BIOL 104 Biodiversity – University of North Carolina, Chapel Hill
Learning Objectives
(updated fall 2023)

Unit 1: What is biodiversity and why does it matter?

Introduction to class

1. **Who** are we in this classroom?
2. **Why** are we all here (in BIOL 104)?
3. **What are we going to learn? And how?**

Why does biodiversity matter?

- How can one be successful in BIOL 104 and learn biology?
- What is biodiversity?
- Why does biodiversity matter and how do we know?

Process of Science + Producing Knowledge

- **Review** the principles and components of the scientific process (Lyme Disease)
- **Formulate** a testable hypothesis and design a controlled experiment (Butterflies)
- **Identify** the independent and dependent variables and control/experimental groups
- **Interpret** different kinds of data
- **Explain** experimental units and confounding factors, replication, sample bias

Measuring Biodiversity

1. **Describe** the different ways biological diversity can be measured and how estimates of diversity are calculated.
2. **Describe** methods of sampling used to estimate diversity.
3. **Practice** calculating Shannon Index (H')
4. **Explain** why a rarefaction plot is made, what data are used, and how these plots are interpreted.
5. **Use** biodiversity estimates to inform decisions

Diversity of Ecosystems

1. How does the tilt and shape of the Earth create both the seasons and atmospheric circulation patterns?
2. How does energy move in an ecosystem?
3. Use global, seasonal, or diurnal patterns of CO_2 emissions to infer the relative magnitudes of gross primary production and respiration.
4. What evidence do we have that Earth's climate is changing rapidly?

Nutrient Cycling

1. Why does nutrient cycling matter for biodiversity?
2. Use a simple compartment model of nutrient cycling to account for all inputs and outputs for an ecosystem.
3. What are the components of the nitrogen cycle? Include the different forms of organic and inorganic nitrogen, and the processes that convert nitrogen from one form to another.
4. Predict changes in pools or fluxes within a compartment model of nutrient cycling based on provided information.
5. Explain how the addition of nutrients affects the biodiversity of an ecosystem; and consider ways to prevent human-caused nutrient inputs.

Overarching Unit Objective: How does biodiversity arise?

Evolutionary Theory

- Identify some reasons many people struggle to accept the fact of evolution.
- Identify some reasons why it is critical to tackle acceptance of evolution in our society.
- Discuss and practice using non-experimental data to distinguish between hypotheses.
- Practice applying the scientific method (Make a prediction and test it with observations from nature.)
- Distinguish between the natural processes of Darwin and Lamarck and the supernatural process of Young-Earth Creationism as alternative explanations for the numbers, geographic locations, and morphological features of species we observe today. Which of these explanations is most consistent with the patterns we observe in nature?
- **Identify** four mechanisms of evolution

Natural Selection and Mutation

1. For any example of adaptive change in the characteristics of a population through time, you should be able to explain HOW it happened.
2. Be able to distinguish between the words inherited and heritable.
3. Interpret experimental data to decide whether mutations arise spontaneously or whether mutations are induced by selection.
4. Explore for how mutations affect allele frequency

Hardy-Weinberg Equilibrium + Population Genetics

Reminder: we assume a basic understanding of Mendelian genetics (AP Biology).

1. Given the probability of event 1 and the probability of event 2:
    - Be able to calculate the probability of event 1 AND event 2.
    - Be able to calculate the probability of event 1 OR event 2.
2. Begin to build intuition for the importance of probabilities in understanding evolution.
3. Use the Hardy-Weinberg model to build a bridge between Mendelian and Population Genetics. Know the assumptions of the Hardy-Weinberg model and the requirements for a population to be in Hardy-Weinberg Equilibrium.
4. Predict genotype frequencies from observed allele frequencies.
5. Calculate allele frequencies from observed genotype frequencies.

Phylogenetics and Parsimony:

- Analyze and choose between evolutionary hypotheses using the principle of parsimony.
- Interpret ancestral relationships using phylogenetic trees.
- Evaluate alternative evolutionary hypotheses given a phylogenetic tree.

Sexual Selection:

- Define the fundamental asymmetry of sex.
- Predict the consequences of this asymmetry for male-male competition.
- Predict the consequences of this asymmetry for female mating preferences.

Genetic Drift

- Be able to predict the effect of genetic drift on:
    - Allele frequencies
    - Genotype frequencies

    - Genetic variation
    - Differences among geographically isolated populations
- Explain how evolutionary mechanisms facilitate speciation.
- Apply to Conservation Biology: Describe the pros and cons of using migration as a tool to restore genetic variation to endangered species.
- Predict the effect of **each** evolutionary mechanism on:

    - Allele frequencies
    - Genotype frequencies
    - Genetic variation
    - Differences among geographically isolated populations

Cooperation (note: removed after Spring 2023)

- Be able to distinguish altruistic behaviors from other types of behaviors, like selfish behaviors.
- Be able to describe the scenarios in which selection favors an altruistic trait that benefits the group at a cost to the individual.
- Be able to define and calculate a coefficient of relatedness between any two individuals.
- Be able to apply Hamilton's Rule to decide which altruistic behaviors individuals should be willing to perform for their relatives.

Overarching Unit Objective: What limits biodiversity?

Population Regulation

- Compare Exponential and Logistic Population Growth
- Practice using the exponential and logistic growth equations
- Explore the dynamics of population growth as we alter the value of r and K
- Describe the difference between density independent and density dependent growth, and identify when regulation of a population occurs.

How disease spreads

1. Show how simple Susceptible-Infected-Recovered (SIR) models can be used to help understand the spread of disease
2. Explain how population density, transmission rate, and infectious period influence the spread of disease.
3. Describe how changes in behavior like social distancing and wearing masks can slow the spread of infectious diseases like the flu or COVID-19.
4. Explain what it means to “flatten the curve” and how doing so can improve a community’s ability to respond to an epidemic.

Food webs

- Explain the difference between a dominant species and a keystone species

- Use a food web diagram to identify both direct and indirect species interactions.
- Explain the role of keystone species in trophic cascades
- Predict how the addition of a top predator would cascade down to affect lower trophic levels.
    - Rocky intertidal
    - North Carolina Salt Marsh
    - Yellowstone National Park

Biogeography

- Describe the effects of island area and isolation on the number of species present on an island.
- Draw immigration and extinction curves for islands of different area and isolation to then use the curves to make predictions about species richness and turnover.
- Identify common features of biogeographic patterns of species richness across taxonomic groups.
- Explain the three hypotheses for why the tropics have more biodiversity than temperate regions

Overarching Unit Objective: How does biodiversity change?

Community Disturbance

- Distinguish between primary and secondary succession.
- Identify traits associated with early and late successional environments.
- Distinguish between tolerance, inhibition, and facilitation as mechanisms of succession.
- Explain the intermediate disturbance hypothesis
- Be able to distinguish between resistance, resilience, and return time as measures of community stability.

Human Evolution

- Explain the statement: Homo sapiens is the only survivor of an adaptive radiation of hominids that occurred in Africa over the last 4-5 million years.
- Describe the role of Morphological Innovation.
- Describe the role of Ecological Opportunity.
- Explain the Out-of-Africa hypotheses for the ancestry of present day *Homo sapiens*.
- Did Neanderthals contribute genes to present day human beings?

Extinctions

- In what ways did early human civilizations impact the local and global biodiversity?

- How is the survival of individuals, populations and species connected?
- What do past mass extinction events have in common, and is there evidence that we are currently experiencing a 6th mass extinction event?

Biological Consequences of Global Change

- Be able to characterize the magnitude of human impact on ecosystems in terms of total NPP used and the Ecological footprint
- Explain why the Earth is warming, and why the warming is of biological concern
- Describe the biological consequences of a warming planet
- Synthesize material from the semester to identify potential impacts of biodiversity loss

Conservation Biology

- Define conservation biology
- Compare two different conservation efforts in North Carolina
- Apply your understanding of biodiversity to determine why conservation efforts are "worth it"

iNaturalist Project Objectives

- **Engage** in collaborative scientific data collection using iNaturalist
- **Practice** observing and noticing North Carolina's biodiversity
- **Quantify** and **compare** biodiversity of different habitats.