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SCIENCE AND GLOBAL ISSUES

BIOLOGY

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NGSS Biology: Looking for Patterns in Species Diversity

Science & Global Issues: Biology – Ecology Unit

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The Lawrence Hall of Science

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Science Education for Public Understanding Program (SEPUP)

- Based at the Lawrence Hall of Science, University of California at Berkeley
- Designing science curriculum, working with teachers, and supporting quality science instruction since 1983
- Specializing in issue-based science
- Published by Lab-Aids (www.lab-aids.com)

Why Issues?

In order for students to develop a sustained attraction to science and for them to appreciate the many ways in which it is pertinent to their daily lives, classroom learning experiences in science need to connect with their own interests and experiences.

Next Generation Framework

National Research Council, 2011

Science and Global Issues: Biology

- Redesigned for the NGSS
- Covers all high school NGSS PEs for Life Science
- Sustainability framework

Unit Theme	Content Focus	Sustainability Focus
Changing Human Impact	Sustainability	4-activity Introduction
Living on Earth	Ecology	Human influence on ecosystems
Improving Global Health	Cell Biology	Global health issues
Feeding the World	Genetics	Genetic modification
Managing Change	Evolution	Changes and threats to biodiversity

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SGI Units

Ecology: Living on Earth

- **Unit Issue**: People rely on natural resources, including fish, for many reasons, including food, yet many of these fisheries are no longer sustainable.
- **Overarching Question**: How can we use our knowledge about ecology to make informed decisions about managing fisheries to be more sustainable?

Cells: Improving Global Health

- **Unit Issue**: Human health is increasingly subject to emerging global patterns, including extreme heat events, changes in the frequency of diseases, and climate effects on the food supply.
- **Overarching Question**: What are the challenges to human health in a changing world?

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SGI Units

Genetics: Feeding the World

- **Unit Issue**: People rely on genetically engineered crop plants to maintain a global food supply, but the use of this technology can impact sustainability.
- **Overarching Question**: How do genetically engineered crops affect the sustainability of food production?

Evolution: Managing Change

- **Unit Issue**: Human activity can have evolutionary consequences for both biodiversity and ourselves.
- **Overarching Questio**n: How do human activities affect the evolution of other species, and what are the consequences for both biodiversity and for ourselves?

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Why Sustainability?

- More avenues to relevance for students, both local and global.
- Issues clearly relate to science.
- Sustainability decision-making and scientific literacy are closely related–one has the potential to develop and inform the other.

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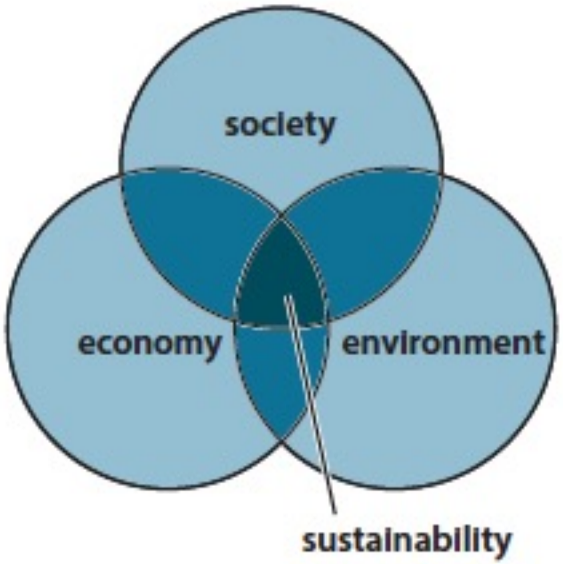
3 Pillars of Sustainability

- Economic Pillar
  - How does the action affect the economy? Does it create or take a way jobs? What is the financial cost or benefit?
- Social Pillar
  - How does the action affect social aspects of the community? Does it protect or improve human health? How does it affect food availability, human interactions, etc.?
- Environmental Pillar
  - How does the action affect the environment? Does it protect or endanger critical ecosystems? Does it create or reduce pollution?



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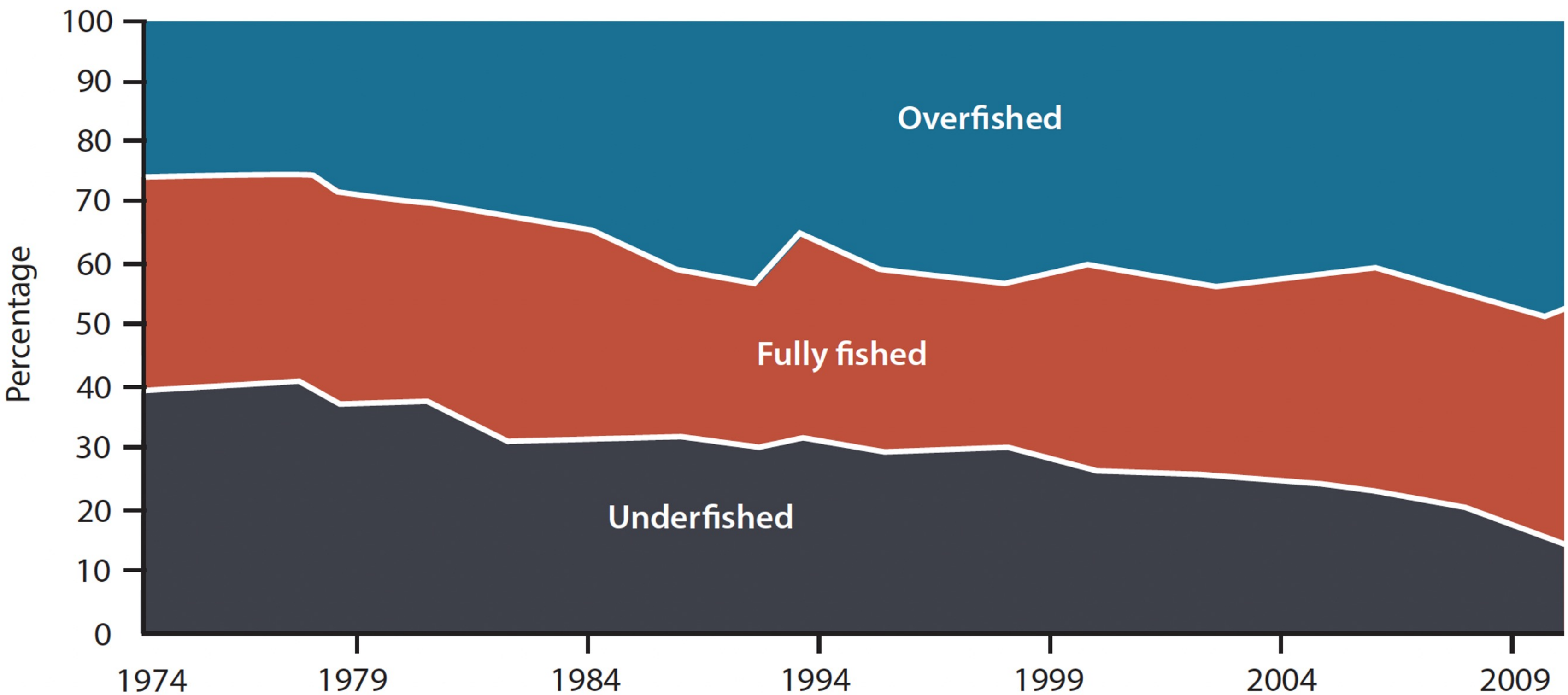
Ecology: Living on Earth

- Unit Issue: *People rely on natural resources, including fish, for many reasons including food, yet many fisheries are no longer sustainable.*

FIGURE B: *Sustainability of fisheries over time*



Ecology: Living on Earth

Learning Sequence	Activities	Investigative Phenomenon	Performance Expectations Addressed
1	1-3	Different populations of organisms can have a wide range of growth patterns over time.	HS-LS2-1
2	4-5	Coral reefs do not all look the same and can be quite different from one another in several ways.	HS-LS2-2
3	6-10	The population of Southern Resident orcas in the Pacific Northwest has not recovered, despite protection from hunting and capture.	HS-LS2-3, HS-LS2-4
4	11-12	Earth's atmospheric carbon dioxide levels have cycled between 300 ppm and 180 ppm for the past 800,000 years ago, until recently.	HS-LS2-5
5	13-17	Ecosystem health can vary.	HS-LS2-6, HS-LS2-7

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PE HS-LS2-2

- PE: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems on different scales.
- SEP:
  - Using mathematics and computational thinking
- DCI:
  - Interdependent relationships in ecosystems
  - Ecosystem dynamics, functioning, and resilience
- CCC:
  - Scale, proportion, and quantity

Activity 4– Scaling Up: Ecosystems

Investigative Phenomenon:

What similarities and differences do you notice?

In the previous learning sequence, you explored individual populations of organisms and factors affecting them. Populations are part of ecosystems that include many kinds of organisms. The song sparrows are part of the Mandarte Island ecosystem, which also includes cowbirds and many other organisms. Coral reefs are another type of ecosystem. Imagine a coral reef in your mind. Which of the photos in Figure 4.1, all of coral reefs, most closely resembles what you imagined? What similarities and differences do you notice among the different reefs? What factors do you think could contribute to these differences? In this learning sequence, you will explore factors that explain some of the differences among ecosystems.






FIGURE 4.1: Coral reefs can be many different shapes, sizes, and colors.

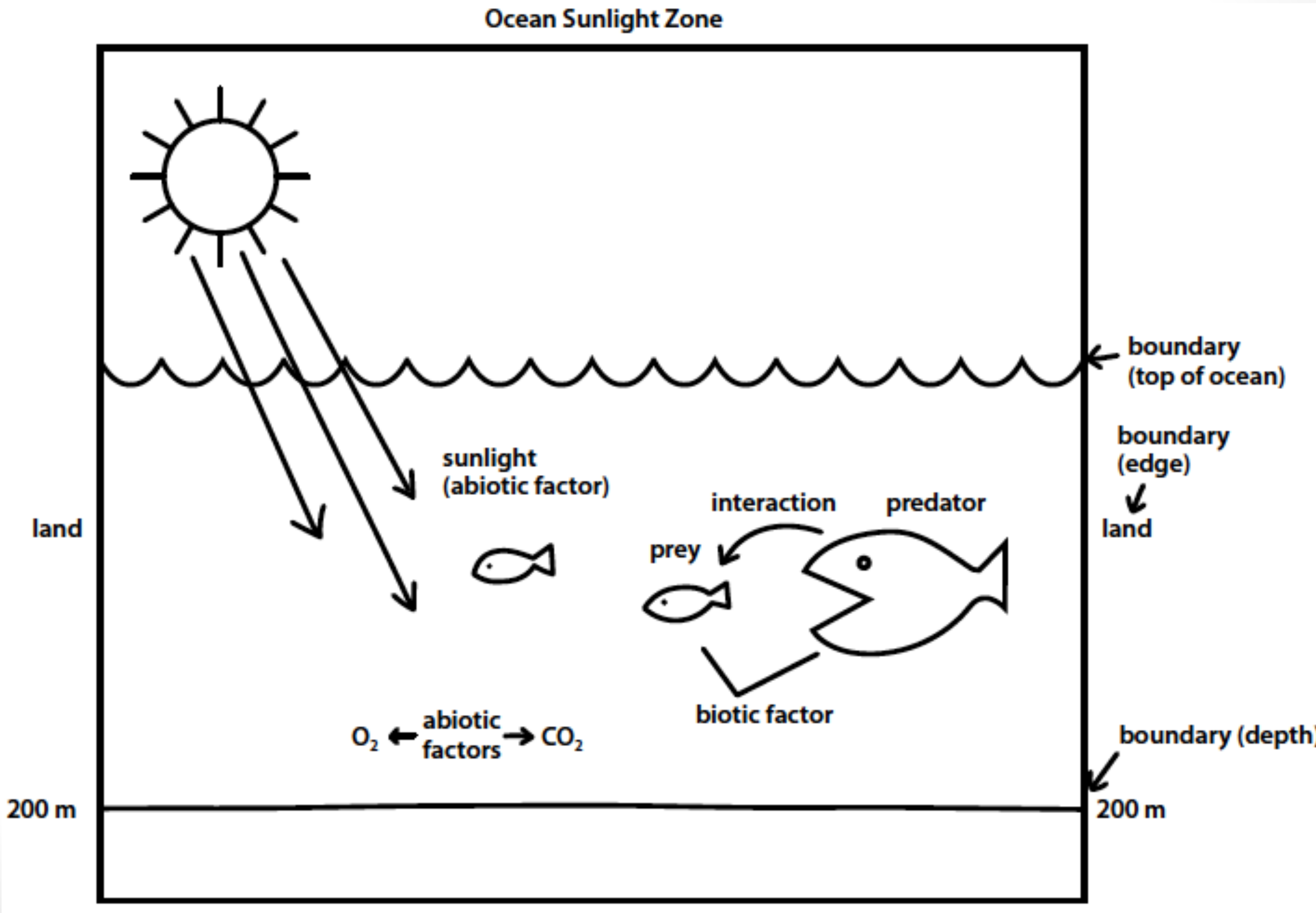
Activity 4–Scaling Up: Ecosystems

- Driving Questions Board
  - *What are the factors that determine the biological diversity of an ecosystem?*
- Introduction & Guiding Question:
  - *What defines an ecosystem?*
- Crosscutting Concept: *Systems and system models*
- Crosscutting Concept: *Scale, proportion and quantity*
- Procedure Step 3
  - Student Sheet 4.1

Activity 4–Scaling Up: Ecosystems

	Ocean Sunlight Zone	Coral Reefs	Intertidal Zone	Humpback Whale Respiratory System
Components	organisms, light, temperature, salinity, depth	organisms, light temperature, depth	organisms, light temperature, air exposure	organisms, oxygen, carbon dioxide
Interactions	abiotic/biotic, predator-prey	abiotic/biotic, predator-prey	abiotic/biotic, predator-prey	abiotic/biotic, predator-prey mutualism
Boundaries	above 200 m	Tropics of Cancer/ Capricorn	near shore, water levels	whale's respiratory system
Scale	most extensive on Earth	about 285,000 km^2	some 100s of meters, some less than 1 meter	size of respiratory system

Activity 4–Scaling Up: Ecosystems



Activity 4–Scaling Up: Ecosystems

Small group and then class consensus on definition of ecosystem:

An ecosystem is a set of biotic and abiotic components that interact on a regular basis within a particular boundary.

Activity 4–Scaling Up: Ecosystems

- Build Understanding Items:
  - Issue Connection (BU 3)
  - Revisit scale, proportion, and quantity (BU 4)
  - Revisit guiding question (BU 5)
- Extension: Engineering Connection

Activity 5–Patterns of Biological Diversity

- Do all places have the same number of species?

- Introduction & Guiding Question:
  - *What patterns of biological diversity occur for different groups of organisms, and what might cause these patterns?*
- Crosscutting Concept: *Patterns*
- Part A: Procedure Steps 1-4
  - Step 1: Explain based on Figure 5.1
  - Steps 2 & 3: Add data, build your explanation
  - Step 4: Revise your explanation

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Global Coral Diversity

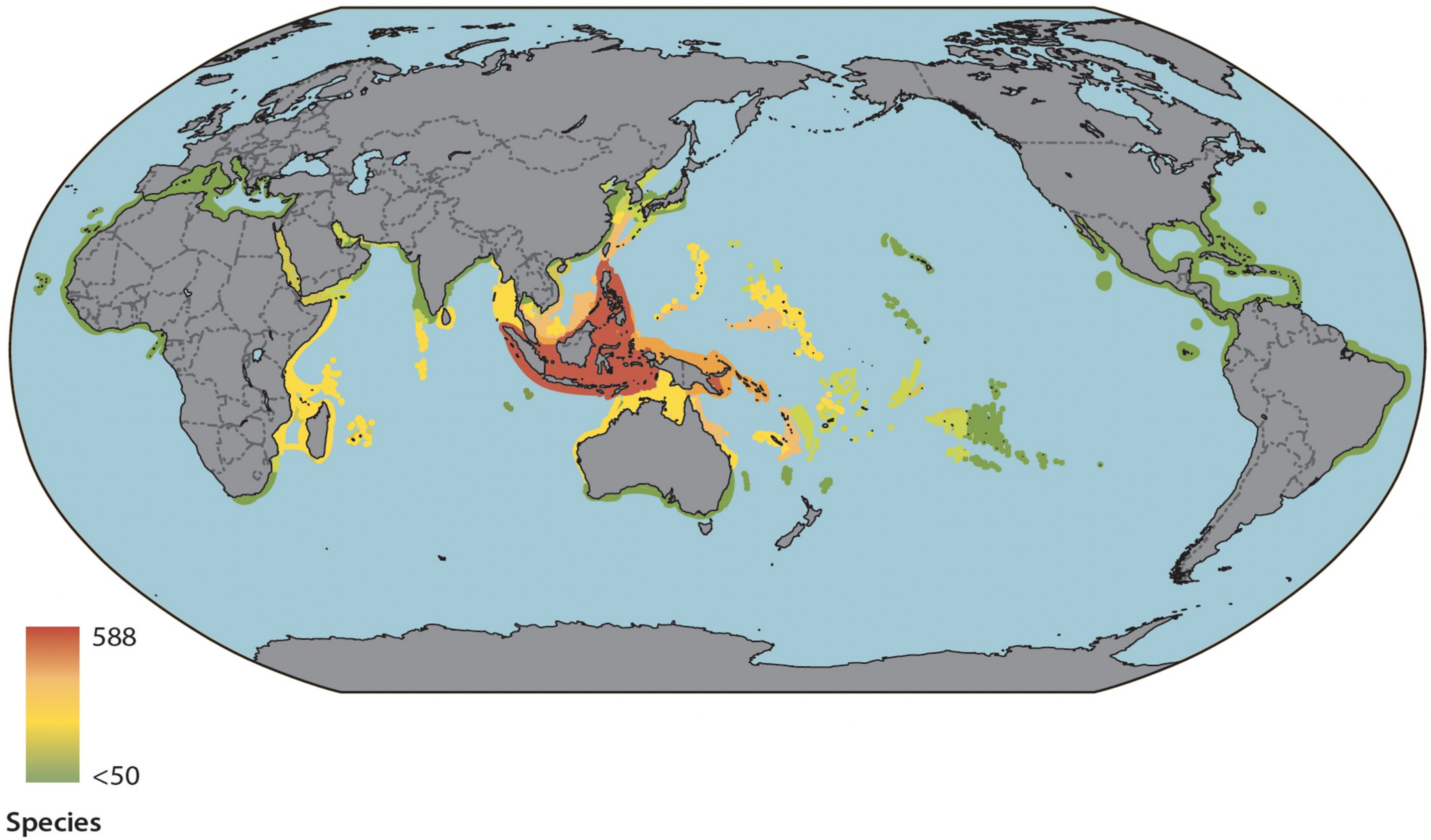
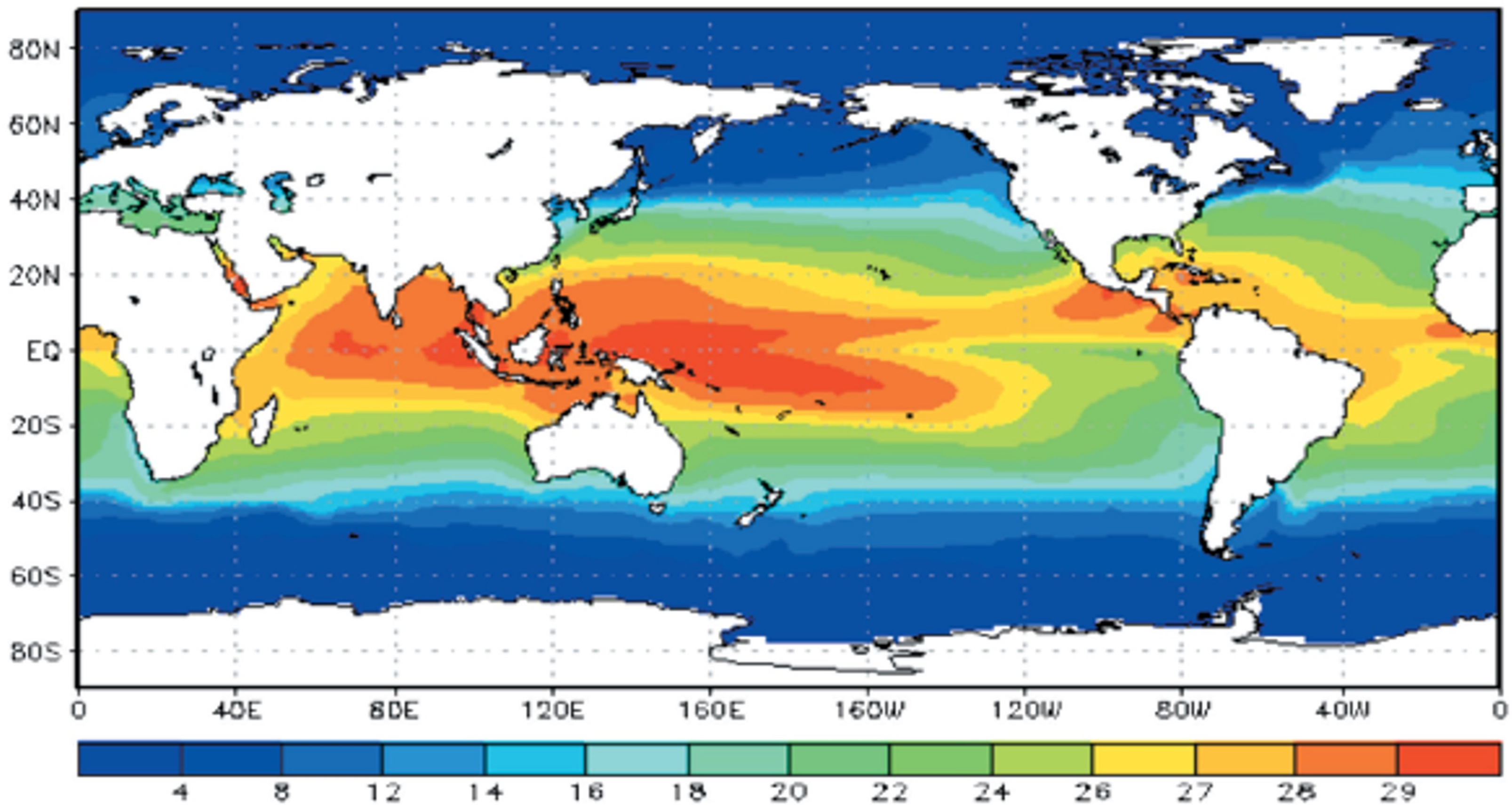


FIGURE 5.1: *Global coral diversity*

Ocean Surface Temperature



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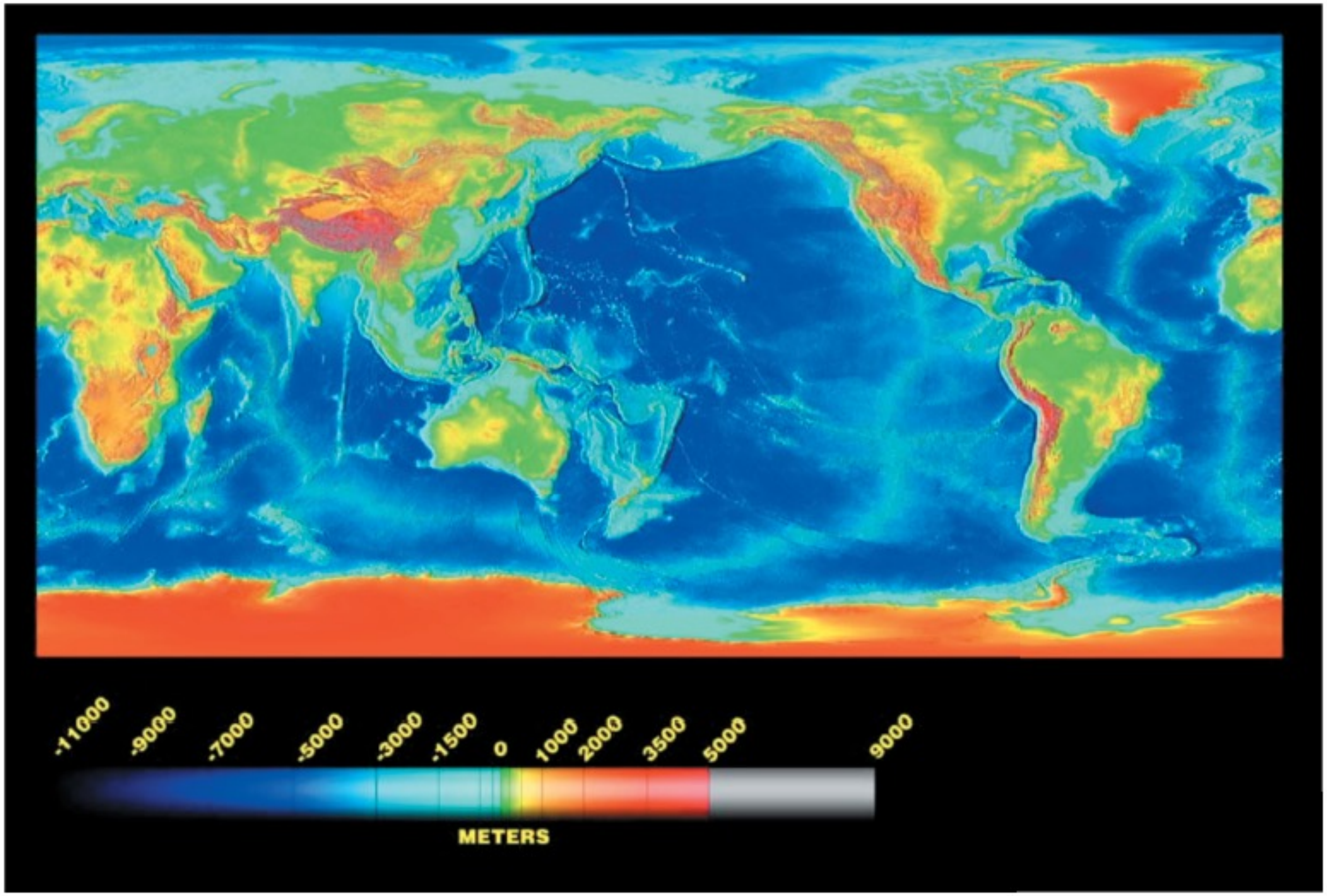
Ocean Depth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-9000
-7000
-5000
-3000
-1500
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3500
5000
9000
METERS

Activity 5–Patterns of Biological Diversity

- Part B: Procedure Steps 5-10
  - Step 5: Vertebrate Diversity Map–reptiles, amphibians, birds, or mammals
- **Reptiles**, such as snakes, lizards, turtles, and crocodiles, are *ectothermic* (cold-blooded) vertebrates. They are characterized by having dry scaly skin, and typically lay soft leathery eggs on land. Reptiles have four limbs or, like snakes, are descended from four-limbed ancestors.
- **Amphibians**, such as frogs, salamanders, toads, and newts, are *ectothermic* (cold-blooded) vertebrates. They typically start their lives as larva living in water and using gills to breathe. As they grow, amphibians develop lungs and spend more time on land.
- **Birds** are *endothermic* (warm-blooded) vertebrates that are characterized by having feathers, laying hard-shelled eggs, and (typically) being able to fly. Birds inhabit every continent and are the most diverse group of vertebrates on Earth.
- **Mammals**, such as humans, koalas, bats, dolphins, and whales, are *endothermic* (warm-blooded) vertebrates. Mammals are characterized by having hair or fur, producing milk to feed their young, and (typically) having live births, rather than from eggs. There are over 4,000 different species of mammals worldwide that live in a variety of habitats.

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Activity 5–Patterns of Biological Diversity

- Part B: Procedure Steps 5-10
  - Step 6: Examine with your group, discuss ideas
  - Step 7: Abiotic Factor Maps, start with Elevation & Topography as a group
  - Step 8: Examine remaining maps individually
  - Step 9: Share observations
  - Step 10: Discuss data and how it might account for patterns

Activity 5–Patterns of Biological Diversity

- Build Understanding Items:
  - PE Assessment (BU 1)
    - Writing Frame
    - Writing Review
  - Revisit Investigative Phenomenon (BU 3)
  - Issue Connection (BU 4)

Teacher's Guide Highlights

- Storyline by learning sequence and by activity
- Sensemaking Progression for each activity
- Connections to Crosscutting Concepts and Science and Engineering Practices
- Diverse Learner supports
- Writing Frames & Writing Review
- NGSS correlations for formative assessments (dots)
- Assessments & Scoring Guides
  - Item-Specific PE Scoring Guides
  - Sample leveled responses

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Item-Specific Scoring Guides

Item Specific Scoring Guide – PE-HS-LS2-2

Constructing Explanations (EXP)

Level	Description	Specific Response
Level 4 Complete and correct	The student's explanation • is supported by sufficient use of appropriate evidence and concepts* AND • links the evidence and concepts to provide a clear and complete causal mechanism for the phenomenon.	The student's response • considers all abiotic factors and identifies which factors are most important in explaining the pattern of distribution for their vertebrate group AND which factors do not seem important, using data from the maps • provides a possible causal mechanism for why the factors are important, based on characteristics of the vertebrate group • in Part b, provides an explanation for how their answer changed as they examined additional factors • in Part c, provides a plausible explanation for whether they would see the same pattern at a larger scale
Level 3	The student's explanation	The student's response

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Units

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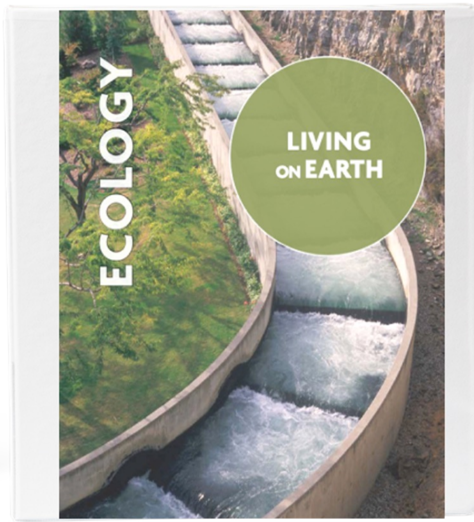

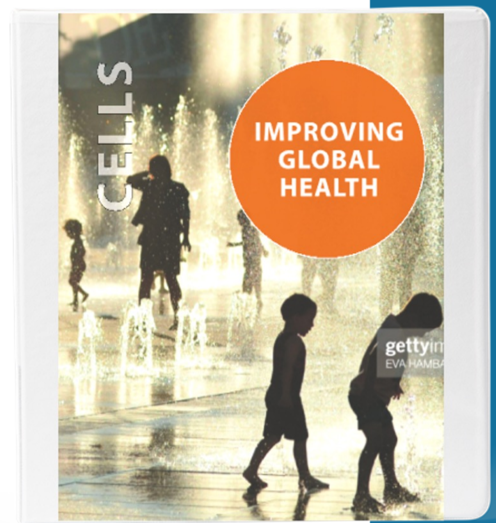

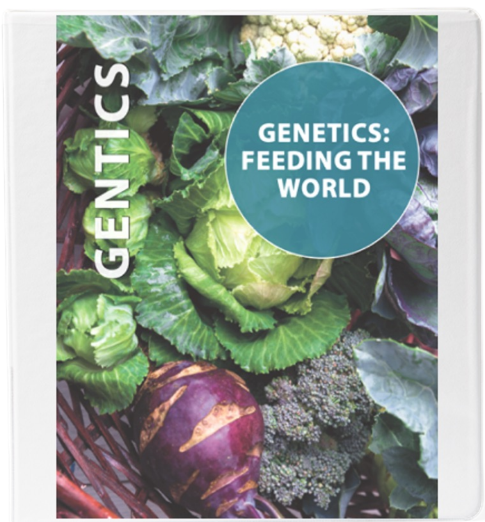

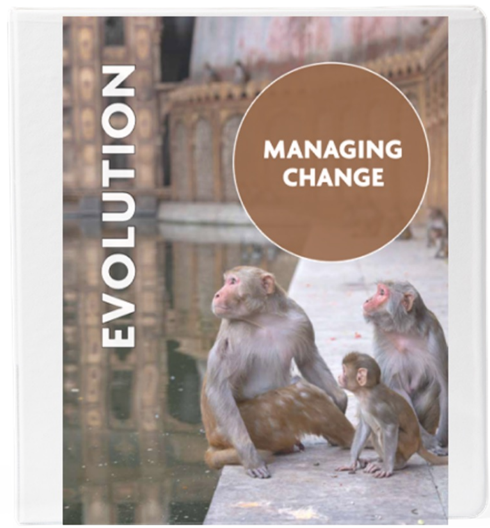

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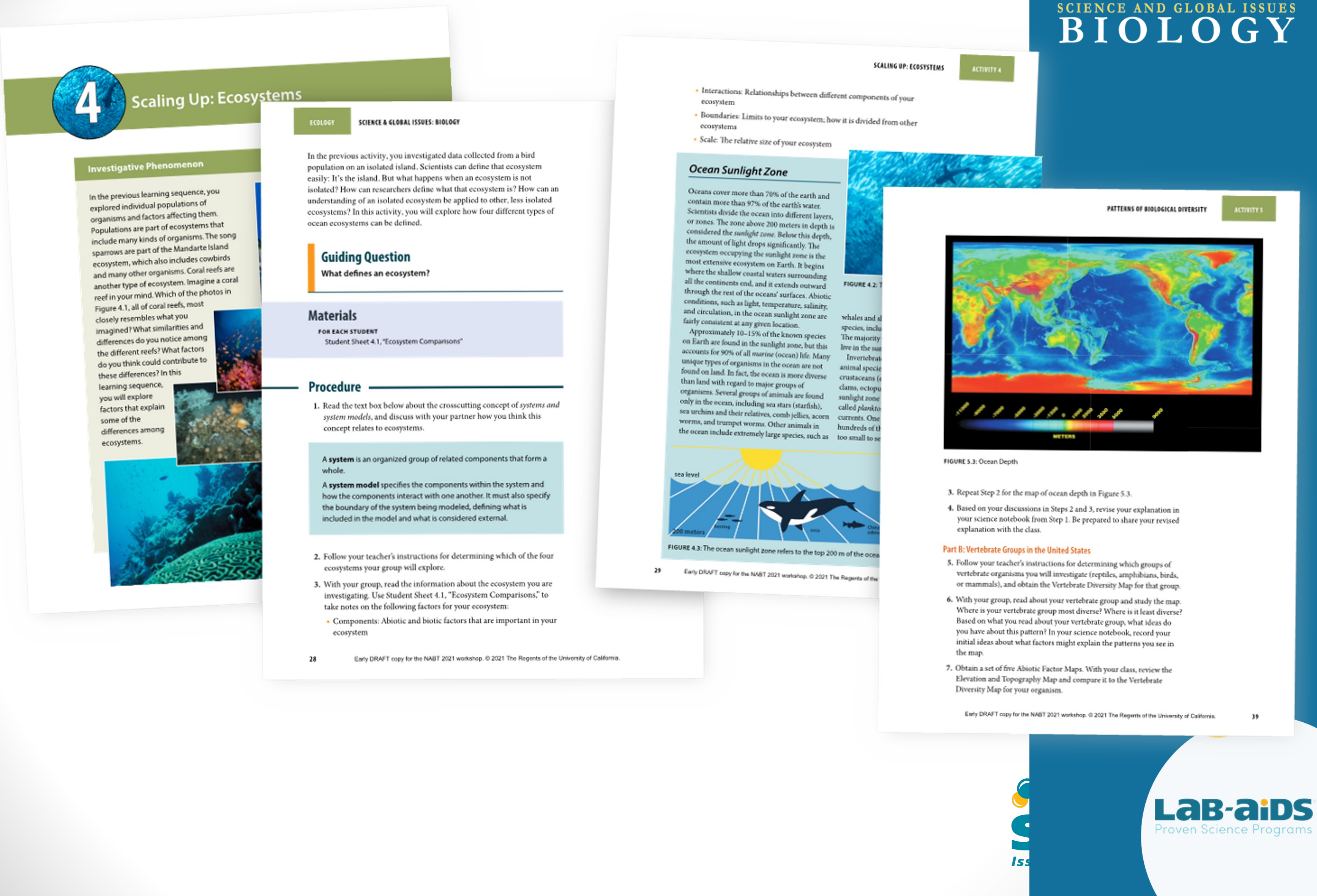
Student Book



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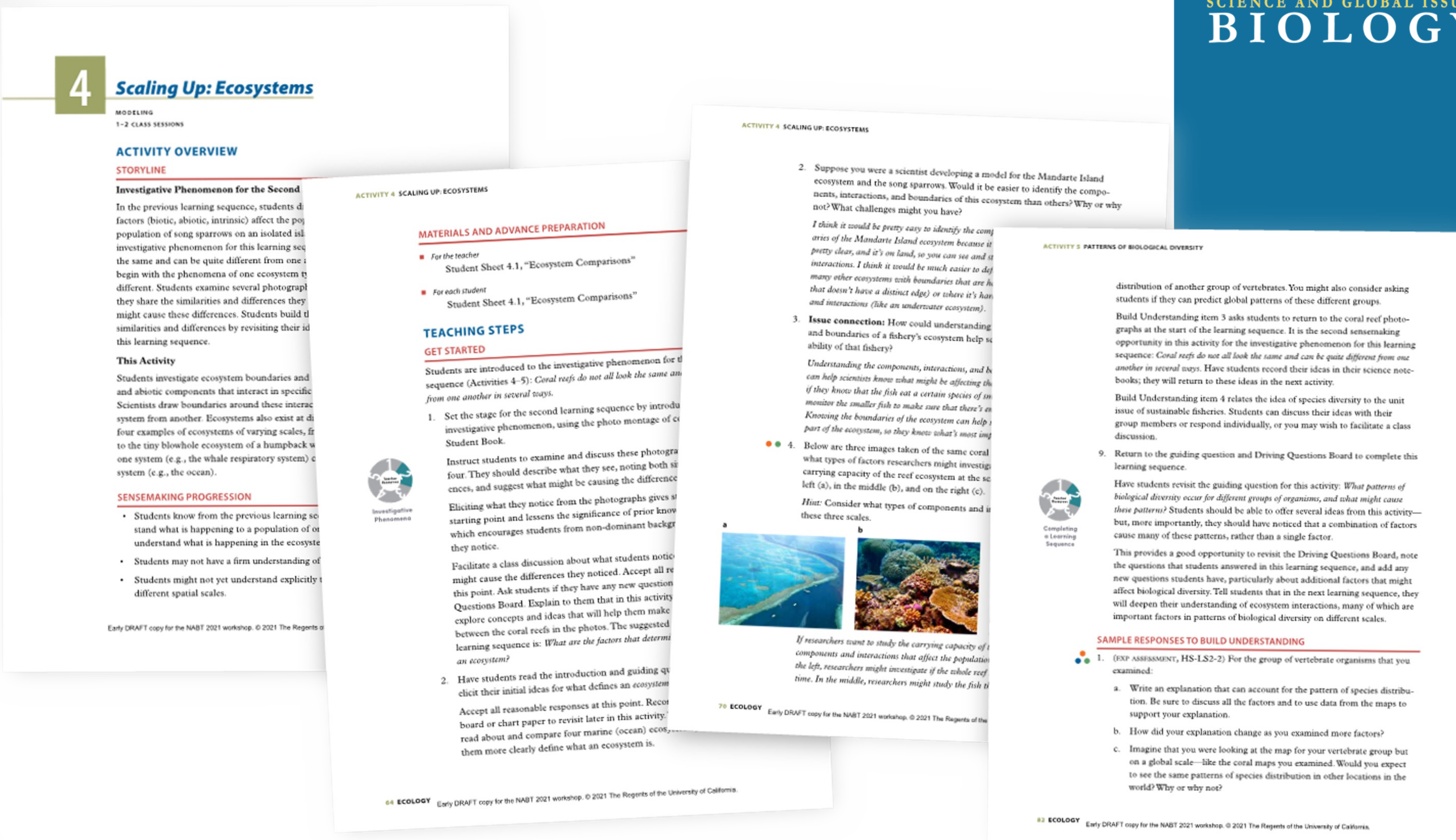

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NGSS OVERVIEW

CELLS: IMPROVING GLOBAL HEALTH

Performance Expectations

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-LS1-5: 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-LS2-3: Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

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-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Activity	NGSS Integration	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
1	**Survival Needs** A scenario involving an environment of extreme heat motivates students' exploration of the phenomenon of *homeostasis* and the environmental conditions that can challenge the body's ability to maintain homeostasis. Students investigate the effects of extreme heat by imagining a survival scenario in a desert and ranking the importance of 13 items (such as food, water, and clothing) for survival. Through this exploration of challenges to homeostasis, students develop concepts related to stability and change in the human body. Students begin to generate questions about how the body maintains homeostasis.	LS1.A ETS1.B	Asking Questions and Defining Problems	Stability and Change Patterns	Mathematics MP.2

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Activity	NGSS Integration	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
2	**Everyday Hydration** Students consider the effects of dehydration on the structure and function of the human body, using plant cells as a model. Students conduct an investigation of plant cells to explore the effects of changing conditions on homeostasis at the level of the cell. They apply what they observe at the cellular level to create an explanation of how these changing conditions affect other levels of structure and function. A question about tourist water consumption raises the issue of sustainability and prompts students to weigh evidence and consider the trade-offs of limiting the number of tourists at popular travel destinations. Note: "Review and Refresh: Cell Structure and Function," an optional reading provided in the Student Book, can serve as either a review of NGSS middle school cell concepts or a reference for students.	LS1.A	Constructing Explanations and Designing Solutions Planning and Carrying Out Investigations	Stability and Change Scale, Proportion, and Quantity	ELA/Literacy RST.11-12.3
3	**Homeostasis Disrupted** Students explore three case studies on infectious and non-infectious diseases that explain how disruptions to homeostasis can result in illness or be caused by illness. They examine models of how the body's systems and subsystems work together to maintain homeostasis when challenged with changing external or internal conditions. The role of negative feedback loops in maintaining homeostasis is introduced. Students apply what they learn about specific feedback loops to create another model.	LS1.A	Developing and Using Models Constructing Explanations and Designing Solutions	Systems and System Models Stability and Change Cause and Effect	ELA/Literacy RST.9-10.1

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Activity	NGSS Integration	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
4	**Body Systems in Balance** As students sort cards representing levels of organization in the human body system, they develop models of four different systems—cardiovascular, digestive, respiratory, and endocrine—at varying levels of organization and scale. They apply what they learn to construct explanations for how various diseases disrupt the normal functions of body systems and	LS1.A	Developing and Using Models Constructing Explanations and Designing Solutions	Structure and Function Stability and Change Systems and System Models Scale, Proportion, and Quantity	ELA/Literacy RST.9-10.7
			Constructing Explanations and Designing Solutions Connections to Nature of Science	Connections to Nature of Science Stability and Change Structure and Function	ELA/Literacy RST.9-10.7
			Developing and Using Models Constructing Explanations and Designing Solutions	Systems and System Models Structure and Function Scale, Proportion, and Quantity	ELA/Literacy SL.11-12.5 ELA/Literacy WHST.9-12.9

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TEACHER PREPARATION OVERVIEW

GENETICS: FEEDING THE WORLD

Listed below is a summary of the activities in this unit. Note that the total teaching time as listed is 23–34 periods (approximately 4½–7 weeks) if you teach the activities as recommended every day).

Activity	What Students Do	Key Scientific Terms	Advance Preparation	Class Sessions
1	**Investigation: Superweeds! Where Did They Come From?** Students brainstorm, generate, and consider different ways that superweeds could have gotten into Farmer Green's fields.	**herbicide** **superweed**	Prepare Student Sheets.	1–2
2	**Laboratory: Creating Genetically Modified Bacteria** Students genetically modify a population of *E. coli* and read a case study about genetic engineering.	**biofuel** DNA gene **gene expression** **genetic engineering** **genetically modified organism (GMO)**	Order live materials in time for class use. Prepare Student Sheets. Prepare LB-only and LB-ampicillin plates. Prepare E. coli source plates. Prepare tubes of plasmid and CaCl2. Decide how students will share the ultraviolet light source. Gather materials for student groups and prepare water bath.	2–3
3	**Modeling: Mitosis and Asexual Reproduction** Students work with an online simulation and physical models to explain the process of mitosis.	asexual repro-duction centromere chromatid chromosomes daughter cells **mitosis** parent cell	Preview the mitosis simulation. Locate additional mitosis simula-tions. (optional) Prepare Student Sheets.	1–2
4	**Investigation: Breeding Corn** Using the traditional model of the Punnett square, students analyze and predict the results of genetic crosses for one trait and are introduced to the concept of *selective breeding* as one way to improve crops.	**alleles** **dominant** **Punnett square** **recessive** **selective breeding** sexual reproduction trait	Prepare Student Sheets.	1–2

Activity	What Students Do	Key Scientific Terms	Advance Preparation	Class Sessions
5	**Investigation: Breeding Corn For Two Traits** Students continue their investigation of patterns of heredity, expanding their model from the last activity to explore two inherited traits, and they read about the history of selective breeding in corn.	llele **dihybrid cross** gamete **genome** genotype phenotype Punnett square selective breed-ing trait	Laminate the corn ears and gather dry-erase markers. (optional) Prepare Student Sheets.	2
6	**Talking It Over: How Did This Happen? Class Consensus** Students draw on their understanding of genetic inheritance to generate a class consensus explanation of how superweeds most likely arrived in the farmer's corn fields and were able to spread.	genetic engineer-ing genome phenotype Punnett square selective breed-ing trait	None	1
7	**Modeling: Protein Synthesis: Transcription and Translation** Students use cards, physical models, and online simulations to explore the molecular process of protein synthesis and what happens inside a plant's cell when a genetic modification is introduced.	**amino acid** DNA **mRNA** mutation protein **protein synthesis** RNA **transcription** **translation** **tRNA**	Prepare Student Sheets. Preview the protein synthesis simulation. Photocopy the Transcription and Translation cards. (optional)	2–3
8	**Modeling: Cell Differentiation and Gene Expression** Students use a physical model to investigate gene expression as it relates to cell differentiation in different cell types.	chromosome **differentiation** DNA expressed (gene) gene expression **repressed (gene)** **stem cells** **transcription factor**	Prepare Student Sheets.	1–2

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SUPPORTS FOR DIVERSE LEARNERS OVERVIEW

ECOLOGY: LIVING ON EARTH

This table summarizes activity-specific supports that are embedded in the Student Book and Teacher Edition (TE). Additional strategies can be found in the Teacher Resources.

Activity	Strategy location	Designed to address
1	TE Step 2, Class Discussion	Students' varied life experiences
2	TE Step 4, Class Discussion	English language development
3	Extension	Opportunities for advanced learning
4	TE Step 2, Small-Group Work	Equitable participation
4	Extension	Opportunities for advanced learning
6	TE Step 11, Class Discussion	Equitable participation
6	Extension	Opportunities for advanced learning
8	TE Step 4, Do the Activity	Learning disabilities and/or neurodiverse learners
8	Extension	Opportunities for advanced learning
9	TE Step 11, Build Understanding Items	Learning disabilities and/or neurodiverse learners
9	Extension	Opportunities for advanced learning
10	TE Step 6, Class Discussion	Equitable participation
11	Extensions 1 and 2	Opportunities for advanced learning
14	TE Step 5, Class Discussion	Students' varied life experiences
14	Extensions 1 and 2	Opportunities for advanced learning
15	Extension	Opportunities for advanced learning
16	TE Step 2, Do the Activity	Learning disabilities and/or neurodiverse learners
16	TE Step 5, Class Discussion	Students' varied life experiences
16	Extension	Opportunities for advanced learning

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Materials Packages

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Online Platform

- Syncs with LMS such as Google Classroom, Schoology, Clever, etc
- Fully digital student book and TE
  - Can be read aloud to students using ReadSpeaker
  - Highlight/take notes right on the page
  - Spanish
- Editable PowerPoint files for each Activity
- Student worksheets
- Videos of all hands-on activities
- Remote learning supports
- Digital assessment tools
  - item banks by unit
  - ability to create assessment items in a variety of formats
  - automatically scored items

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Professional Learning

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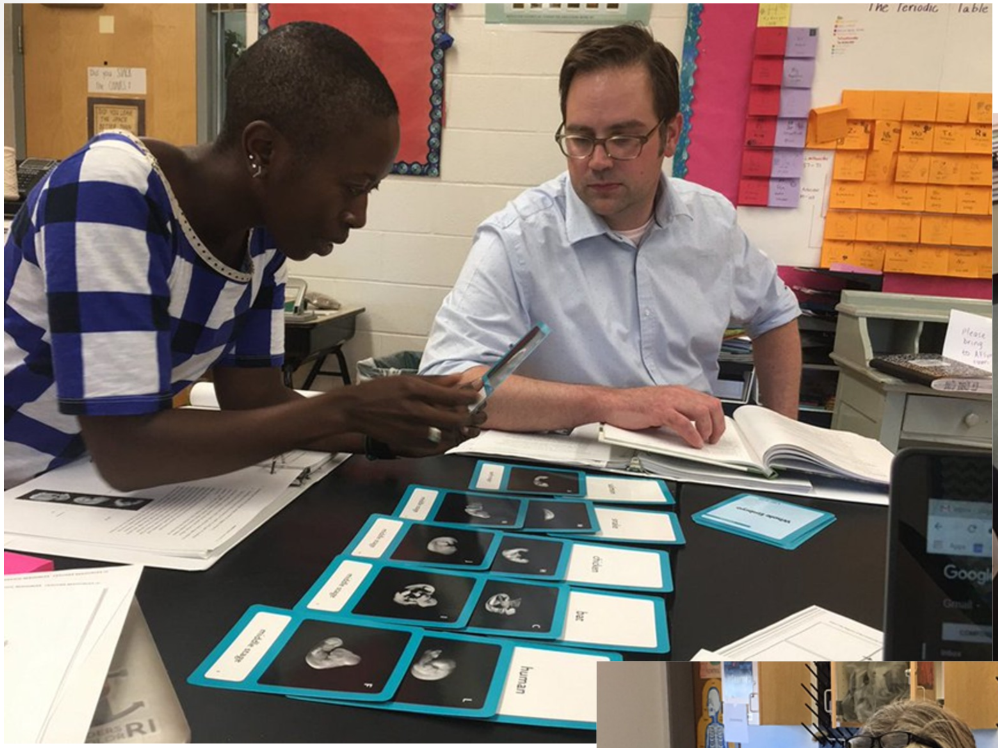

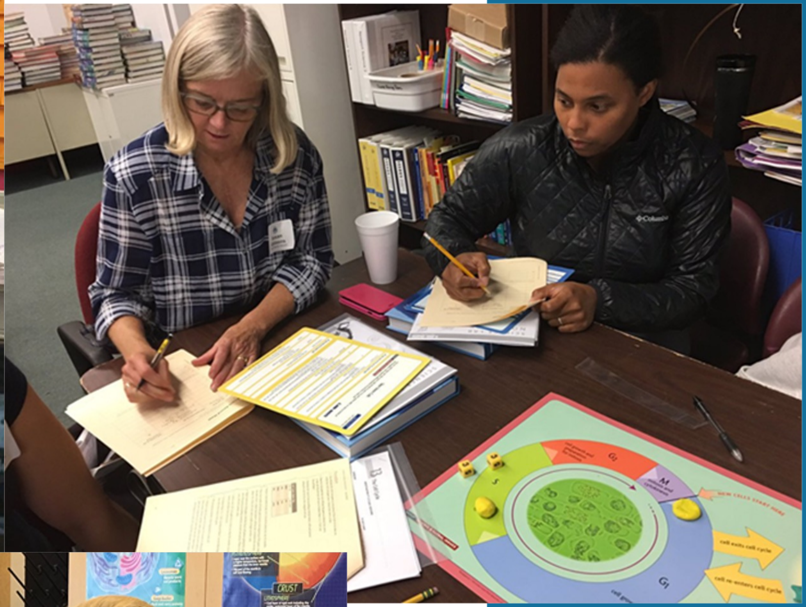

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