Biodiversity

Course: EEEB W1001x
Meeting: MW, 2:40-3:55 pm

Instructor: Don J. Melnick
Room: 717 Hamilton

Course Catalogue Blurb:

The Earth's biological diversity is declining. Many believe we need to stem that decline. In this course, we will use genetics, evolutionary biology, and ecology to address three simple questions: What is biological diversity? Where can we find it? How can we conserve it? Limited prior knowledge of science or mathematics is assumed.

Introduction:

Much has been made of both the decline in biological diversity and the need to conserve it. However, to conserve biodiversity, one must first understand it; what it is, where it is, and how it responds to disturbance and protection. This introductory course for non-science majors is meant to do just that – introduce you, the student, to the genetic, evolutionary, and ecological processes that gave rise to the diversity we find on Earth today.

To qualify as a "science for non-science majors course," I believe a course should impart to all who enroll in it (a) a coherent body of scientific knowledge; (b) an understanding of hypothesis testing and deductive reasoning; and (c) a minimal facility with the quantitative reasoning necessary to follow a scientific argument. Should all students completing this course be able to independently develop a hypothesis, collect the necessary data, and then use a statistical model to test that hypothesis? No. But they should be able to follow a description of a study that has done just that.

<u>A Body of Scientific Knowledge</u>. We will look at biological diversity at three major levels; Genes, Species, and Ecosystems. At each level, we will examine what processes are involved in creating, maintaining, and distributing that diversity in time and space. We will also make a detailed assessment of where the existing diversity is and why we find it there.

In essence, this course is an introduction to the disciplines of genetics, evolutionary biology, and ecology. However, rather than providing an abstract exposure to these fields, we will instead have an overarching goal for understanding them – learning the magnitude, distribution, and inter-relationships of biological diversity at all levels.

My ultimate goal is to sensitize you to the natural world around you and to get you to think about the interrelationships of genes, species, and ecosystems. Once you understand these interrelationships, you will be ready to understand why disrupting them has the effects that it seems to have.

Hypothesis Testing. The fields of genetics, evolutionary biology, and ecology are largely inductive – one doesn't test *a priori* hypotheses as much as carefully describe natural phenomena. However, whenever possible, we will examine examples of experimentation and hypothesis testing. The most successful of these are "natural experiments" that predict certain patterns in a natural system (e.g. level of genetic difference between populations) based on the theory of the effects of certain processes (e.g. random genetic drift and its impact on the differentiation of populations of different sizes) and then seek to test those predictions by collecting data on real organisms. These are the kinds of examples you and I will work through.

Quantitative Reasoning. To examine experimental data and test hypotheses and predictions, a minimum of quantitative reasoning will be required. I will not assume that any of you already have these skills, but will instead teach you how to work through simple algebraic formulations to develop a set of expectations and to perform simple statistical tests to see whether the observations (i.e. the data) from an experiment are close enough to the expectations to corroborate the hypothesis and support the theory behind it. This sounds tough, but it is really quite easy and satisfying once you know how to do it.

The Follow-Up. It is my intention to give every one of you the background and skills necessary to go on and take a course on the conservation of biological diversity. Once you know how systems work, you will be able to look in greater detail into how they react to human induced disturbance and stress. To make the connection between biodiversity and its conservation for non-science majors, we have linked this course (EEEB W1001: Biodiversity) with EEEB W3087: Conservation Biology. If you take these two courses, they will both count toward your overall "science for non-science majors" requirement. The first semester will be focused on the biological diversity itself, and the second semester will focus on conserving that diversity.

Now, I know that higher motives have led you to EEEB 1001: Biodiversity, so you can consider the above an added bonus. Should you be worried about taking a 3000-level course as the second part of a sequence on Biodiversity, you need not worry any longer. Conservation Biology will be taught at a level accessible to non-science majors who have already taken EEEB 1001. For you, the second course will have a 1000-level designation. For science majors, additional practical exercises and instruction will be required rendering it a course at the 3000 level. Hence, there will be an additional meeting each week for science majors.

One final possibility. If you truly become interested in the field of environmental biology or biodiversity studies, we have developed a 6-credit summer course called Summer Ecosystem Experiences for Undergraduates (SEE-U). If you even think you will be interested in SEE-U for the summer of 2009, please inquire now on the 10th floor of Schermerhorn Extension. SEE-U is a unique intensive exposure to ecology in tropical forests of Brazil, marine environments of the Dominican Republic, or temperate forests of New York state. You will live and work in one of these ecosystems for five weeks, learn a great deal about it, and even conduct your own research project.

Syllabus:

Part I: Why?

Lecture 1 – September 9 – What's in it for Me? – Why we should all care about conserving nature.

In this lecture, I will offer a personal view of the current crisis of biodiversity loss and **why** we should be concerned about this decline, even if we ourselves feel neither an affinity nor affection for nature and its abundantly diverse organisms. This is the last time I will talk about biodiversity conservation until the end of the course (see the **How** section below).

Part II: What?

In order to conserve biological diversity, we have to first know what it is. That is, we need to define the units on which we will focus our conservation efforts. This part of the course represents the engine that will drive our understanding of where the diversity is and how we can conserve it.

A. <u>Gene Level</u>

The fundamental level of all biological diversity is genetic. Genetic diversity underlies how an organism looks and behaves, which in turn provides the variation upon which natural selection acts. Knowing what genetic diversity is and how it is regulated is thus critically important.

Lecture 2 – September 14 – What is the "Mechanical" Basis of Genetic Diversity? – Mendel and the Mechanics of Heredity.

Lecture 3 – September 16 – What is the Cellular Basis of Genetic Diversity? – Genes, Chromosomes, and Mendelian Inheritance.

Lecture 4 – September 21 – What is the Molecular Basis of Genetic Diversity? – The Chemical Structure of Hereditary Material.

Lecture 5 – September 23 – What drives Genetic Diversity in Populations? – Sources and Measures of Genetic Diversity.

September 28 – Yom Kippur – No Class.

Lecture 6 – September 30 – What drives Genetic Diversity in Populations? – Mating, Population Subdivision, and Population Size.

Lecture 7 – October 5 – What drives Genetic Diversity in Populations? - Mutation, Migration, and Natural Selection

B. Species Level

Most conservation action and environmental legislation is focused on species. Beyond the gene and the organism itself, it is these groupings that we most readily recognize – we can all tell a dog from a cat, a canary from a turtle. But does the term species have a more exact definition? Does everyone agree on that definition? How are species formed? This set of lectures will focus on these critical issues.

Lecture 8 – October 7 – Darwin and the Theory of Evolution

Lecture 9 – October 12 – Darwin, Evolution, and the Origin of Species

Lecture 10 – October 14 – How are Species Formed?

Lecture 11 – October 19 - Reconstructing Species Relationships

C. Ecosystem Level

The terms ecology, ecosystem, and the like are used often in discussions of environmental issues. And yet, different people mean different things when they talk about biomes, ecosystems, habitats and eco-niches. Unless we have a firm understanding of what each of these ecological variables means and what processes have created them, we will not be able to truly understand why they are where they are, and why they are as diverse as we see them today. This section of the course focuses specifically on ecological diversity – what it is and how it came to be.

Lecture 12 – October 21 – What are the Diversity of Population/Species Interactions?

Lecture 13 – October 26 – What is an Ecological Community?

Lecture 14 – October 28 – What is an Ecosystem?

November 2 – The Day before Election Day – NO CLASS!

Lecture 15 – November 4 – What is a Biome?

Midterm Exam – November 9 – in class.

Part III: Where?

Once we determine what the units of biodiversity are, we then must locate where those units are in geographical space. Here again, there are processes determining distribution, but they are different from the processes determining the diversity itself. In this part of the course, we will focus on where the diversity is and why it is there.

A. <u>Gene Level</u>

Genetic diversity, whether it is within a population or an entire species, is generally not uniformly distributed. In this set of lectures we will examine how to map where that diversity is, how to understand what processes have led to its current distribution, and ultimately address the question of whether we can divide up the world into areas of greater or lesser evolutionary genetic diversity.

Lecture 16 – November 11 – Where is Genetic Diversity? - Mapping Genetic Landscapes

Lecture 17 – November 16 – Can One Define "Areas of Genetic Endemism"?

Lecture 18 – November 18 – Defining Metapopulations – The True Spatial Dynamics of Local Genetic Diversity

B. <u>Species Level</u>

Species diversity is also not uniformly distributed across the globe. There are a number of reasons for this unequal distribution. In this section of the course, we will examine the effects of area size, distance to the equator, paleogeography, and evolutionary time on the level and distribution of species diversity.

Lecture 19 – November 23 – Do larger areas have more species diversity than smaller areas?

Lecture 20 – November 25 – Do the tropics really have more species than the temperate zones?

Lecture 21 – November 30 – Do Time and Past Geography affect where species diversity is found today?

C. <u>Ecosystem Level</u>

Different parts of the surface of the Earth have a different array of ecosystems. Different altitudes and different latitudes also generate unique arrays of ecosystems. Below the level of ecosystem, we find different distributions of habitats and niches.

These mosaics are important and the processes underlying their distribution are equally important. In this lecture, we will explore where ecological diversity is and why its there.

Lecture 22 – December 2 – Where are the Earth's major Biomes?

Part IV: How?

After defining **What** the units of biological diversity are and describing **Where** they can be found, we will close this course by briefly examining **How** we can use science to develop long-term strategies for conserving that diversity where it currently resides. This last set of lectures will discuss methods for conserving diversity at all three levels and how they must be integrated to be successful. It is a brief introduction to the field of Conservation Biology.

Lecture 23 – December 7 – How can we conserve the Earth's biodiversity I: What is the problem?

Lecture 24 – December 9 – How can we conserve the Earth's biodiversity II: Why does it matter?

Lecture 25 – December 14 - How can we conserve the Earth's biodiversity III: How do we fix it?

Final Exam: Location, Date, and Time will be announced.

<u>Readings</u>:

I personally do not like textbooks, but for a course of this type they are a necessary evil. There are two text books for this course:

An Introduction to Biological Evolution, Kardong, K.V., 2005. McGraw Hill, New York.

The Economy of Nature (5th Edition), Ricklefs, R.E., 2001. W. H. Freeman & Company: New York.

In addition to pages from these texts, I am likely to assign other relevant readings from a variety of sources. When I do, I will provide multiple master copies of those readings for photocopying. The master copies will be put on reserve at Butler Library.

<u>Requirements</u>:

1. Students must attend two 75-minute lectures each week.
2. Students must attend one 50-minute discussion section each week.

3. Students will be responsible for approximately 10-20 pages of reading for each lecture.
4. There will be two exams, a mid-term and a final. The Mid-term will cover Parts I and II of the course and be conducted during one of the lecture periods. The Final will be comprehensive, covering Parts I – IV and take place during the assigned three-hour final exam period.
5. A student's grade will be entirely based on discussion section participation (see below) and their mid-term and final grades.

NOTE: I will accept virtually no excuse for missing an exam. Any excuse I do accept will need to be transmitted to me by your Dean – not you.

Discussion Sections:

You are fortunate to have two very bright graduate students from the Department of Ecology, Evolution, and Environmental Biology as Teaching Assistants for this course. Their names are Ms. Danielle Adams (dma2133@columbia.edu) and Ms. Hara Woltz (aww2101@columbia.edu). We have set up times for four recitation sections on Wednesday and Thursday evenings, 6:10-7:00 and 7:10-8:00 pm. **You should have registered for one of them already. If not you should register immediately.** It is our aim to keep each section to no more than **15** students. Ms. Adams and Ms. Woltz will use these sections to discuss the week's lectures and reading material. I urge you to attend each meeting of your discussion section - attendance and participation will be noted. Previous years' performance in the course was highly correlated with attendance at discussion sections.

Speak to me!

If you would like to talk to me about any of the material I cover or anything else, I will hold office hours from 4:30 – 6:00 pm on Wednesdays on the 11th floor of Schermerhorn Extension. If you need to meet me at some other time you MUST make an appointment with my assistant, Ms. Natalia Agüeros-Macario, at na2259@columbia.edu or by phone at 4-8186.