CHICAGO BOTANIC GARDEN

Climate Change in my Backyard
Activity Guide for Grades 10–12

Unit 1: The Earth as a system

In Unit 1, students learn about the carbon cycle and the role that plants play in maintaining atmospheric concentrations of CO_2, including photosynthesis and respiration of different plants under different conditions. They define provisioning, regulating, and cultural ecosystem services and look at the ways that they contribute to human wellbeing.

Activity 1.1: The Carbon Cycle

1. Modeling the Carbon Cycle: Students discuss the components of the carbon cycle as a class and then break into groups to create their own models of the carbon cycle. Once they have completed their models, they research other models of the carbon cycle as found in research texts and on line. They add to their model and discuss the differences. They then address the role of natural and human-induced carbon sinks, sources, and release agents in modifying the carbon cycle.
2. The Carbon Cycle Game: Students play a game in which they take on the role of a carbon atom moving through the carbon cycle. They will follow their atom based on random flip of the coin through the various levels of the food chain, and through biotic and abiotic processes that make up the carbon cycle. They then answer discussion questions based on their experiences in the game.

Activity 1.2: Carbon, Greenhouse Gases, and Climate

1. Modeling the Greenhouse Effect: This lab activity demonstrates the role that carbon, greenhouse gases, and particles in the atmosphere play in maintaining the temperature of our planet.
2. Greenhouse Gases and Climate: Using GEEBITT, a NASA data analysis tool, students model the role of CO_2 and other greenhouse gases in moderating climate and propose atmospheric conditions that could have produced the climates of the past.

Activity 1.3: Are All Plants Created Equal?

1. Introduction to Photosynthesis (optional: if students have not yet covered photosynthesis): Students will explore photosynthesis, investigating how and where it takes place, how plants obtain the materials necessary for it to occur, and its products. Students make observations of stomata and compare the stomata from different plants. Students discuss their results and draw conclusions about why stomata are important for photosynthesis, how carbon dioxide gets into the plant, and how plants then get the carbon they need to make sugar.
2. Photosynthesis and Cellular Respiration: Students explore the factors that may affect rates of photosynthesis and cellular respiration. Students will design experiments to test, describe, and explain the cyclical relationship between photosynthesis and cellular respiration. Students generate hypotheses on the relationship between photosynthesis and cellular respiration. They use electronic data collection probes to determine the amount of CO_2 and O_2 produced by different plants under different conditions. Students then

analyze that data and draw conclusions about how plants impact the composition of the atmosphere.

Activity 1.4: Ecosystem Services
Students are introduced to the concept of ecosystem services. Ecosystem services are functions and values of intact ecosystems to humans. Students will research ecosystem services in different states/regions and identify the role that plants play in providing essential ecosystem services.

Unit 2: Identifying the key changing conditions of the Earth system

In Unit 2, students explore historical temperature cycles including paleoclimate data, more recent historical temperature changes, and current changes in temperature. They then apply one of those methods and use real temperature and tree-ring data to understand how tree growth is affected by both temperature and precipitation, and draw conclusions about what that means for the impact of changing climate on forests. They then expand the climate model beyond temperature to look at changes in precipitation and cloud cover in the United States. The unit continues by having students compare regional climate changes with overall global trends to identify similarities and differences in climate by region. Students recognize that climate change does not impact all areas of the globe equally or in the same ways. The unit concludes by having students write a persuasive essay using what they know about climate and ecosystem responses to climate change.

Activity 2.1: Historical Climate Cycles
Students look at historical records of CO_2 data from various sources (fossils, ice cores, tree rings) to understand historical climate cycles. They use this historical background to begin the discussion of how current changes in climate are different from what has happened in the past.

Activity 2.2: What Can Trees Rings Tell Us About Climate?
Students analyze historical tree rings from different locations and species in the United States and draw conclusions about the climatic conditions present during the growing season of each year. They will analyze and interpret tree-ring data, and correlate that data to historical climatic conditions. They will use this knowledge to describe and explain how tree-ring appearance is affected by environmental conditions, how we can recognize seasonal and annual growth in trees, and how we can use this information to develop hypotheses as they relate to current environmental conditions in their region.

Activity 2.3: Are Global CO_2 Levels Changing?

1. Are Global CO_2 Levels Changing? During this activity, students learn where CO_2 data has been collected, how long it has been collected, and then visualize the overall trends in the data. Students then compare different environments to see if CO_2 concentrations are changing all around the world or if changes are only occurring in certain locations.
2. Temperature and CO_2: Students use the NASA GISS Surface Temperature Station Data website (GISTEMP http://data.giss.nasa.gov/gistemp/station_data/) to determine whether global CO_2 trends students identified in part 1 are consistent with patterns of temperature

change around the world. Students discuss why different locations around the world are affected differently or to different degrees by changing climates.

Activity 2.4: Climate Change Around the World

1. Global Climate Change: Up until now, students have focused on only on temperature in evaluating climate change. Now students will add other climatic factors to their analysis and investigate how changes in atmospheric carbon dioxide levels affect temperature while also creating changes in precipitation levels and cloud cover and extreme weather events.
2. Climate Change in my Hometown: Students use the MY NASA DATA website to determine whether U.S. and global patterns of climate change are directly reflected in their city and in cities around the world. They discuss why different locations around the world are impacted differently or to different degrees by changing climates.

Activity 2.5: Review & Assessment: Causes and Effects of Climate Changes

This activity will give students an opportunity to work alone and in groups to summarize what they have learned so far about climate change. Students use graphic organizers to identify the natural and human-induced causes of climate change and its effects on plants, animals, and humans.

Unit 3: Earth system responses to natural and human-induced changes

In Unit 3, students learn how living things and ecosystems respond to and are impacted by changing climates. Students learn about how plant life-cycle events can be used to understand climate and how they have been used in the past. They participate in Project BudBurst, a national citizen science project, and study how changing climates impact the timing of plant life-cycle events. Students explore the impacts of changing climates on plant migration by calculating seed dispersal rates for a variety of plant species and predicting whether they will be able to migrate quickly enough to keep pace with changing climates.

Activity 3.1: Preparing for Project BudBurst

This activity serves as an introduction to phenology and project BudBurst, and will prepare students to start collecting data. In this activity students learn how to use the Project BudBurst website, begin to collect and record data on plant phenology, and add that data to the Project BudBurst database (data collection will be ongoing throughout the rest of the curriculum).

NOTE: BudBurst data collection can begin at any point in the curriculum. *Before you begin data collection, implement* ***Activity 3.1: Preparing for Project BudBurst*** *and continue making observations as often as possible so students are able to observe each phenological event.*

1. Introducing Project BudBurst: Students are introduced to the concept of phenology, the timing of periodic life cycle events. Students begin by discussing life cycles of organisms and the environmental factors that can impact those cycles.
2. Plant ID and Dichotomous Keys: Students make observations of plants unfamiliar to them, create a field guide for their plants, and practice identifying other plants by using

their classmates' field guides. Students then learn how to use a dichotomous key to identify plants, and use the keys to identify the plants that they will be collecting data on for Project BudBurst. This is an outdoor activity, but can also be done inside on collected or purchased flowers/plants.

3. BudBurst Data Collection: Students collect data on their chosen plant species throughout the growing season and enter it into the BudBurst website over a period of weeks or months. Students can write the data on the BudBurst data collection sheets Plant ID sheets and phenophase guides are available on the BudBurst website.

Activity 3.2: Impacts of Climate on Forest Succession

1. Tree Identification Activity – See the Forest for the Trees: Students learn how to identify the most common trees found in a local forest using a dichotomous key. They explain and identify common tree features such as leaf arrangement (opposite vs. alternate), leaf complexity (simple vs. compound), leaf shape, and leaf margins. This activity is in preparation for part 2, a study of local forest succession. Students practice identifying leaves on trees around their school.
2. Is the Environment Really Changing? A Study of Local Forest Preserve Succession: Students describe and give examples of the progression of several stages for a local environment such as a forest preserve or an old field. Students collect data on the species distribution for an area and based on that data predict past and future species composition of a local environment. Students use basal area, relative density, relative dominance, and other importance values for each plant species to determine how the forest is changing and how natural succession may be impacted by a changing climate.

Activity 3.3: Climate and Forest Ecosystem Services

This activity ties the concepts of ecosystem services and climate change to the forest succession activity. Students will learn about climate sequestration, and brainstorm what types of trees can sequester the most carbon.

Activity 3.4: Plant Phenology Data Analysis

1. Historical Phenology Data: Students will learn the story behind more than 150 years of plant phenology data collected in Concord, Massachusetts. Then, they graph plant phenology data and draw conclusions about how climate and climate change affect plant phenology.
2. Graphing Historical Data: Students graph plant phenology data and draw conclusions about how climate and climate change affect plant phenology.
3. Explaining the Variation: Students will determine if the variation in first flowering date in Concord, Massachusetts, can be explained by temperature (maximum, minimum, or mean) or precipitation (annual rainfall).
4. BudBurst and NASA Green-up Data: Students review and compare historical data and their BudBurst data, to NASA Normalized Difference Vegetation Index (NDVI) visualization and graphs. Students will discuss how BudBurst can contribute to our understanding of plants' responses to climate change.

Unit 4: Predicting the consequences of change for human civilization

In Unit 4, students explore the impacts of climate change on individuals around the world. They learn that climate change impacts people differently and that there are economic, social, cultural, and political factors that influence each individual's beliefs about and decisions related to climate change. They then consider how their own choices can impact climate. Specifically they consider the energy requirements and environmental impacts of their food choices. The final lessons focuses on positive steps students can take to reduce their ecological footprint.

Activity 4.1: The Faces of Climate Change
In this activity, students will learn how climate change affects individuals in other parts of the world in different ways. In a role-playing scenario, they learn that climate change impacts people differently and that there are economic, social, cultural, and political factors that influence each individual's beliefs about and decisions related to climate change. This activity can either be done as a two-day culmination or can be used as the basis for a research project in which students investigate the impacts of climate change on specific regions, countries, or cultures around the world.

Activity 4.2: Calculating Your Carbon Footprint
Students will understand the concept of an ecological or carbon footprint. They will use online calculators to visualize how their choices affect the planet.

Activity 4.3: Personal Choices and the Planet
This lesson focuses on positive steps students can take to reduce their ecological footprint. During the opening of this lesson, the class revisits the concept of energy use, then students identify how changes in their daily habits can reduce their carbon footprint.

