Randolph Township Schools
Randolph High School
Botany Curriculum

"The leaves of the world comprise countless billion elaborations of a single, simple machine designed for one job only – a job upon which hinges humankind."
Hope Jahren, *Lab Girl*

STEM+B
Anthony Emmons

Curriculum Committee
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Curriculum Developed:
July, 2020

Date of Board Approval:
September 15th, 2020

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Mission Statement

We commit to inspiring and empowering all students in Randolph schools to reach their full potential as unique, responsible and educated members of a global society.

Affirmative Action Statement
Equality and Equity in Curriculum

The Randolph Township School district ensures that the district's curriculum and instruction are aligned to the state's standards. The curriculum provides equity in instruction, educational programs and provides all students the opportunity to interact positively with others regardless of race, creed, color, national origin, ancestry, age, marital status, affectional or sexual orientation, gender, religion, disability or socioeconomic status.

N.J.A.C. 6A:7-1.7(b): Section 504, Rehabilitation Act of 1973; N.J.S.A. 10:5; Title IX, Education Amendments of 1972

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EDUCATIONAL GOALS
VALUES IN EDUCATION

The statements represent the beliefs and values regarding our educational system. Education is the key to self-actualization, which is realized through achievement and self-respect. We believe our entire system must not only represent these values, but also demonstrate them in all that we do as a school system.

We believe:

- The needs of the child come first
- Mutual respect and trust are the cornerstones of a learning community
- The learning community consists of students, educators, parents, administrators, educational support personnel, the community and Board of Education members
- A successful learning community communicates honestly and openly in a non-threatening environment
- Members of our learning community have different needs at different times. There is openness to the challenge of meeting those needs in professional and supportive ways
- Assessment of professionals (i.e., educators, administrators and educational support personnel) is a dynamic process that requires review and revision based on evolving research, practices and experiences
- Development of desired capabilities comes in stages and is achieved through hard work, reflection and ongoing growth

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Introduction

This course is a dual-enrollment option offered with the County College of Morris. Designed for the non-science major, this course provides an introductory study of botany including the topics of plant anatomy, growth and development, reproduction, photosynthesis, respiration, and a survey of diversity within the plant kingdom including angiosperms, gymnosperms, bryophytes, and ferns. Students will also study the relationship humans have with plants and how human actions can affect ecosystems.

This course affords the student the opportunity to receive not only high school credit, but also credit for one college-level class from The County College of Morris (CCM) upon successful completion. The expectation is that students taking the course will register for these CCM credits and purchase or rent the college-level textbook for the year.

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Curriculum Pacing Chart

SUGGESTED TIME ALLOTMENT	UNIT NUMBER	CONTENT - UNIT OF STUDY
4 weeks	**I**	**Plant Structure and Function**
5 weeks	**II**	**Energy and Water**
4 weeks	**III**	**Growth and Development**
3 weeks	**IV**	**Classification, Origin of Eukaryotic Cells, and Algae**
3 weeks	**V**	**Nonvascular Plants**
3 weeks	**VI**	**Vascular Plants without Seeds**
3 weeks	**VII**	**Gymnosperms**
3 weeks	**VIII**	**Angiosperms**
3 weeks	**IX**	**Ethnobotany**
5 weeks	**X**	**Ecology and Environmental Science**

36 weeks

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Unit I: Plant Structure and Function

TRANSFER: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

STANDARDS / GOALS:	ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. HS-LS1-6 Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.	Plants have a hierarchy of organization and cellular structure that determines tissue, organ, and organism function.	• How does structure determine function?
	Plant stems and roots have a structure that impacts their function in the transportation of nutrients and support.	• How do stems and roots support plant growth and development?
	Plant leaves have a structure that supports their function of photosynthesis and transpiration.	• How do leaves support plant growth and development? • Why do we prune plants?
	Plants have various reproductive strategies that involve different organs.	• What types of strategies have plants evolved in order to reproduce? • How does the structure of the plant support the reproduction strategy?

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Unit I: Plant Structure and Function

HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.	**KNOWLEDGE** **Students will know:**	**SKILLS** **Students will be able to:**
	Plants have organelles, tissues, and organs that determine their growth and function.	Identify and describe the function of organelles in plant cells. Illustrate how various types of cells are organized in tissues to enable unique functions. Discuss the structure and function of organs in plant cells.
	Stems have a structure that determines their function.	Identify the major functions of stems. Describe the components of basic stem organization. Provide examples of modifications to basic stem components. Order the processes of primary growth.
	Roots have a structure that determines their function.	Define the three main functions of roots. Explain the structure of individual roots. Compare and contrast various types of roots.

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Unit I: Plant Structure and Function

	Leaves have a structure that determines their function.	Identify the three functions of leaves. Explain the differences between simple leaves and compound leaves. Determine the functions of the epidermis, mesophyll, vascular tissue, and petiole. Analyze various types of leaves.
	Plant reproduction involves multiple strategies and organs.	Compare and contrast mitosis and meiosis. Evaluate the advantages and disadvantages of sexual and asexual plant reproduction. Identify four types of floral appendages. Illustrate types of pollination. Describe ways to classify fruits.

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Unit I: Plant Structure and Function

	KEY TERMS: anthropomorphism, botany, hypothesis, observations, scientific method, phloem, photosynthesis, reproductive organs, vascular plant, xylem, chloroplast, endoplasmic reticulum, Golgi apparatus, nucleus, plasmodesmata, ribosome, mitosis, meiosis, prophase, metaphase, anaphase, telophase, cell plate, cuticle, epidermis, primary growth, leaf primordium, petiole, spongy mesophyll, root cap, root hairs, zone of elongation, anthers, carpels, fruit, ovary, petals, pollen, seeds, stigma, stamen	

ASSESSMENT EVIDENCE: Students will show their learning by:

- Recording observations of root growth, including but not limited to growth rates and patterns.
- Writing lab reports to compile, analyze, and draw conclusions based on recorded data.
- Designing an investigation to determine the effects of various factors on root growth.
- Modeling the similarities and differences in mitosis and meiosis.

KEY LEARNING EVENTS AND INSTRUCTION:

- Observe and document various plant cells (Microscope Lab).
- Compare and contrast cell division (Mitosis and Meiosis lab).
- Dissect leaves, flowers, fruits, and seeds (Dissection Labs).

SUGGESTED TIME ALLOTMENT	**4 weeks**
SUPPLEMENTAL UNIT RESOURCES	Botany (Mauseth) Textbook Chapters 1, 2, 4-7, 8, and 10 Botany Lab Photographic Atlas and Slide Set

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Unit II: Energy and Water

<table>
<tr><td colspan="3">TRANSFER: Understand obtaining and using energy and water are critical for all living things.</td></tr>
<tr><td>STANDARDS / GOALS:

HS-LS1-6 Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.</td><td>ENDURING UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td></td><td>Photosynthesis converts light energy into chemical energy.</td><td>• How do plants combine carbon and water to produce glucose and oxygen?
• What factors influence the rate of photosynthesis?</td></tr>
<tr><td></td><td>Climate and evolution determine a plant’s use of C3, C4, or CAM pathways of photosynthesis.</td><td>• Why did the various photosynthetic pathways develop?
• What role did climate play in the evolutionary development of the photosynthetic pathways?</td></tr>
<tr><td></td><td>Plants utilize the energy stored in photosynthesis by releasing it in a process called cellular respiration.</td><td>• What is the relationship between photosynthesis and cellular respiration?
• How are aerobic and anaerobic respiration different?</td></tr>
<tr><td></td><td>Plants contains specialized structures for transporting and conserving water and nutrients.</td><td>• What are the specialized plant structures used to transport and conserve water?
• What are the specialized plant structures used to transport and store nutrients?</td></tr>
</table>

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Unit II: Energy and Water

	KNOWLEDGE **Students will know:**	**SKILLS** **Students will be able to:**
	Photosynthesis converts carbon dioxide, water, and sunlight into glucose and oxygen.	Identify the key steps in light-dependent reactions and in stoma reactions. Explain how plants convert glucose into compounds for long-term energy storage. Describe the factors that influence the rate of photosynthesis.
	Multiple pathways for photosynthesis have developed over time through the process of evolution.	Evaluate the role that climate had in the evolution of photosynthetic pathways. Compare and contrast the C3, C4, and CAM pathways.
	Cellular respiration converts the chemical energy in complex carbon molecules into ATP, which is utilized by cells to do cellular work.	Identify the complex carbon molecules used to store energy in plants. Describe how cellular respiration is utilized by plants to convert energy into ATP to carry out cellular work. Compare aerobic and anaerobic respiration. Summarize the factors that influence the rate of cellular respiration.

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Unit II: Energy and Water

	Fermentation is the chemical breakdown of a substance by bacteria, yeasts, or other microorganisms.	Explain the process of fermentation and how humans have utilized various plants to produce alcohol.
	Plants must obtain water to perform photosynthesis.	Model how cells move water across the cell membrane. Discuss the importance of water to cellular functions. Explain how water potential drives the movement of water in plants. Describe how various plants obtain water in order to complete photosynthesis and how the availability of water in the environment impacts water absorption.
	Plants require nutrients such as nitrogen, phosphorus, calcium, magnesium, and sulfur.	Classify three important functions of soil. Describe how soil is formed. Identify the important macro- and micronutrients and explain their role in plant growth and development. Summarize the steps of the nitrogen cycle.

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Unit II: Energy and Water

	KEY TERMS: absorption spectrum, ATP synthetase, C_3 cycle, C_4 cycle, CAM, cytochromes, electron transport chain, grana, light-dependent reactions, oxidative phosphorylation, pigment, RuBP, stroma reactions, aerobic respiration, anaerobic respiration, citric acid cycle, glycolysis, Krebs cycle, fermentation, active transport, aquaporins, diffusion, osmotic potential, water potential, denitrification, eutrophication, nitrogen assimilation, nitrogen fixation, weathering	

ASSESSMENT EVIDENCE: Students will show their learning by:

- Writing lab reports to compile, analyze, and draw conclusions based on recorded data.
- Designing an investigation to determine the effects of various factors on photosynthesis.
- Modeling the relationship between cellular respiration and photosynthesis.

KEY LEARNING EVENTS AND INSTRUCTION:

- Monitor the growth of various plants (Greenhouse Labs).
- Separate pigments of leaves (Chromatography Lab).
- Design EcoColumns to simulate or model a simple ecosystem (EcoColumns Project).

SUGGESTED TIME ALLOTMENT	**5 weeks**
SUPPLEMENTAL UNIT RESOURCES	Botany (Mauseth) Textbook Chapters 11-14 Botany Lab Photographic Atlas and Slide Set https://teachingapscience.com/everything-ecocolumns/

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Unit III: Growth and Development

TRANSFER: Explain evolutionary change as organisms grow and develop unique structures that allow them to thrive and reproduce in their environment, the results of mutations in DNA.

STANDARDS / GOALS:	ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.	All organisms begin life as a fertilized egg, with differences in genes, gene expression, growth, and morphogenesis producing all the different types of individuals.	• How does one fertilized egg develop into all the different structures needed for a plant to survive and reproduce?
	Genes control development by directing the synthesis of proteins that serve as enzymes, affect structure, or otherwise modulate metabolic pathways.	• What role do genes play in the development of metabolic pathways? • How can chemicals determine the different structure of plants?
	Each plant will have hundreds or thousands of flowers, and it is possible that pollinators will bring pollen from so many other plants that each seed has a different pollen parent.	• What mechanisms allow for one plant to be fertilized by both itself and other plants?
	Both primary and secondary growth in woody plants are the result of gene expression and lead to vertical or horizontal growth, making the organism fit for its environment.	• How does primary growth lead to vertical growth? • How does secondary growth lead to horizontal growth? • What enables woody plants to compete within their environment?

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Unit III: Growth and Development

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-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.	Mutations can lead to changes in the gene pool of a population which can result in evolution and the creation of new species.	• Why do mutations lead to change within an organism? • How can changes within individual organisms produce variations in the gene pool and ultimately produce new species?
	<u>KNOWLEDGE</u> **Students will know:**	**<u>SKILLS</u>** **Students will be able to:**
	Changes in various factors lead to modifications in gene expression which leads to development and other variations in plant structure. In many species of plant, transition to flowering is triggered by day length. The central dogma of biology states that the flow of information is from DNA to RNA to proteins. The proteins produced by an organism's DNA serve as enzymes, affect structure, or otherwise modulate metabolic pathways.	Analyze the effects of environmental stimuli that influence development in plants. Describe the role of plant hormones in the differentiation of plant structures. Summarize how differing photoperiods affect plant growth and flowering. Name the processes involved in gene expression. Illustrate the flow of information from genes to proteins. Explain how proteins can act as enzymes within organisms. Analyze the effects enzymes have on plant structures and metabolic pathways.

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Unit III: Growth and Development

HS-LS4-2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. HS-LS4-3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations. HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.	Sexual reproduction has advantages over asexual reproduction. Punnett squares can be used to predict the offspring of two parents and the genetic traits they will possess. Unlike animals, polyploidy is common in plants and is often acted upon by natural selection as an instrument of speciation. Most woody plants add a new layer of wood around their trunk, branches, and roots every year. A collection of all the genes in a population is known as a gene pool, and population genetics describes how the gene pool varies year to year as a result of sexual reproduction.	Evaluate the benefits of sexual and asexual reproduction. Illustrate crosses between organisms using Punnett squares. Utilize Punnett squares to determine the percentages of offspring expected. Discuss how triploid and tetraploid cells occur and give plants an advantage. Explain the advantages and disadvantages of secondary growth. Describe the arrangement of cambial cells. Compare secondary phloem to secondary xylem. Discuss secondary root growth. Define gene pool. Evaluate data from population genetics to describe the changes in the gene pool over time. Model how environmental factors can influence changes in the gene pool.

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Unit III: Growth and Development

	Gene flow, due to reproductive isolation or another factor, can lead to speciation.	Identify three ways that gene flow can occur. Explain a biological reproductive barrier. Explain phyletic, divergent, and convergent speciation as well as the factors that lead to each.
	KEY TERMS: apical dominance, auxin, circadian rhythm, cytokinins, differentiation, gibberellins, hormones, negative feedback loop, positive feedback loop, signal amplification cascade, tropic response, differential activation of genes, exon, gene, intron, messenger RNA, ribosomes, transcription, complete dominance, dihybrid cross, genotype, heterozygous, homozygous, incomplete dominance, phenotype, Punnett square, somatic mutations, annual ring, cork cambium, hardwoods, periderm, primary tissues, radial system, rays, sapwood, secondary phloem, secondary xylem, softwoods, vascular cambium, allopatric speciation, convergent evolution, divergent evolution, gene flow, gene pool, genetic drift, natural selection, phyletic speciation, reproductive barrier, sympatric speciation	

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Unit III: Growth and Development

ASSESSMENT EVIDENCE: Students will show their learning by:

- Writing lab reports to compile, analyze, and draw conclusions based on recorded data.
- Designing an investigation to determine the effects of hormones on plant growth.
- Evaluating Punnett Squares.

KEY LEARNING EVENTS AND INSTRUCTION:

- Use multiple techniques to grow plants (Plant Propagation Labs).
- Model the movement of genes within a population (Gene Flow Activity).
- Analyze the effects of various factors on tree growth (Virtual Dendrochronology Lab).
- Model the possible results of crosses between individuals (Punnett Squares).
- Illustrate the flow of information from DNA to proteins (Gene Expression Activity).

SUGGESTED TIME ALLOTMENT	**4 weeks**
SUPPLEMENTAL UNIT RESOURCES	Botany (Mauseth) Textbook Chapters 9, 15-18 Botany Lab Photographic Atlas and Slide Set Virtual Dendochronolgy Lab https://scied.ucar.edu/tree-ring-interactive Population Genetics Lab http://virtualbiologylab.org/population-genetics/ Tree ring article: https://www.sciencealert.com/hundreds-of-years-of-tree-rings-reveal-an-extreme-weather-anomaly-that-began-in-the-20th-century

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Unit IV: Classification, Origin of Eukaryotic Cells, and Algae

TRANSFER: Understand organisms are classified based on evolutionary relationships that show the acquisition of adaptations from the evolution of a eukaryotic cell to algae.

STANDARDS / GOALS:	**ENDURING UNDERSTANDINGS**	**ESSENTIAL QUESTIONS**
HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. HS-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.	A cladogram shows evolutionary patterns.	• How can evolutionary patterns be represented visually?
	Autoapomorphies and synapomorphies help to define clades.	• What are the different ways to define clades?
	The differences between prokaryotes and eukaryotes are extensive and involve many of the most basic metabolic processes and cellular organization.	• What are the processes and structures that determine if an organism is a prokaryote or a eukaryote?
	Algae evolved through endosymbiosis.	• What is endosymbiotic theory and how is it used to explain the evolution of algae?
	Green, red, and brown algae differ in their basic anatomy and reproduction.	• What characteristics define the green algae? • What characteristics define the red algae? • What characteristics define the brown algae?

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Unit IV: Classification, Origin of Eukaryotic Cells, and Algae

HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. HS-LS4-2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations. HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.	**KNOWLEDGE** **Students will know:**	**SKILLS** **Students will be able to:**
	The natural classification systems have a defined order of levels (taxa).	List the major categories used in modern taxonomy. Explain how the natural classification system is used to categorize species.
	A cladogram shows evolutionary patterns.	Recognize that a cladogram illustrates evolutionary patterns.
	Various characters are used to place organisms into clades.	Name the type of characters that can be used to differentiate organisms. Draw cladograms to use the evolutionary relationships between species.
	Prokaryotes and eukaryotes differ in both structure and function.	Summarize the differences in organization and metabolism of prokaryotes and eukaryotes.
	The endosymbiont theory explains the acquisition of organelles in eukaryotes.	Name the precursor species to primary and secondary endosymbiosis. Describe how various algae evolved by means of primary endosymbiosis and secondary endosymbiosis.

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Unit IV: Classification, Origin of Eukaryotic Cells, and Algae

	The taxons that contain the green, red, and brown algae have similar characteristics.	Determine the characteristics that green algae share. Identify the characteristics that red algae share. Describe the characteristics that brown algae share.
	KEY TERMS: analogous features, binomial system of nomenclature, clade, cladistics, cladogram, class, common ancestor, dichotomous key, family, genus, homoplasies, kingdom, monophyletic group, order paraphyletic group, phylogeny, polyphyletic group, species, symplesiomorphy, synapomorphies, taxon, brown algae, colony, diatoms, dinoflagellates, endosymbiont theory, filamentous body, green algae, pneumatocyst, red algae	

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Unit IV: Classification, Origin of Eukaryotic Cells, and Algae

ASSESSMENT EVIDENCE: Students will show their learning by:

- Classifying organisms using a dichotomous key.
- Investigating the evolutionary relationship between organisms based on physical characteristics and classification.

KEY LEARNING EVENTS AND INSTRUCTION:

- Diagram the relationships among species (Cladogram activity).
- Practice plant identification both in the lab and field (Dichotomous Key activity).
- Categorize multiple species (Taxonomic Keys Activity).
- Review kingdom classifications (Survey of Kingdoms Activity).
- Produce a visual collection of various local flora (Student Photo Collection).

SUGGESTED TIME ALLOTMENT	**3 weeks**
SUPPLEMENTAL UNIT RESOURCES	Botany (Mauseth) Textbook Chapters 19-20 Botany Lab Photographic Atlas and Slide Set

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Unit V: Nonvascular Plants

TRANSFER: Recognize the diversity of plant life. Nonvascular plants, also known as bryophytes, lack vascular tissues, leaves, seeds, and flowers and use rhizoids to anchor themselves and absorb water and minerals.

STANDARDS / GOALS:	**ENDURING UNDERSTANDINGS**	**ESSENTIAL QUESTIONS**
HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations. HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.	Bryophytes evolved to be multicellular and have structures that aid in their survival and reproduction.	• What traits did bryophytes acquire through evolution to allow them to occupy new niches? • How have nonvascular plants evolved to maintain their niche in current environmental conditions?
	Mosses have unique structures that allow for functions such as water transport, development, and reproduction.	• What are the structures that make mosses unique among the nonvascular plants?
	Liverworts have unique structures that allow for functions such as water transport, development, and reproduction.	• What are the structures that make liverworts unique among the nonvascular plants?
	Hornworts have unique structures that allow for functions such as water transport, development, and reproduction.	• What are the structures that make hornworts unique among the nonvascular plants?

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Unit V: Nonvascular Plants

	KNOWLEDGE **Students will know:**	**SKILLS** **Students will be able to:**
	Evolution led to multicellularity and specialized structures in nonvascular plants.	Explain the adaptations that lead to multicellular plants. List the structures that exist in nonvascular plants and explain how they allow plants to survive on land where water is not always present. Describe the niches that nonvascular plants occupy.
	Reproduction in nonvascular plants utilizes gametophytes and sporophytes.	Describe the sporophytes of mosses. Describe the sporophytes of liverworts. Describe the sporophytes of hornworts.
	Rhizoids are specialized structures that transport water in nonvascular plants.	Explain the roles that rhizoids have in nonvascular plants.
	KEY TERMS: archegonia, gametophytes, hornworts, liverworts, mosses, rhizoids	

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Unit V: Nonvascular Plants

ASSESSMENT EVIDENCE: Students will show their learning by:

- Modeling the life cycle of mosses, showing the gametangia and sporangia and explaining which ones are haploid and diploid.
- Comparing and contrasting three moss species in three different niches and explaining how each has unique adaptions to obtain water.
- Observing and labeling the structures present in the bryophytes.

KEY LEARNING EVENTS AND INSTRUCTION:

- Identify and draw structures found in nonvascular plants (Microscope Lab).
- Field identification of nonvascular plants (Nature Walks).

SUGGESTED TIME ALLOTMENT	**3 weeks**
SUPPLEMENTAL UNIT RESOURCES	Botany (Mauseth) Textbook Chapter 21 Botany Lab Photographic Atlas and Slide Set

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Unit VI: Vascular Plants without Seeds

<table>
<tr><td colspan="3">TRANSFER: Appreciate the resilience of plant life. Vascular plants without seeds do not produce flowers, seeds, fruit, or wood, and occupy very diverse habitats.</td></tr>
<tr><td rowspan="6">STANDARDS / GOALS:

HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

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.</td><td>ENDURING UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td>The development of vascular tissues allows plants to become stronger and taller, as well as able to differentiate and have specialized structures.</td><td>• When did vascular tissues evolve?
• What advantages does vascular tissue provide to plants?</td></tr>
<tr><td>Vascular plants without seeds developed internal conducting tissues, true leaves, and roots that function in absorption and anchorage.</td><td>• What did the advent of roots enable plants to do?
• What are the advantages that leaves provide?
• How do seedless vascular plants reproduce?</td></tr>
<tr><td>Ferns have unique structures that allow for functions such as water transport, development, and reproduction.</td><td>• Why are ferns a highly studied group of plants?
• What processes do ferns use to reproduce?</td></tr>
<tr><td><u>KNOWLEDGE</u>
Students will know:</td><td><u>SKILLS</u>
Students will be able to:</td></tr>
<tr><td>Xylem and phloem are internal conducting tissues found in vascular plants.</td><td>Identify the two aspects of vascular tissue.

Draw a cross-section of vascular tissue.</td></tr>
</table>

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Unit VI: Vascular Plants without Seeds

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-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. HS-LS4-2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.	The strong, vertical stems of vascular plants allow them to be taller. The development of true roots provides the ability to absorb nutrients and anchor the plant. Alternation of generation allows plants to reproduce both asexually and sexually. Ferns have existed for more than 360 million years.	Describe the benefits of vascular tissue. Explain the processes that allow plants to grow taller. Determine the advantages that taller plants possess. Explain how the structure of roots allows for the absorption of water and nutrients. Describe how strong and deep roots contribute to a plant's vertical growth. Compare and contrast asexual and sexual reproduction. Explain how the alternation of generation is used by vascular plants without seeds. Explain how the adaptations of both extinct and extant species of fern have allowed them to thrive in a wide variety of habitats for 360 million years.

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Unit VI: Vascular Plants without Seeds

<table>
<tr><td>HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.</td><td>KEY TERMS: alternation of generations, leaf gap, leaf trace, megaphylls, microphylls, overtopping, protostele, sporophyll, sporangiophore</td><td></td></tr>
<tr><td colspan="3">ASSESSMENT EVIDENCE: Students will show their learning by:
• Creating a diagram that illustrates the similarities and differences between vascular and nonvascular plants
• Drawing the life cycle of a fern, labeling all structures, and explaining why ferns demonstrate alternation of generations.

KEY LEARNING EVENTS AND INSTRUCTION:
• Identify and draw structures found in vascular plants with seeds (Microscope Lab).
• Recognize vascular plants with seeds (Nature Walks).
• Create a local field guide for species of ferns (Fern Guide Project).</td></tr>
<tr><td>SUGGESTED TIME ALLOTMENT</td><td colspan="2">3 weeks</td></tr>
<tr><td>SUPPLEMENTAL UNIT RESOURCES</td><td colspan="2">Botany (Mauseth) Textbook Chapter 21

Botany Lab Photographic Atlas and Slide Set</td></tr>
</table>

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Unit VII: Gymnosperms

<table>
<tr><td colspan="3">TRANSFER: Recognize common gymnosperms, plants that produce seeds and wood, but no flowers or fruit.</td></tr>
<tr><td rowspan="6">STANDARDS / GOALS:

HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

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.</td><td>ENDURING UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td>Seed differs from spores.</td><td>• How are spores and seeds different?
• What is the structure of seeds and how do they aid survival species?</td></tr>
<tr><td>Seed ferns have a ring of vascular bundles surrounding a pith.</td><td>• How does the vascular structure of gymnosperms allow them to become so large?</td></tr>
<tr><td>Conifers have needle-like leaves.</td><td>• How are conifers different from leaf-bearing trees?</td></tr>
<tr><td>Wood and cones give conifers advantages.</td><td>• What is the advantage of having a woody stem?
• How do cones assist in reproduction of gymnosperms?
• What aspect of some cones ensure a faster recovery after a fire event?</td></tr>
<tr><td><u>KNOWLEDGE</u>
Students will know:</td><td><u>SKILLS</u>
Students will be able to:</td></tr>
<tr><td>Seeds contain a protective coat and a supply of nutrients.</td><td>Explain how seeds differ from spores and provide an advantage to gymnosperms.</td></tr>
</table>

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Unit VII: Gymnosperms

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-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. HS-LS4-2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations.	The vascular tissues of gymnosperms are more complex. Conifer leaves have unique characteristics that aid in photosynthesis, water retention, and protection. Conifers have both pollen cones and seed cones. Cones protect seeds and aid in the release of seeds at the most opportune time. Gymnosperms are important to humans.	Describe the vascular tissues of gymnosperms. Illustrate different vascular tissues. Explain how conifer leaves assist gymnosperms living in habitats with limited water and sunlight. Compare and contrast pollen cones and seed cones. Diagram various seed cones in order to highlight the differences Describe how the structure of cones provide some reproductive advantages. Explain how cones do not always provide an advantage. Investigate how humans utilize gymnosperms.

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Unit VII: Gymnosperms

HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.	**KEY TERMS:** compound cones, cone bracts, coprolites, gymnosperms, long shoots, ovuliferous scale, pollen chamber, progymnosperms, seed ferns, simple cones, spermatophytes	

ASSESSMENT EVIDENCE: Students will show their learning by:

- Drawing a generalized pine tree life cycle and identify all necessary structures.

KEY LEARNING EVENTS AND INSTRUCTION:

- Describe and diagram tree rings and cells of trees (Wood Anatomy Lab).
- Analyze local plant life (Survey of Conifers).
- Identify and draw structures found in gymnosperms (Microscope Lab).
- Field identification of gymnosperms (Nature Walks).

SUGGESTED TIME ALLOTMENT	**3 weeks**
SUPPLEMENTAL UNIT RESOURCES	Botany (Mauseth) Textbook Chapter 23 Botany Lab Photographic Atlas and Slide Set

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Unit VIII: Angiosperms

TRANSFER: Recognize angiosperms, vascular plants that have stems, roots, leaves, and also produce common flowers and fruits.		
STANDARDS / GOALS: HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. 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.	**ENDURING UNDERSTANDINGS**	**ESSENTIAL QUESTIONS**
	Flowering plant gametophytes develop in separate structures.	• How are flowing plants different that non-flowering plants? • What structures allow plant fertilization to take place?
	Pollination is the transfer of pollen from an anther to a stigma.	• How can flower plants be both self-fertilized and cross-fertilized? • What mechanisms exist for pollen to transfer between plants? • What adaptations have plants developed that attract particular pollinators?
	Significant evolutionary changes occurred in the transition from gymnosperms to angiosperms.	• What are some of the evolutionary changes that lead to flowering plants? • How are pollen and spores different? • What are some evolutionary advantages of fruit?
	Eudicots have reticulated leaf veins, stems containing vascular bundles in rings, and often have secondary growth.	• How are eudicots different from monocots? • What is unique about the vascular bundles of eudicots? • What is the advantage of secondary growth?

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Unit VIII: Angiosperms

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-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. HS-LS4-2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations.	Monocots have parallel leaf veins, scattered vascular bundles in the stem, and often lack secondary growth.	• What sets monocots off from other flowering plants? • What type of the root system do monocots utilize?
	<u>KNOWLEDGE</u> **Students will know:**	**<u>SKILLS</u>** **Students will be able to:**
	The stamen produce pollen, while the carpels produce eggs. Pollination is the transfer of pollen grains from an anther to a stigma. Pollination is brought about by insects, wind, and other agents.	Identify how pollen and eggs are produced. Describe the reproductive structures of flowering plants. Discuss the process of pollination. Describe the life cycle of flowering plants. List the different methods of pollen transfer. Compare and contrast the benefits of multiple pollinators. Explain how some pollinators are specific to certain plants. Discuss how both flowering plants and pollinators have evolved adaptations to both advantage and disadvantage each other.

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Unit VIII: Angiosperms

HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.	The ability to produce bisexual flowers, leaves to maximize photosynthesis, and efficient vessel elements are adaptations that evolved in angiosperms. Eudicots have broad leaves, flower parts in fours or fives, vascular bundles in the stem arranged in a ring, vascular bundles in the stem arranged in one ring, and woody growth or an annual or biennial herbaceous body. Monocots can generally have long, strap-shaped leaves, flower parts in threes, parallel leaf venation, numerous vascular bundles in the stem that are not arranged in a ring, and no ordinary secondary growth. Humans rely on angiosperms for many resources, most notably food.	List the major adaptations of flowering plants. Describe how broad leaves increase photosynthetic efficiency. Discuss the benefits of vascular structures in moving materials through flowering plants. List the benefits of broad leaves. Identify the parts of eudicots flowers. Discuss the advantages of vascular bundles that are arranged in rings. Describe the methods of secondary growth. Evaluate the benefits of secondary grow to both the plant and to humans. List the benefits of the leaf types of monocots. Identify the parts of monocot flowers. Describe the arrangement of vascular bundles in monocots. Explain the limitations of primary growth in a monocot and their impact on secondary growth. Describe the various resources that angiosperms provide humans.

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Unit VIII: Angiosperms

	KEY TERMS: angiosperm carpels, anther, basal angiosperms, carpel, dioecious, double fertilization, endosperm, eudicots, generalized flower, monocots, monecious, pistil, pollen grains, tricolpate, zygomorphy	

ASSESSMENT EVIDENCE: Students will show their learning by:

- Diagramming the life cycle of a flowering plant indicating shifts from haploid to diploid cells, and representing female and male gametophyte development.
- Creating a model illustrating key characteristics of both plants and pollinators and explaining how they coevolved.
- Writing lab reports to compile, analyze, and draw conclusions based on recorded data.
- Observing and documenting the adaptation of plants to environmental stress.

KEY LEARNING EVENTS AND INSTRUCTION:

- Diagram five different pollination strategies and the floral characteristics used to promote pollination (Pollination Project).
- Classification of monocots and eudicots (Student Photo Collection).
- Identify the structures and habits that plants have developed (Plant Wars: A Story of Offense and Defense).
- Determine the roles of pollinators (Survival Quest: A pollination Game).
- Propose a unique new species (Create-A-Plant).

SUGGESTED TIME ALLOTMENT	**3 weeks**
SUPPLEMENTAL UNIT RESOURCES	Botany (Mauseth) Textbook Chapter 24 Botany Lab Photographic Atlas and Slide Set

Randolph Township Schools
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Botany Curriculum

Unit IX: Ethnobotany

TRANSFER: Understand that humans rely on plants to provide many resources and that cultivation of plants contributes greatly to human population growth.

STANDARDS / GOALS:	ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. HS-LS1-6 Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.	Humans have relied on plants for food and shelter for at least 125,000 years.	• How long have humans relied on plants? • How did humans first begin to use plants?
	Humans began to domesticate crops about 12,000 years ago.	• What does it mean to domesticate a plant species? • What advantages did humans gain when they shifted from picking wild plants to harvesting planted crops?
	Various plants provide humans with carbohydrates, fats, and proteins.	• What types of plants are high in each of the nutrition requirements of humans? • How have humans identified plants that meet their needs?
	Plants provide spices and other substances that make foods more appealing.	• What is the role of spice in human diets?
	Plants provide drugs that can be helpful and/or harmful.	• How have plants been utilized for both beneficial and harmful drugs?

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Unit IX: Ethnobotany

<table>
<tr><td rowspan="4">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-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.</td><td>Plants provide fibers, chemicals, and wood that humans rely on.</td><td>• What are some plants that produce the most useful fibers?
• How have some chemical been produced from plants?
• Why is wood one of the most important benefits of plants to humans?</td></tr>
<tr><td>Humans have genetically modified plants (called GMOs) to improve their yield, make them pest resistant, increase their resistance to heat or drought, and many other reasons.</td><td>• What are some commonly genetically modified plants?
• Why do scientists genetically modify plants?
• How do scientists genetically modify plants?
• What are the consequences of GMOs?</td></tr>
<tr><td><u>KNOWLEDGE</u>
Students will know:</td><td><u>SKILLS</u>
Students will be able to:</td></tr>
<tr><td>Humans have relied on plants for many resources for over 125,000 years, but that relationship changed with the advent of agriculture 12,000 years ago.

Plants make carbohydrates in many forms with various characteristics that are beneficial in different ways.</td><td>Discuss why humans have always relied on plants for our survival.

Explain how human population growth increased once agriculture was developed.

Identify the different forms of carbohydrates that plants produce.

Explain how humans benefit from these different forms of carbohydrates.</td></tr>
</table>

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Unit IX: Ethnobotany

	Humans utilize the wide variety of proteins, fats, and vitamins that plants produce.	Identify the types of plants that are high in proteins and fats that humans require for a healthy diet. Describe how vitamins are utilized by the human body.
	Plants produce substances like spices, chocolate, vanilla, coffee, and tea which are important to humans.	Explain how humans have used certain substances produced by plants. Categorize the uses and benefits of substance like chocolate, vanilla, coffee, and tea.
	Humans utilize plants for medicinal purposes.	List plants that can be used for medicinal purposes. Describe how both early humans and modern humans rely on various useful properties of plants.
	Humans utilize some plants as drugs, even though they may have a harmful effect on human health.	Discuss the harmful effects that some plant substances can have on human health.
	Plants provide fibers that have been used by humans for a wide variety of functions.	Explain how humans use plant fibers both historically and today. Describe new plants that can provide fibers while causing less harm to the environment.

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Unit IX: Ethnobotany

	Humans have used wood for fuel, protection, and tools. Scientists modify the genomes of plants to increase their usefulness to humans.	Describe humans' use of wood and its impact on the environment. Construct a model of how scientists genetically modify plants. Analyze research to develop a logical argument either for or against the use of GMOs.
	KEY TERMS: acid-free paper, antioxidant, capsaicin, cereal grains, complete/incomplete proteins, engineered wood, ethnobotany, fertile crescent, GMO, gluten, glycemic index, hard/soft fiber, herb, legumes, old growth forest, spice, tetrahydrocannabinol (THC), wood fiber	

ASSESSMENT EVIDENCE: Students will show their learning by:

- Documenting their daily food choices and evaluating them for nutrition, composition of macronutrients, and sustainability.
- Classifying the macromolecules found in plants and use that information to design a meal that is healthy for humans and has minimal environmental impact.

KEY LEARNING EVENTS AND INSTRUCTION:

- Document the effects that humans have on plants (Ethnobotany Research project).
- Prepare meals and explain their impact on the environment (Sustainable Feast).

SUGGESTED TIME ALLOTMENT	**3 weeks**
SUPPLEMENTAL UNIT RESOURCES	Botany (Mauseth) Textbook Chapters 3 and 16

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Unit X: Ecology and Environmental Science

TRANSFER: Understand that ecosystems are made up of biotic and abiotic factors that interact and affect the growth of populations in communities and human activity can have a significant impact on these ecosystems.

STANDARDS / GOALS:	**ENDURING UNDERSTANDINGS**	**ESSENTIAL QUESTIONS**
HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. HS-LS1-6 Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.	Both abiotic and biotic factors can impact organisms.	• How are plants reliant on biotic factors and abiotic factors? • When can abiotic factors be more critical for plants than other organisms?
	Energy flows and matter cycles through ecosystems.	• What roles do plants play in the flow of energy within an ecosystem? • What roles do plants play in the cycling of matter within an ecosystem?
	There are four common structures of ecosystems.	• How are ecosystems structured? • What common interactions that happen within ecosystems?
	Many factors affect community diversity.	• How can the number of species within a community be affected?
	Biomes are groupings of ecosystems that are distinctive and contain similar species.	• What factors influence the composition of biomes?
	Human activity often has a significant, negative effect on ecosystems.	• How have humans affected the ecosystem?

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Unit X: Ecology and Environmental Science

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-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. 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.	**KNOWLEDGE** **Students will know:**	**SKILLS** **Students will be able to:**
	Climate, soil, latitude, altitude, and disturbances affect organisms. Other plant species as well as other organisms can affect plants. Competition, mutualism, and herbivory are interactions between organisms that can affect the growth of populations. Plants are critical to the flow of energy and the cycling of matter in an ecosystem. Different botanists study the structure of ecosystems in different ways.	List some critical abiotic factors within all plant ecosystems. Discuss the role that disturbances can play within an ecosystem. Describe how plants interact with other species. Illustrate some important interactions plants have with other organisms. List the major interactions that occur in all ecosystems. Use model species to examine interactions. Name the steps involved in the flow of energy within an ecosystem. Name the steps involved on the cycling of matter within an ecosystem. Compare and contrast energy and matter with respect to plants and ecosystems. Describe four common ecosystem structures. Explain how the amount of plant species diversity is so critical to overall ecosystem structure.

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Unit X: Ecology and Environmental Science

HS-LS2-8 Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.	Scientists measure community diversity and study the changes that occur in a community over time.	Name the common types of changes that happen within ecosystems over time. Model critical aspects of communities that influence ecosystem development.
	A keystone species has an impact out of proportion with its size or the number of individuals present.	List several examples of a keystone species. Describe the role that keystone species have within an ecosystem. Analyze why keystone species loss can severely change an ecosystem.
	The climate of a particular area is determined by its size, latitude, nearby ocean currents, wind, and rain shadows produced by mountains.	Explain the role of climate in sustaining life. Describe how climate is influenced by both global and local features. Illustrate some local features that affect ecosystems.
	Humans' use of natural resources, agriculture, and urbanization can dramatically impact ecosystems.	Describe how humans' energy use impacts ecosystems. Evaluate the different types of farming (corporate, organic, sustainable) and how they affect ecosystems. Describe how human population growth can contribute to deforestation, soil erosion, habitat loss, invasive species, and global climate change.

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Unit X: Ecology and Environmental Science

	A biome is an extensive grouping of ecosystems characterized by the distinctive aspects of the dominant plants.	Describe where biomes fall within the levels of organization on Earth. Discuss how scientists describe biomes as groupings of similar ecosystems.
	KEY TERMS: carrying capacity, community, competition, ecosystem, habitat, herbivory, k-selected, limiting factor, mutualism, pioneers, population, predation, primary producers, primary consumers, r-selected, trophic range, climax community, energy flow web, food web, habitat fragmentation, habitat loss, invasive species, keystone species, maximum sustained yield, primary succession, secondary succession, alpine tundra, arctic tundra, biomes, boreal coniferous forest, chapparal, deserts, grassland, montaine forests, permafrost, rain shadow, savanna, shrublands, taiga, temperature deciduous forest, temperate rainforest, tropical rainforest, tundra, agriculture, deforestation, global climate change, soil erosion, urbanization	

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Unit X: Ecology and Environmental Science

ASSESSMENT EVIDENCE: Students will show their learning by:

- Writing lab reports to compile, analyze, and draw conclusions based on recorded data.
- Observing and documenting the flow of energy through an ecosystem.
- Predicting the impact of an environmental disturbance on an ecosystem.
- Investigating the origin and impact of an invasive species and constructing a plan to control and possibly eliminate it.

KEY LEARNING EVENTS AND INSTRUCTION:

- Illustrate multiple characteristics of a biome (Biome Postcards).
- Model the interaction between producers and consumers (Herbivory Activity).
- Trace the movement of energy within an ecosystem (Energy Flow Lab).
- Research and repost the impacts of an invasive species (Invasive Species Project).

SUGGESTED TIME ALLOTMENT	**5 weeks**
SUPPLEMENTAL UNIT RESOURCES	Botany (Mauseth) Textbook Chapters 25-27

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APPENDIX A

Mauseth, J. D. (2021) *Botany: An Introduction to Plant Biology, 7th Ed.* Jones and Bartlett Learning.

Rushforth, S. R., Robbins, R. R., Crawley, J. L., Van De Graaff, K. M. (2016) *A Photographic Atlas for the Botany Laboratory, 7th Ed.* Morton Publishing.

Web Resources:
http://labsci.stanford.edu/images/Botany-SA.pdf
http://www.lamission.edu/lifesciences/bio3labs/Bio3%20Lab6%20-%20Photosynthesis%20%20Respiration%20-%20To%20Post.pdf
http://www.lamission.edu/lifesciences/bio3labs/Bio3%20Lab6%20-%20Photosynthesis%20%20Respiration%20-%20To%20Post.pdf
https://www.wlwv.k12.or.us/cms/lib/OR01001812/Centricity/Domain/1338/LAB%20-%20Plant%20Pigment%20Chromatography_NM_NEW.pdf
https://teachingapscience.com/everything-ecocolumns/
https://www.sciencealert.com/hundreds-of-years-of-tree-rings-reveal-an-extreme-weather-anomaly-that-began-in-the-20th-century
http://www.tnstate.edu/faculty/ablalock/documents/Plant%20Propagation%20101.pdf
https://scied.ucar.edu/tree-ring-interactive
https://www.morriscountyfarms.com/
https://appliedeco.org/product/new-national-native-plant-curriculum-project-botany/

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APPENDIX B

Opportunities exist for interdisciplinary units with courses such as Biology, Environmental Science, Genetics, Business, Technology, or other science and mathematics courses and electives.