Lesson Overview: Biodiversity + Open Science

Grades 9-12

Snapshot

Students will explore the incredible biodiversity across the globe and understand that there are millions of species that have not yet been discovered. They will learn how citizen science and open science allows the public to participate in the scientific process and contribute to global biodiversity projects. Students will learn how to use a biodiversity observation platform called iNaturalist to make their own observations, contribute to open science projects, and analyze observation data from the iNaturalist City Nature Challenge.

Big Ideas/Themes

- Biodiversity and Society
- Citizen Science and Open Science
- Science Practices and Skills

Essential Questions

- **How many** different species are on Earth and how do we **find** them?
- What are the **benefits** and **limitations** of iNaturalist to observe/measure global biodiversity?
- How do organisms **interact** with each other and humans in urban ecosystems?
- What are citizen science, open science, and open data?
- How will observations from iNaturalist contribute to citizen science and open science resources?
- What are the benefits and challenges of citizen science?
- How does iNaturalist work and what are the key features?
- How did our observations from iNaturalist City Nature Challenge **compare** across U.S. cities?
- What are the **benefits** and **limitations** of iNaturalist to observe/measure global biodiversity?

Objectives

Cognitive

- Students will **compare and contrast** global biodiversity at different scales
- Students will **describe** that organisms can be classified with taxonomic systems based on their characteristics and genome sequences
- Students will **explore** the diversity of terrestrial, freshwater, and marine ecosystems in the Greater Boston area, including urban habitats
- Students will **identify** local examples of different taxa
- Students will **understand** that their community is also home to a great diversity of organisms
- Students will address **misconceptions** about science and who can "do" science
- Students will **explore** how the public can participate in the scientific process through **citizen science** and **open science pathways**
- Students will **explore** the features of iNaturalist

Skills

- Students will **observe** differences in organisms that they name across the tree of life
- Students will **hypothesize** the numbers of species of plants, animals, fungi, and other organisms
- Students will **compare and contrast** citizen science with other scientific endeavors
- Students will **demonstrate** one way to contribute to citizen science and open science through open biodiversity platforms
- Students will **discuss** the benefits and challenges of citizen science
- Students will **contribute** to the ongoing effort to discover and document biodiversity
- Students will **practice** how to filter, search, and organize observations in iNaturalist
- Students will **compare/contrast** observations in different cities from the City Nature Challenge
- Students will **practice** scientific skills such as analyzing data, drawing conclusions, and communicating results
- Students will **investigate** the presence of invasive, threatened, and endangered species, and species with unique adaptations in their communities
- Students will **draw inferences** about the habits, preferences, and biases of observers

Affective

- Students will feel **humbled** by the biodiversity across the world and in their local ecosystems
- Students will **feel more invested and empowered** in citizen science projects and continue to participate independently
- Students will feel **connected** to their local ecosystem and community, and understand how their knowledge can be applied globally
- Students will **reflect** on their contributions to citizen science, and identify their role as valuable members of the scientific community

Assessments

Diagnostic

- Recalling local species (Activity 1)
- Drawing scientists (Activity 2)
- Questioning (All activities)

Formative

- Scaffolded questioning (All activities)
- Analyzing and synthesizing graphical and numerical data (All activities)

Summative

- Scaffolded questioning (All activities)
- Discussions and Reflection (All activities)
- Student-designed investigation questions (Activities 1, 3, 4)
- Analyzing and synthesizing graphical and numerical data (All activities)
- Poster presentations (Activity 4)

Activities

1. Activity 1: Introduction to Biodiversity
2. Activity 2: Citizen Science and Open Science Presentation
3. Activity 3: Introduction to iNaturalist
4. Activity 4: iNaturalist Data Exploration: City Nature Challenge

Vocabulary

Annelid: an invertebrate characterized as a worm with segmented parts; includes earthworms
Arthropod: an invertebrate phyla characterized by jointed body and exoskeleton; includes insects, spiders, and crustaceans
Biological Classification: Biologists organize living things according to taxonomic rank in hierarchy
Classify: To arrange a group of organisms into categories according to shared characteristics (physical or genetic)
Hierarchy: The system or model for organizing living things in biological classification
Mollusk: An invertebrate phyla characterized by soft bodies and ability to grow a hard shell
Species: Most diverse ranking of organisms in which individuals can produce fertile offspring
Taxon: In biology, a group of one or more populations of an organism or organisms that forms a unit (falcons, birds, vertebrates, animals)
Taxonomy: The branch of biology associated with classification of organisms
Tree: In taxonomy, the model used to show hierarchical relationships among organisms, with a common ancestor at top and branches where characteristics of organisms diverge

Recommended Reading + Resources

Organisms are organized into different groups based on shared characteristics - both physical (e.g., shape, size) and those not visible to the naked eye (e.g., genetic barcodes). We are able to classify organisms into a hierarchical system called taxonomy based on these characteristics. Worms have a certain set of shared characteristics, while sponges have another, as do all other groups of organisms. Visit the following EOL pages to learn more about animal diversity and taxonomy:

- ***Biodiversity Articles***
- ***What is an Animal?***
- ***What is Biological Classification?***
- ***What is Biodiversity?***
- ***What is a Species?***
- ***Biodiversity Educational Resources***
- ***EOL Flowering Plants article***
- ***EOL Plants article***
- ***EOL Trees article***
- ***National Wildlife Federation Plants***

Additional Resources:

- Khan Academy / Cal Academy of Sciences: https://www.khanacademy.org/partner-content/cas-biodiversity
- Shape of Life - Animal Diversity: http://www.shapeoflife.org/

- HHMI Biointeractive Biodiversity Resources: https://www.hhmi.org/biointeractive/search?sort_by=created&redirect=1&field_biointeractive_topics%5B0%5D=26632
- MCB-HHMI Harvard Outreach - Exploring Biodiversity: http://outreach.mcb.harvard.edu/lessonplans_S10.htm

Next Generation Science Standards

Performance Expectations

- HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales
- HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

Science and Engineering Practices

- Asking Questions and Defining Problems
- Planning and Carrying Out Investigations
- Analyzing and interpreting Data
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence
- Obtaining, Evaluating and Communicating Information

Relevant Nature of Science Principles (Appendix H)

- Scientific Investigations Use a Variety of Methods
- Scientific Knowledge is Based on Empirical Evidence
- Scientific Knowledge is Open to Revision in Light of New Evidence
- Science is a Way of Knowing
- Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Science is a Human Endeavor
- Science Addresses Questions About the Natural and Material World