

ESE BS CONCENTRATION IN ASTROBIOLOGY AND BIOGEOSCIENCES

1. PURPOSE AND NATURE OF PROGRAM

Astrobiology is the study of the origins, evolution, distribution, and future of life in the universe. Biogeosciences focuses on the interaction of biological and geological processes on Earth at present and in the geologic past. These topics are closely related because the concepts of biogeoscience inform the study of planetary habitability and the search for habitable worlds. Therefore, the Astrobiology and Biogeoscience concentration is designed to offer students a strong foundation for exploring the interaction of geological and biological processes, how such interactions sustain life on Earth, and how they might operate on other planets. This scientific background is needed to contribute to the search for life on other planets as well as the exploration of extreme environments here on Earth. It also provides training in the interplay of forces that impact global change.

This concentration requires a strong foundation in math, chemistry, physics, geology and biology, which permits specialization through advanced courses in geosciences, astrophysics, and life sciences.

Exploration is a fundamentally interdisciplinary pursuit, especially when we investigate how planets like the Earth become habitable and continue to support life over the vastness of geologic time. Earth and Space Exploration undergraduates who major in the Astrobiology and Biogeosciences concentration will bring novel perspectives to the capstone exploration projects, which will complement the geologic, astrophysics and engineering skills of other participating students.

2. NEED AND DEMAND FOR THE PROGRAM

There is a growing public appreciation for how the interplay of geological and biological processes determines habitability. At the same time, NASA's highly publicized efforts in astrobiology have engendered a new curiosity about life in the universe. In response, student interest in astrobiology and biogeosciences in general is increasing. ASU is internationally recognized as a leading institution in the study of astrobiology, and we have had astrobiology and biogeosciences courses in our curriculum for many years. The field has now developed to the point that a concentration for the Earth & Space Exploration degree is warranted.

While there will be astrobiology jobs associated with space exploration, it is likely that there will be many opportunities for employment in other fields where a unified view of geological and biological processes is essential. These include the many facets of society impacted by global climate change, from direct involvement in research to emerging opportunities as businesses explore the potential of adopting sustainable practices. Human efforts to mitigate climate change will rely on fundamental understanding of how geology and biology work together to produce habitats.

ASU will be unique in offering a bachelor's degree program in astrobiology and biogeosciences. There are astrobiology minors offered at Penn State and Rensselaer, and one is planned to begin in Spring 2010 at the University of Arizona. Cal Tech offers an undergraduate degree in the related field of geobiology.

There is no other major offered in Arizona that takes planetary habitability as a fundamental focus. Deeper understanding of the links between geology and biology can lead to better solutions for many problems facing the world including the human response to climate change and re-thinking the sustainable use of resources.

useful link:

<http://astrobiology.nasa.gov/nai/education-and-outreach/astrobiology-career-path-suggestions>

3. LEARNING OUTCOMES AND ASSESSMENT

- A. **List the knowledge, competencies, and skills** students should have when they graduate from the proposed degree program. (You can find examples of program Learning Outcomes at (<http://www.asu.edu/oue/assessment.html>))

Competencies

- Reduce complex problems to their most important attributes; and design and carry out experiments, models, or observations that address these attributes.
- Capacity for critical thinking regarding scientific and engineering problems and findings
- Ability to work collegially, fairly, and effectively in groups on relevant projects.
- Ability to use technology effectively in learning and research.
- Capacity for informal and formal communication of science concepts through various media (writing, graphics, oral presentations).

Knowledge Outcomes

- Physical and chemical nature of materials that make up the universe, galaxies, stars, planets, and the Earth.
- Internal and external forces and processes that shape the Earth and planets.
- Current theories on the origin of life and the nature of biological and planetary evolution and the fundamental biogeochemical principals and processes that control them.
- Principles of planetary habitability.
- Interpretation of planetary history from the rock record.
- Supporting concepts of biology, chemistry, geoscience, physics, and mathematics.

Skills Outcomes

- Observe and measure relevant aspects of biogeochemical systems.

- Integrate geological and biological data and processes. Design and execute experiments to test biogeochemical hypotheses.
- Integrate science and engineering in a capstone project.
- Preparation to progress to professional positions or to graduate studies.

B. Describe the plan and methods to assess whether students have achieved the knowledge, competencies and skills identified in the Learning Outcomes. (You can find examples of assessment methods at (<http://www.asu.edu/oue/assessment.html>))

Student *Formative* Assessment Metric

- Quality of sample of work completed in milestone course SES 311 Essentials of Astrobiology.

Student *Summative* Assessment Metric

- Quality of work and effectiveness of integration of science and technology in the completed Senior Exploration Project (SES 410/411).

Program Assessment Metrics

- Track career trajectories of graduates for 10 years.
- Annually review quality and effectiveness of capstone course(s) in integrating overall features of the degree program.

4. REQUIREMENTS FOR THE MAJOR

A. SPECIFIC LIST OF COURSES REQUIRED

The BS degree in Earth and Space Exploration, Concentration in Astrobiology & Biogeosciences requires the following core courses (**20 units**):

SES 100 Introduction to Exploration (3)

¹SES 101 Earth, Solar System, and Universe I (3)

¹SES 102 Earth, Solar System, and Universe II (3)

¹SES 103 Earth, Solar System, and Universe Laboratory I (1)

¹SES 104 Earth, Solar System, and Universe Laboratory II (1)

SES 311 Essentials of Astrobiology (3)

GLG 321 Mineralogy (3)

GLG 481 Geochemistry (3)

¹GLG 101-104 or AST 111-114 may be substituted for SES 101-104 with advisor approval

²Both GLG 101 and 103 must be taken to secure SQ credit.

³Both GLG 102 and 104 must be taken to secure SG credit.

In addition, **two** upper division electives from AST/GLG/SES and **6 units of capstone** SES 410/411 (3/3). Select from of the following or substitute with advisor approval (**12**):

SES 310 Concepts of Elec. and Mech. Engin. Design (3)

GLG 404 Fund. Of Planetary Sci (3)

GLG 430 Paleontology (3)

GLG 435 Sedimentology (3)
GLG 460 Astrobiology (3)
GLG 461 Geomicrobiology (3)
GLG 485 Meteorites and Cosmochemistry (3)
GLG 490 Topics in Geology: Remote Sensing
GLG 490 Field Geochemistry
GLG 490/581 Isotope Geochemistry
AST 321 Intro of Planetary and Stellar Astrophys
BIO 320 Fundamentals of Ecology
BIO 340 General Genetics
BIO 345 Organic Evolution

Required courses in other related fields include the following (**33 units**):

BIO 187 General Biology I (4)
BIO 188 General Biology II (4)
CHM 113 General Chemistry I SQ (4)
CHM 116 General Chemistry II SQ (4)
MAT 265 Calculus for Engineers I (3)
MAT 266 Calculus for Engineers II (3)
MAT 267 Calculus for Engineers III (3) or MAT 275 Modern Differential Equations (3)
PHY 121 University Physics I: Mechanics SQ¹ (3)
PHY 122 University Physics Laboratory I SQ¹ (1)
PHY 131 University Physics II: Electricity and Magnetism SQ² (3)
PHY 132 University Physics Laboratory II SQ² (1)

¹Both PHY 121 and 122 must be taken to secure SQ credit.

²Both PHY 131 and 132 must be taken to secure SQ credit.

Total: 65 units

B. MAJOR MAP

See Attached for revised BS in ESE concentration in Astrobiology and Biogeosciences Major Map – end of this section.

5. REQUIRED NEW COURSES

None are required for the BS in ESE with concentration in Astrobiology and Biogeosciences

6. PRIMARY FACULTY PARTICIPANTS

SESE faculty for core classes. Electives specific to this concentration: Anbar, Christensen, Desch, Farmer, Greeley, Hartnett, Knauth, Malhotra, Rhoads, Robinson, Scannapieco, Sharp, Shock, Starrfield, Timmes, Wadhwa, Windhorst, Young, Zolotov.

7. MINIMUM RESIDENCY REQUIREMENT

30 units.

Critical Requirements: Students who follow the 20__-20__ catalog year and are entering ASU as either a first-time freshman or transfer from any Arizona public university or Arizona community college must complete critical requirements.

School of Earth and Space Exploration, Tempe Campus
Catalog Year: 20__-20__

Critical Courses in Grey

Course Subject and Title	Critical Course	Hrs.	Completed ATP: ___ Yes ___ No			Completed AGECC: ___ Yes ___ No
			Upper Division	Transfer Course/Grade	Minimum Grade if Required	Additional Critical Requirements and/or Notes
TERM ONE: 0-15 CREDIT HOURS						
CHM 113: General Chemistry I (SQ)	<input checked="" type="checkbox"/>	4	<input type="checkbox"/>			Grade of C or better
SES 100: Introduction to Exploration	<input checked="" type="checkbox"/>	3	<input type="checkbox"/>			Grade of C or better
SES 101/103: Earth, Solar System, Universe I/Laboratory	<input type="checkbox"/>	4				Grade of C or better
ENG 101 or 102: First-Year Composition or ENG 105: Advanced First-Year Composition or ENG 107 or 108: English for Foreign Students	<input type="checkbox"/>	3	<input type="checkbox"/>			Grade of C or better
MAT 170 (if necessary) or elective	<input type="checkbox"/>	3	<input type="checkbox"/>			
Academic Success Class or First Year Seminar		1				
TERM TWO: 16-30 CREDIT HOURS						
CHM 116: General Chemistry II (SQ)	<input checked="" type="checkbox"/>	4	<input type="checkbox"/>			Grade of C or better
MAT 265: Calculus with Analytic Geometry I (MA)	<input checked="" type="checkbox"/>	3	<input type="checkbox"/>			Grade of C or better
SES 102/104: Earth, Solar System, Universe II/Laboratory	<input type="checkbox"/>	4	<input type="checkbox"/>			Grade of C or better
ENG 101 or 102: First-Year Composition or ENG 105: Advanced First-Year Composition or ENG 107 or 108: English for Foreign Students	<input type="checkbox"/>	3	<input type="checkbox"/>			Grade of C or better
TERM THREE: 31-45 CREDIT HOURS						
GLG 321 Mineralogy	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			Grade of C or better
MAT 266: Calculus with Analytic Geometry II	<input checked="" type="checkbox"/>	3	<input type="checkbox"/>			Grade of C or better
BIO 187 General Biology I	<input type="checkbox"/>	3	<input type="checkbox"/>			Grade of C or better
Humanities, Fine Arts & Design (HU) and Cultural Diversity in the US (C), Global Awareness (G), or Historical Awareness (H)	<input type="checkbox"/>	3	<input type="checkbox"/>			
Literacy and Critical Inquiry (L)	<input type="checkbox"/>	3	<input type="checkbox"/>			
TERM FOUR: 46-60 CREDIT HOURS						
PHY 121/122: University Physics I/Laboratory	<input checked="" type="checkbox"/>	4	<input type="checkbox"/>			Grade of C or better
SES 311 Essentials of Astrobiology	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			Grade of C or better
MAT 267: Calculus with Analytic Geometry III OR MAT 275 Modern Differential Equations	<input type="checkbox"/>	3	<input type="checkbox"/>			Grade of C or better
BIO 188 General Biology II	<input type="checkbox"/>	3	<input type="checkbox"/>			Grade of C or better
Social & Behavioral Science (SB) and Cultural Diversity in the US (C), Global Awareness (G), or Historical Awareness (H)	<input type="checkbox"/>	3	<input type="checkbox"/>			
TERM FIVE: 61-75 CREDIT HOURS						
AST/GLG/SES Elective	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			Grade of C or better

PHY 131/132: University Physics II/Laboratory	<input type="checkbox"/>	3	<input type="checkbox"/>		Grade of C or better
Computer/Statistics/Quantitative applications (CS)	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>		
Social & Behavioral Sciences (SB) and Cultural Diversity in the US (C), Global Awareness (G), or Historical Awareness (H)	<input type="checkbox"/>	3	<input type="checkbox"/>		
Upper division General Elective	<input type="checkbox"/>	3	<input type="checkbox"/>		
TERM SIX: 76-90 CREDIT HOURS					
GLG 481 Geochemistry	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>		Grade of C or better
AST/GLG/SES Elective	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>		Grade of C or better
CLAS Science and Society	<input type="checkbox"/>	3	<input type="checkbox"/>		Grade of C or better
Upper Division Literacy and Critical Inquiry (L)	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>		
Humanities, Fine Arts & Design (HU)	<input type="checkbox"/>	3	<input type="checkbox"/>		
TERM SEVEN: 91-105 CREDIT HOURS					
SES 410: Senior Design Project I	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>		Grade of C or better
Computer/Statistics/Quantitative applications (CS)	<input type="checkbox"/>	3	<input type="checkbox"/>		
Upper division Humanities, Fine Arts & Design (HU) or Social Behavioral Science (SB)	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>		
Upper division CLAS Science & Society	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>		Grade of C or better
Upper division General Elective	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>		
TERM EIGHT: 106-120 CREDIT HOURS					
SES 411: Senior Design Project II	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>		Grade of C or better
Upper division General Elective	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>		
Upper division General Elective	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>		
Upper division General Elective	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>		

Graduation Requirements Summary:

Total Hours (120 minimum)	Total Hrs at ASU (30 hour minimum)	Hrs Resident Credit required for Academic Recognition (56)	Major GPA (2.000 minimum)	Total UD Hrs (45 minimum)	Total Community College Hrs. (64 maximum)
120					

General University Requirements: Legend

- General Studies Core Requirements:
 - Literacy and Critical Inquiry (L)
 - Mathematical Studies (MA)
 - Computer/Statistics/Quantitative applications (CS)
 - Humanities, Fine Arts, and Design (HU)
 - Social and Behavioral Sciences (SB)
 - Natural Science-Quantitative (SQ)
 - Natural Science-General (SG)
- General Studies Awareness Requirements
 - Cultural Diversity in the US (C)
 - Global Awareness (G)
 - Historical Awareness (H)
- First Year Composition

Additional Notes:

- There is room in this map to add a concurrent degree, minor, or certificate