GEL 53 Introduction to Geobiology - Course Syllabus Instructor: Prof. Dawn Sumner TA: Sarah King

Welcome to Geobiology! In this class, we will explore life on Earth with a focus on how biological and geological processes are entwined. We will study feedbacks and interaction styles, how life on Earth functions, evolution, and ecology, and how several billion years of interactions have shaped both us and our planet. As an instructor, I will focus on helping you learn how to approach understanding life on Earth as a scientist who understands processes. My goal is for you to effectively apply your understanding of geobiology to a final project, consisting of a science-based game or portfolio representing what you accomplish in the quarter.

Accommodations and Professional Behavior

This class will be in person with the understanding that there may be times any of us can't attend due to COVID-related (or other) issues. I have designed the class to be collaborative but also possible to follow along remotely as required. I am willing to work with each of you to help you succeed. Please, please, please feel free to ask me for accommodations for your personal circumstances as needed. I will not ask for explanations beyond what I need to know to help you, and I will not ask for documentation. I trust you. In return, I request that each person abides by the UCD principles of community. In addition, I expect professional behavior from myself, Sarah King (the TA), and each of you. Professional conduct includes contributing to the goals associated with each activity, treating others with respect at all times, and being considerate of how your actions affect others. There are two documents posted in Canvas that describe professional behavior. We need to act professionally in our learning and working environments. And we can have fun while doing so.

A Learning Community with a Growth Mentality

It is really important that we build a learning community for class given that we have faced a number of unprecedented challenges in the last 2 years. With the extra challenges we are facing, it is even more important than normal to do our best to maintain our mental wellness. UCD has a number of resources that can help:

- Mental Wellness Resources
- Racial Trauma Resources
- <u>Campus Coronavirus Information</u>

This is a time like no other in human history. By recognizing the challenges we are facing, discussing them openly as appropriate, and focusing on learning, we can build resilience and grow as individuals and as a community learning together. Communities are more resilient than individuals (as well see from the ecology parts of this class!), particularly diverse communities where each member shares their strengths and knowledge with the group. I'm looking forward to working with you this quarter.

Course Structure

The course materials are designed to give you a basic understanding of biology in the context of Earth at a level that is appropriate for Geology Majors (and other majors are also welcome!). My overall learning goals for each of you are described in the Outcomes section of Canvas and at the bottom of this document. They emphasize the importance of interactions, what life is, evolution, ecology, and biogeochemistry as 5 "units". We will cover this material in about the first 7 weeks of the quarter. These units will be covered using pre-recorded videos, online reading, and in-class discussions and games, as well as homework questions. The last few weeks will be dedicated to diving more deeply into topics of specific interest and applying them in your final projects.

Detailed Course Structure: Scheduled class times will focus on interactive activities that will help deepen your understanding of the course Outcome materials. They will include answering questions about the materials, discussing ideas in small groups, playing games relevant to the learning goals, analyzing game play in terms of scientific concepts, and brainstorming ideas for new games and projects. If you cannot make it to class, it is possible for you to learn the material from asynchronous resources, but it will be very important to keep in touch with me and Sarah with respect to your progress in the class.

The course is structured around helping you master the course learning goals described in the Outcomes section of Canvas. Each Outcome will have associated links to videos, reading, game instructions, additional materials, and homework questions. The homework questions are designed to allow you to demonstrate your understanding of the Outcome content and will be graded as:

Redo	(not relevant to the question)
Progressing	(partially correct but key item(s) missing or wrong)
Competent	(demonstrates a good understanding)
Proficient	(explains how the concept is relevant to an example)

Comments will be provided about what is missing or wrong and what you have done well. You will have two opportunities to revise your homework to demonstrate your understanding. These opportunities can be either written or oral, your choice.

To demonstrate a deep understanding of course Outcomes, you will apply your understanding of the concepts to the development of a science-based game for people to play or to a mini-research portfolio. These can be group projects, and each has assignments to help guide you to a strong outcome. In the past, the games have been really fun to develop and play. Project assignments will be graded as redo, progressing, or meets expectations for a deep understanding for a particular Outcome, and you will have multiple opportunities to demonstrate a deep understanding of any given Outcome.

Grading: Your grade will be based on your demonstrated understanding of the learning goals represented in the 10 Outcomes. We will be using an alternative grading method to both help keep your workload down and facilitate a deep learning process. This grading method focuses on the level of understanding an answer demonstrates rather than a partial credit system for how much is correct. For this class, once you demonstrate a certain level of understanding, you do not need to demonstrate it again and you know to concentrate your time on learning other concepts. Your grade will be based on the number Outcomes you demonstrate that you have a given level of understanding. Levels of demonstrated understanding will be marked as competent, proficient and deep. If you demonstrate proficiency, you will also have demonstrated competency, and deep understanding also demonstrated proficiency and competency.

	Level of Understanding			
Grade:	Competent	Proficient	Applied	
D	8	2	1	
С	9	5	2	
В	All 10	8	3	
A	All 10	All 10	5	

Each grade requires obtaining the following number of competent, proficient, and deep understanding outcomes through the homework questions and the final projects. In addition, passing requires that you demonstrate progress toward becoming a scientist. These criteria include:

- 1. At least 3 demonstrations of a growth mentality by revising work, asking scientific questions in class or office hours, or applying your knowledge.
- 2. At least 3 collaborative activities, including playing games together in class or working in a group.
- 3. At least 3 demonstrations of clear communication in your assignments. This consists of assignments with effective flow in the logic of what you are saying as well as sufficient detail to allow anyone in the Earth and Planetary Sciences Department to understand the science you are discussing, including undergraduates who have not taken this class.

Responding to the questions for the 5 Scientist Spotlights and pre/post surveys in a way that shows you read about their life path as a scientist will earn you a '+' on your grade.

One of the advantages of this grading approach is that you can evaluate where you are in your progress toward the grade you wish to earn. Each time you demonstrate competency, proficiency, or application of an Outcome, you have that credit in the "bank" toward your grade. In addition, if you demonstrate proficiency or apply an Outcome, you automatically demonstrate the lower levels of understanding. Thus, if you miss an assignment, you can apply the topic as applied to the game to receive full credit. I recognize that this grading system is probably new to you. I hope that it will help you demonstrate what you have learned with less work overall.

Communications

I use the UCDavis e-mail class lists and Announcements section of Canvas for official class communication as well as help with homework, clarifications on lecture material, and answers to student questions that I think will be of general interest. Please read these messages. Also, please send me class-related emails through Canvas because I can then tell that I need to pay attention to them. (I get hundreds of email messages a day!)

Collaboration

I encourage you to talk about the class lectures and homework with your fellow students because that increases understanding. In addition, there is the option for group work for game projects. With collaboration, it is important to keep the focus on learning. Each student must do and turn in their own work unless it is a group assignment. Doing this work will help you learn the material. If you have any doubts about whether a particular collaboration is allowed, ask yourself, "Does what we're doing improve the understanding of all of us?" If the answer is yes, it's probably allowed. Or if the answer to "Would someone benefit more if they did the work by themselves?" is yes, then it probably isn't a good collaboration. Please ask me if you are in doubt!

Learning Outcomes

1 Feedbacks and Interactions

Life requires interactions at all levels from elements to the scale of the Earth and the Sun. Many of these interactions amplify or dampen changes, leading to changes and stability for Earth's environments and ecosystems. We tend to think about competition, but life also has many mutualistic relationships. Understanding how these relationships affect organisms, evolution, ecology, and Earth is a major focus of this class.

Students are expected to demonstrate an understanding of the basic types of feedbacks and interactions in the context of who benefits and how changes are amplified or dampened.

1.1 Feedbacks

Interactions among organisms and processes can lead to change or stability. If there is a small change in something and an interaction increases the change, we say that it is an amplifying or positive feedback. In contrast, interactions can work against the change, providing a dampening or negative feedback. Amplifying and dampening feedbacks structure ecosystems and environments on Earth.

- Competent: Describe how feedbacks can amplify or dampen changes and the different outcomes between the two.
- Proficient: Explain examples of an amplifying and a dampening feedback from the natural world.
- Deep: Apply your understanding of amplifying and dampening feedbacks to your game or portfolio development in one of the game/portfolio assignments.

1.2 Interaction Types

Organisms interact with in different ways, often with benefits or costs, but sometimes neutrally. Types of interactions can be defined by the cost/benefit distribution and include: Neutralism, Mutualism, Commensalism, Amensalism, Competition, Predation, and Parasitism. There are others as well - nature does not always categorize well!

Competent: Describe how mutualistic, neutral, competitive, predation, and parasitic interactions among organisms vary in the benefits and costs to each participant.

- Proficient: Explain examples of mutualistic, neutral, competitive, and exploitive interaction types from the natural world.
- Deep: Apply your understanding of at least three of these interaction types to your game or portfolio development in one of the game/portfolio assignments.

2 Life Functions

Life as we know it is maintained by chemical reactions that use resources to build bodies, perform actions, and reproduce. We think that there are some universal features that all life likely has as well as a number of things we think life anywhere requires. These features and requirements are implemented by life on Earth in a very specific way with DNA, many other organic molecules, and innumerable processes shaped by our specific evolutionary history.

Students are expected to demonstrate their knowledge of the characteristics and requirements for life, why we think they might be universal for all life, how some of these characteristics are implemented by life on Earth, specifically the links between genes, enzymes and an organism's function.

2.1 Universal Features and Needs

We only know of life on Earth, and we study that life to understand what differentiates living from non-living things. Sometimes the distinction is ambiguous, particularly when we consider the search for life elsewhere in the Universe. And also when we think about viruses.

- Competent: Describe five universal characteristics of life and the three most fundamental needs. Include why each is important for life.
- Proficient: Explain why these features are necessary for life (as we define it). OR Explain how these features structure our search for evidence of life elsewhere in the universe.Deep: Apply several features of life and its requirements to your game or portfolio development in one of the game/portfolio assignments.

2.2 Implementation of Life on Earth

Life on Earth has a very specific evolutionary history shaped by the successful reproduction of organisms that passed on information on how to perform the organic chemistry to live successfully. Through billions of years, life has evolved suites of reactions that allow us to function. We – and all life on Earth – represent a specific implementation of life.

- Competent: Describe the process going from genetic information to enzymes. Include about 5 steps.
- Proficient: Explain an example set of conditions that influence which enzymes get produced.
- Mastered: Apply your understanding of connections between genetics and function to your game or portfolio development in one of the game/portfolio assignments.

3 Evolution

Evolution requires inheritance, variation, selection, and time. The inheritance, facilitated by DNA, allows successful variations to be preserved and passed on to future generations. The "success" of variations depends on how well they help an organism reproduce in its environment. Over time, selection acts on populations of organisms, amplifying those variations than make organisms more functional in their environment.

Students are expected to be able to connect variations in the functions of organisms to their genomes, explain how genomes change through time and result in new types of organisms, and how interactions and feedbacks affect the fitness of organisms and thus natural selection.

3.1 Variations in Function

Variations in organisms emerge from differences in genes and gene expression. Differences in genetic content emerge from a number of different processes. In addition, gene expression varies. Both the genetic content and the use of those genes by an organism affect its function.

- Competent: Describe how genomes in lineages of life can change and cause variations in function.
- Proficient: Explain how variations in function or morphology of an example lineage of organisms has changed through time due to mutations and/or variations in gene expression.
- Deep: Apply your understanding of realistic causes in variations in function to your game or portfolio development in one of the game/portfolio assignments.

3.2 Selection Based on Function

Some organisms function better than others in specific environments. The variations among organisms only become selected for or against if they affect how an organism functions. Not all variations affect function, and those that do can be selected for or against based on whether they increase or decrease an organism's rate of reproduction and survival of offspring.

Competent: Describe how natural selection leads to changes in a lineage of organisms through time.

Proficient: Explain how interactions among organisms can affect natural selection. Deep: Apply your understanding of at least three interaction types to your game or portfolio development in one of the game/portfolio assignments.

4 Ecology

Organisms all interact with each other, creating ecosystems with various interactions and feedbacks. These ecosystem interactions shape opportunities and challenges for organisms and thus influence their fitness and, on longer time scales, their evolution. Ecosystems also evolve, in the communities present, interactions among organisms, and geological processes.

Students are expected to know how ecosystems are supported, how interactions within ecosystems influence the fitness of different organisms, how these interactions create feedbacks that are critical to ecosystem functions, and ways in which ecosystems can change through time.

4.1 Fitness Depends on Ecology

Different organisms have different fitness in different environments and ecosystems. Photosynthesis provides the basic chemical energy for almost all ecosystems on Earth, but it does not happen in the dark. Most other organisms need "food" to eat and depend on the ecosystem to provide it. Many organisms are at risk of being eaten or dying if their needs are not met. The fitness of an organism depends on the intersection of its needs with what is available.

- Competent: Describe how organisms depend on primary productivity and each other to survive.
- Proficient: Explain how the fitness of a specific organism varies in three ecosystems with different organisms present.
- Deep: Apply your understanding of how fitness varies with the ecosystem to your game or portfolio development in one of the game/portfolio assignments.

4.2 Community Complexity and Resilience

Ecosystems consist of communities of organisms that interact to provide each others' needs, with amplifying and dampening feedbacks. The complexity of interactions and how they are structured affects whether an ecosystem is stable or changing, whether it is resilient to change (strong dampening feedbacks) or poised to transform into something new (strong amplifying feedbacks).

- Competent: Describe how and why the complexity of an ecosystem changes through time from colonization of a new landscape to a mature state.
- Proficient: Explain why more complexity in an ecosystem makes it more adaptable to change.
- Deep: Apply your understanding of ecological interactions to your game or portfolio development in one of the game/portfolio assignments.

5 Earth-Life Interactions

Earth (and the Sun) provide the resources critical for life, and biological processes influence all aspects of Earth's surface as well as some aspects of its interior (like the composition of crustal rocks). The interactions among geological and biological processes have shaped evolution and transformed Earth's surface. There is no separating the histories of life and Earth – they are deeply entwined.

Students are expected to understand the connections between biological metabolism and geochemistry with specific reference to O_2 and the carbon cycle. They will demonstrate how interactions and feedbacks shape Earth's surface chemistry with various reservoirs and fluxes.

5.1 Organisms as Agents of Geochemical Change

Photosynthesis converts light energy into chemical energy by producing organic compounds and molecular oxygen (or other oxidized species). Other metabolisms extract energy from chemical reactions that release energy. All of these reactions influence the chemistry of their environment and thus local to global geochemistry.

- Competent: Describe how metabolism depends on and influences environmental chemistry (B1).
- Proficient: Explain the biological and geological feedbacks (A1) that allowed oxygenic photosynthesis to change the oxidation state of Earth's surface.
- Deep: Apply your understanding of requirements and effects of metabolism to your game or portfolio development in one of the game/portfolio assignments.

5.2 Carbon Cycle - Earth's Core to Life

Earth's carbon cycle is dominated by life. Life catalyzes transformations of carbon among inorganic ions (carbon dioxide, methane, etc.), organic molecules, and carbonate rocks, with geological processes providing long-term boundary conditions on the carbon cycle. Feedbacks among these processes are critical for stabilizing Earth's climate.

- Competent: Describe the carbon cycle from the core to life's metabolism. You can draw your own image of the cycle if you wish, rather than only using words. Include: 1) Earth's interior convection, metamorphism and tectonics; 2) weathering, carbonate mineral formation, and burial of organic carbon; 3) primary productivity, respiration/fermentation, and other biological transformations of carbon. Include how much carbon is in the atmosphere, oceans, biosphere, crust, mantle, and core.
 Proficient: Explain how the various fluxes and time scales in the carbon cycle lead to amplifying and dampening feedbacks at different time scales.
- Deep: Apply your understanding of the dynamics of the carbon cycle to your game or portfolio development in one of the game/portfolio assignments.

Being a Scientist

Being a scientist is more than accumulating technical knowledge. It includes asking questions about how things work and why things work they way they do. It requires you to make connections between observations, experiments, and theory. Science when we build communities where we learn from and teach others, share and listen to multiple perspectives and ideas, and work toward a deeper understanding together.

To help you develop these skills, there are three classes of activities you will need to take part in to demonstrate your growth as a scientist. They include having a growth mentality (e.g. demonstrating a desire to learn and apply your knowledge), effective collaboration with other students, and clear communication in your demonstration of mastery of some of the scientific concepts.

Clear Communication

Activities that demonstrate "mastery" for scientific concepts clearly communicate the concepts to an appropriate audience, in addition to applying the concepts in a scientifically appropriate way.

Effective Collaboration

1. Work with others in small groups during class, learning from them and helping them learn. 2. Either work with a group to create a game or provide peer reviews of game rules to those working in a group.

Growth Mentality

To demonstrate a growth mentality, during the quarter, we expect you to:

- 1. Explore ideas that interest you, documented in your choices of examples of the concepts.
- 2. Revise your work and improve your understanding over the course of the quarter.
- 3. Apply your knowledge in a creative way through development of a game or a portfolio.