there are not any seeds present in the herbarium specimens molecular data will allow us to determine the species. *Mentzelia monoensis* can be distinguished from *M. albicaulis* and *M. montana* in the field using a few morphological characteristics. The most reliable characters are the shape and color of the seeds, requiring a hand lens or dissecting scope. However, seeds are only present during a brief period of the annual life cycle are are not present on all herbrium specimens. Thus, a DNA bar code is needed to provide a highly reliable method to recognize both taxa they can determine what the conservation status needs to be.

Mentzelia monoensis is narrowly endemic to the Mono Craters area in California. *Mentzelia monoensis* may be specialized to use volcanic substrates found in the region. However, this has not been confirmed. The term neoendemism refers to a species that has recently arisen. This could be a species that has diverged and become reproductively isolated or one that has formed following hybridization and is now classified as a separate species. Such hybrid speciation can be a common process in plants, especially those which exhibit polyploidy, such as *M. monoensis*. It is thought that neoendemism best describes the evolution of *M. monoensis* because data produced by Brokaw and Hufford (2011b) suggest that *M. monoensis*, is a relatively young species formed through an allopolyploidization event.

Because *M. monoensis* is likely a new species, it is possible that eventually it will spread throughout the western portion of the United States, as have *M. albicaulis* and *M. montana*. To determine how far it has spread, we will begin obtaining specimens from herbariums in the counties around Mono county. We will then gather their molecular data in order to confirm the species. The plastid spacer *ndhF-rpl32* can be used as a genetic 'barcode' to consistently distinguish this species when mature seeds are not available.

Conclusions

- Molecular data from new and wider sampling have supported earlier hypotheses that *M. monoensis* is closely related but genetically distinct from *M. albicaulis* and *M. montana*.
- The plastid intergenic spacer *ndhF-rpl32* can be used as a genetic 'barcode' to consistently distinguish *M. monoensis*, *M. albicaulis* and *M. montana* when mature seeds are not available.
- Molecular data will allow us to identify the range of *M. monoensis* from herbarium specimens in order to determine the conservation status of *M. monoensis*.

Fig 5. Mono Craters.

Fig 6. *M. monoensis.*

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Acknowledgements

We thank Levi Gates, Alexandra Smith, Joel Thompson, Larry Hufford, Rebecca Hunter, Qiong Xu, and the U.S. Bureau of Land Management for assistance. Tissue samples were provided by the Abilene Christian Herbarium. Funding was provided by the Betty W. Higinbothom Trust, Hardman Foundation, and Abilene Christian University.

Phylogentic relationships in the rodent genus *Thomasomys*

Michael Maeker, Tanya Daughtry, Joshua M. Brokaw, J. Delton Hanson, and Thomas E. Lee, Jr. – Abilene Christian University, Abilene, TX 79699

Introduction

The numerous rodent species of the genus *Thomasomys*, native to the slopes of the Andes Mountains in Ecuador, are a large group with the potential for interesting patterns of diversity. Several taxa have been assigned to sequences deposited in GenBank and specimens in the ACU Natural History Collection from Sangay National Park (Fig. 1). However, as of yet, the various species have not been subjected to a rigorous phylogenetic study.

A primary objective of this study is to test previous taxon descriptions (Voss, 2003) in order to facilitate creation of an updated key to the mammals of Ecuador. As part of this research a previous study has suggested that the taxon *T. baeops* is polyphyletic (Lee et al., 2011; Fig. 2). Here we use sequences from the cytochrome *b* gene to test the hypothesis that *T. baeops* is a single species. This study should provide insight into the evolutionary history of *Thomasomys* species of the region as well as help clarify identification of species.

Figure 1: Sangay National Park

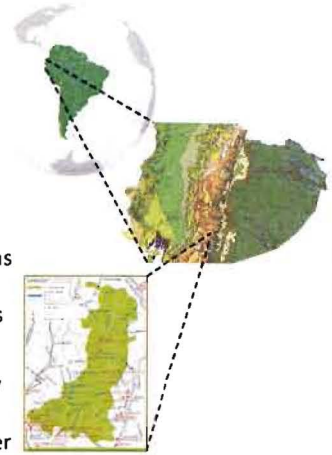
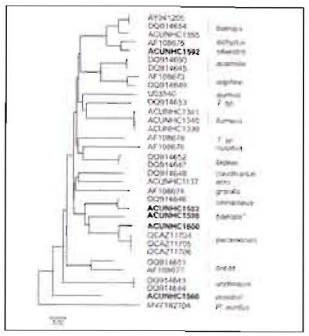
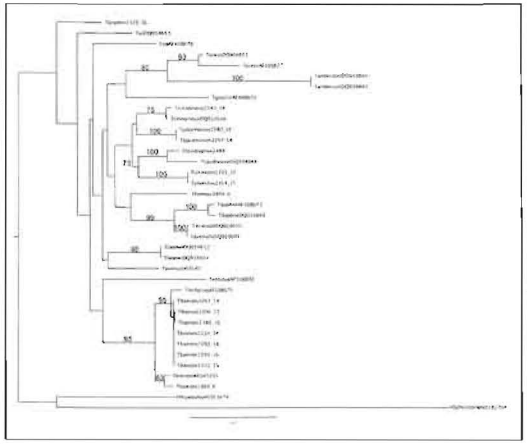


Figure 2: Neighbor joining tree Lee et al. (2011)



Results

Figure 3: The maximum likelihood (ML) tree based on cyt *b* sequences from accessions from the ACU Natural History Collection and GenBank. Boot strap values ≥ 70% are shown above internodes. Branch lengths are proportional to the number of substitutions per site (see scale bar). Tree is rooted with *Reithrodon* and *Rhipidamys* as outgroups.



Most species of *Thomasomys* in the tree are shown to be monophyletic, with the exception of *T. baeops*. A subclade of *T. baeops* is grouped together with *T. ischyurus* with a bootstrap value of 95. Note that the *T. baeops* specimens are otherwise all grouped together with a 85 bootstrap value.

The nodes at the species level are well resolved. However, the more deeply seated nodes joining multiple species into clades were not confident enough for display (≥70) bootstrap value. One notable exception is *T. silvestris* and *T. caudivarious*, which are grouped with a bootstrap of 73. These specimens were collected from the eastern slope and western slope of the Andes respectively.

Discussion

Findings in this study are generally consistent with taxonomic keys we are developing to describe rodent diversity in Ecuador based on previously published species descriptions (Voss, 2003). However, a previous study, suggested that *T. baeops* is not a monophyletic taxon, calling into question its status as a species. In this study, the clade that includes the *T. baeops* specimens also includes a specimen identified as *T. ischyurus* from northwestern Peru (Smith and Patton, 1999). The sequence data for the *T. ischyurus* specimen was collected from GenBank (AF108675). This reconstruction suggests that *T. baeops* might not be a monophyletic group and, thus, could represent more than one species. However, one other explanation is that the *T. ischyurus* specimen could have been misidentified. *Thomasomys ischyurus* is not known to occur in Ecuador, and we currently have no other *T. ischyurus* specimens for comparison. More specimens and additional analysis are needed for further investigation.

This study of the cyt *b* gene found that, while having more variation that is potentially useful in phylogenetic study, cyt *b* may also contain more homoplasy than nuclear genes (Koepfli, 2003). Homoplasy can negatively impact the resolution of the deeper nodes in a tree by disguising genetic variation and change, this provides poor support for deep branches in reconstructions, which makes testing hypothesis on speciation difficult (Koepfli, 2003). To account for these shortcomings, we are exploring *RAG1* (a nuclear gene) with the possibility of less homoplasy in order to get a more accurate estimation of the nodes more deeply seated in the tree.

One of the objectives of our broader research program is to understand diversification of mammalian groups in Ecuador. This work involves comparison of the geographic distributions of species on both the eastern and western slopes of the Andes. The Andes average height is approximately 4,000 meters, and these mountains are expected to represent a geographic barrier that affects speciation and the distribution of diversity (Graham et al. 2009). We expect that the Andes have also impacted the diversification of *Thomasomys*. For example, our current data suggest that *T. caudivorious* and *T. silvestris* are monophyletic. However, they found on different slopes of the Andes mountains. *Thomasomys caudivarious* was collected from the western slope of the Andes in the high paramo, while *T. silvestris* was collected in the cloud forest on the eastern slope. Even without the geographic barrier, the different habitats that the two organisms occupy can be important in the study of ecological diversity. The specimens themselves are very similar but can be distinguished by color (Fig. 4).

Figure 4: *Thomasomys caudivarious* shown on the left with a grey underbelly. *Thomasomys silvestris* is shown on right with a dark brown underbelly.

In order to address these questions, we will need determine the biogeographical history of the different species and their ancestors, which would require a fully resolved tree, especially with better resolution of the deeper nodes within the tree.

Methods

Molecular Systematics. We sampled the following: ***T. fumeus, T. cinnomeus, T. praetor, T. paramorum, T. silvestris,*** and ***T. baeops***. Specimens were collected from the Eastern slope of the Andes in the Sangay National park in Ecuador, with the exception of ***T. caudivarious*** from the western slope and samples taken from GenBank (accessions numbers listed in images, Fig. 2, Fig 3). Specimens in the field were collected using Sherman traps. Extraction and amplification for the genomic DNA were conducted using standard protocols (Hanson et al., 2010); polymerase chain reaction was used to amplify the complete 1183 base pairs (bp) of cyt *b* using the primers P484 and P485 (Steppan, 1999). Amplified DNA was cycle sequenced and sequenced by the DNA Analysis Facility at Yale University; sequences were edited using Sequencher version 4.10 (Gene Codes Corp., Ann Arbor, Michigan, USA) and aligned manually using SE-AL (v2.0a11; Rambaut 1996-2002). A neighbor-joining (NJ) tree was estimated with PAUP* v4.0b10 (Swofford, 2002) using all codon positions and complete deletion of gaps. Maximum likelihood (ML) analyses were performed using the RAxML program (Stamatakis, 2006) as implemented through the CIPRES web portal (http:// www.phylo.org/). Gaps were treated as missing data, and each codon position was treated as a separate partition, allowing GTR model parameters, branch lengths, and alpha parameter of the gamma distribution to be estimated independently for each codon position. The ML tree was chosen from the combined results of 1000 replicated searches. Bootstrap support values were estimated by 1000 ML bootstrap searches using search procedures above. Trees were rooted using *R. auritus* as an out-group.

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Acknowledgements

We thank Grayson Allred, Rebecca Hunter, Jennifer Huddleston, and Qiang Xu for assistance. Tissue samples were provided by the ACU Natural History Collection. Funding was provided by the Abilene Christian University Department of Biology.

ACU ABILENE CHRISTIAN UNIVERSITY

Estimation of the Paleoniche of *Mentzelia thompsonii* (Loasaceae)

Jonathan Stites, Emily Crain, Elizabeth V. Lurz, and Joshua Brokaw — Department of Biology, Abilene Christian University, Abilene, Texas 79699

Introduction

Population genetics, biogeography, and systematics are currently converging in the multidisciplinary field of evolutionary ecology (Nogués-Bravo 2009). Climate models have become a widely used tool to address evolutionary changes in ecology by projecting species' niches to different periods in the past.

Among the most useful tools that climate models allow within phylogeographical research are alternative hypotheses concerning past migration pathways. These predictions can then be tested by other variables such as genetic data and soil type (Nogués-Bravo 2009).

Mentzelia section *Trachyphytum* is a monophyletic group composed of approximately 20-30 annual plant species (Darlington 1934; Zavortink 1966; Brokaw and Hufford, 2010a; Brokaw and Hufford, 2010b). Section *Trachyphytum* is generally limited to areas of low competition such as recently disturbed or stressful environments. One of the most recently described species in this group is *M. thompsonii* (Figure 1), the only diploid species in section *Trachyphytum* to occur only outside California (Figure 2; Brokaw et al. 2011).

In a previous study, we determined the genetic distribution and isolation of populations of *M. thompsonii* in CO, NM, and UT. Here we use estimated paleoclimate data to propose a possible migration pattern of these mentzelias.

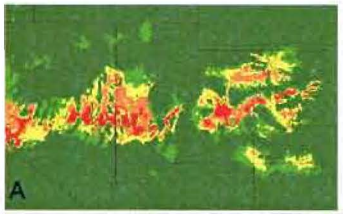
Fig 1. Arrows: *M. thompsonii*

Fig. 2. Distribution of *M. thompsonii* (red) and other diploids in *Mentzelia* section *Trachyphytum* (green).

Results

Compared to the true current distribution of *M. thompsonii*, the current estimated niche includes large areas of western Utah and Nevada where *M. thompsonii* is not known to occur (Fig. 4A).

Compared the estimated current climate niche, the estimated paleoniche shows the western half of the potential distribution of *M. thompsonii* shifted north to the Great Salt Lake region. However, most of the favorable habitat is located in the eastern distribution. In the eastern portion of the distribution much of the northern range is lost and the most southern part of the distribution has moved north and west in the paleoniche. In comparison to the current estimated niche, the middle area of the distribution has moved west and been broadened, and pushed further down the Colorado Valley in the paleoniche. Further, the Grand Canyon is a potential habitat only in the paleoniche (Figs. 4A & 4B).



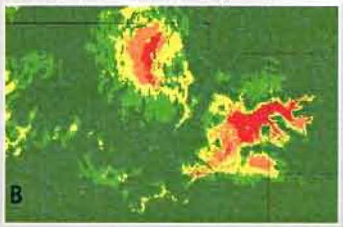


Fig. 4. A. Current potential distribution of *M. thompsonii*. B. Potential past distribution of *M. thompsonii*. The different colors indicate how likely the species would be found in that certain location based on climate alone. Red indicates areas in which the species would most likely thrive; whereas the green indicates locations with climates that are inappropriate for *M. thompsonii*. Small green circles represent current populations of M. thompsonii.

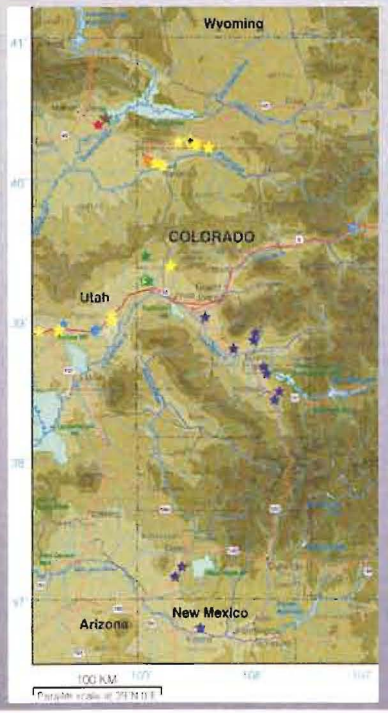


Fig. 3. Populations of *Mentzelia thompsonii* sampled from western Colorado, northwestern New Mexico and eastern Utah. Stars represent sample locations. Colors of stars match haplotypes. Stars with different fill and outline colors represent populations with two haplotypes.

Discussion

By analyzing the current and paleoclimate data, we are able to speculate where the past distribution of *M. thompsonii* could have been. However, in the current distribution model, there are potential sites where *M. thompsonii* has never been observed (Fig. 3). All spots west of the center of Utah are outside its current distribution. This discrepancy is likely due to specializing by *M. thompsonii* for calcareous soil types. To further this research, we need to examine the different types of soil in each of these regions to create more precise niche models. Thus, for the purposes of the current study, we focus on potential migration patterns in the eastern portions of the niche models that are consistent with the current distribution.

Based on our previous molecular study (Fig. 3), we can see that the populations south of the Colorado River all have the same haplotype, which is very genetically distinct from haplotypes of the northern populations. Why might there be low genetic variation in the southern populations? These populations are limited to the Gunnison River Valley and a disjunct range in the Four Corners region. It is likely that these populations somehow remained separated from those north of the Colorado River. However, within the Gunnison River Valley migration was not limited within that one region. This could have allowed one genetic type to take over. In contrast, the low diversity in the Four Corners region seem likely to have been caused by a founder effect due to a rare colonization from the Gunnison River Valley. This recent colonization is consistent with the lower availability of habitat in northern New Mexico in the paleoniche model.

In the more genetically diverse ranges north and west of the Colorado River, our paleoclimate model suggests that *M. thompsonii* has likely migrated northeast up the Colorado River Valley and north into northern Utah and Colorado. Our paleoniche estimate suggests that this portion of the range has remained large and geographically diverse throughout historical episodes of climate change, and this may explain the preservation of genetic diversity.

However, this experiment has still left us wondering why the plants on either side of the Colorado do not mix.

In a later experiment, we hope to analyze where these plants might be in the future based on soil typing and climate mapping.

Conclusions

- Our data suggest that north of the Colorado River *Mentzelia thompsonii* has been spread over a wide range with many disjunct populations, producing higher genetic diversity in that region.
- In contrast, the habitable range in the Gunnison River Valley seems to have been smaller and more homogenous in the past, explaining the low genetic diversity in that region.

Methods

Molecular Data

Tissue samples were collected from populations of *M. thompsonii* on the Colorado Plateau along the Colorado/Utah border and south to the Four Corners region and from herbarium specimens provided by the ACU, COLO, and WS herbaria (Figure 3). We sampled 1–15 individuals from a total of 29 locations to determine how closely related these plants are in order to create a more accurate migrational history.

Climate Data

We gathered current and paleoclimate data for the United States from the WorldClim database (http://www.worldclim.org/). We converted the WorldClim data into a readable ASCII format using DIVA-GIS (Hijmans et al., 2001) for creation of current and paleoniche models in Maxent (Phillips et al., 2004) based on the current distribution of populations of *M. thompsonii*. Maps of the estimated current and paleoniches were visualized using DIVA-GIS.

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Biology Research

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ABILENE CHRISTIAN UNIVERSITY

REQUEST TO ADD OR CHANGE *COURSE* FEES

Course fees or changes to existing course fees must be approved and published in the ACU Catalog for the following year in order for them to be assessed on a student's account. **Course fees which are not processed by February 1st will not be included in the fall catalog.**

Request Date 1 November 2013 Amount of Fee $50 per credit hour

Department Making Request Biology Contact Person Joshua Brokaw

Check the appropriate fee category below: Semester(s) applicable: F X, Spr X, May X, Sum X

X Fee is the same for every section and every student. Semester and year for fee to begin Fall 2014

___ Fee applies to certain sections only.

This request applies to the following course:

Course Number/Section	*Course Title*	*FOAP*
BIOL 399	Biology Research	100000 20720 60435 10

State the justification for your request below. You will be notified of final approval or denial.

This is an unusually diverse course requiring of variety of consumable supplies. See back page.

We request a laboratory fee of $50 per credit hour for this 1-3 hour course.

The following signatures must be obtained before any request is approved.

		Approved	Decline
X Thomas E Zell Department Chair	4 Nov 2013 Date	✓	
College Dean	Date		
Associate Provost	Date		
Vice President for Finance	Date		

If approved by all above, route to:

Controller	FOAP	Date Completed
Accounts Receivable	Fee Code for use on course	Date Completed
Registrar's Office		Date Completed

Copy to: Department making request

Course Fee Aprvl.3/4/05.RO

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November 11, 2010

Dr. Gregory Straughn, Dean
College of Arts and Sciences
Sherrod Building Rm 127
ACU Box 29210
Abilene, TX 79699-9210

Dear Dr. Straughn:

Please consider this application for the creation of Biology Research (BIOL 399) as a new course in the Department of Biology. I am seeking a signature for preliminary approval in section "V." of the ACU Application for a New Course.

Thank you for your consideration of this request. Questions can be directed to Joshua Brokaw at josh.brokaw@acu.edu or 325-674-2168.

Sincerely,

Joshua Brokaw, Assistant Professor, Biology