Habitat Earth

Educator Guide

Grade 3–Grade 5

What's Inside:

A. SHOW OVERVIEW

B. KEY CONCEPTS

C. VOCABULARY

D. MUSEUM CONNECTIONS

E. RESOURCES

CALIFORNIA ACADEMY OF SCIENCES

We live in a connected world...

Habitat Earth explores the dynamic connections that exist within and between Earth's ecosystems. This show uses cutting-edge science visualization to take you on an immersive journey through our planet's stunning systems, highlighting the connections between organisms and networks that range from microscopic to global in scale. The show takes less than an hour, and during that time, you will explore systems ranging from the microscopic process of fungal hyphae exchanging nutrients with a tree's roots to the global migration paths of whales, birds, and humans.

The show's exploration begins in the San Francisco Bay at the intersection of industrial and natural environments, diving into a small section of a larger food web that includes birds, fish, otters, kelp, and sea urchins. The role of the sun is highlighted as the ultimate source of energy that is transferred with each meal within this food web: from primary producers' conversion of the sun's energy into food for consumers, to decomposers' recycling of energy back into the ecosystem. Other ecosystems are also visited to discover and explore the many ways that life is interconnected.

The show's final segment focuses on how humans have influenced *Habitat Earth.* The human species' appetite for energy and food are unraveling ecological networks that have existed for millions of years, in addition to creating new global connections between Earth's systems. Invasive species, often introduced by humans traveling along air and water routes, threaten the balance and test the resilience of existing ecosystems. By valuing humans' connection to other species, we can learn from these systems, and do more to support the diversity of life in our habitat, Earth.

Otters feed on sea urchins at Point Lobos' marine protected area.

The following main themes are found in the *Habitat Earth* show:

» All life on Earth is part of a complex web of connections within and sometimes across ecosystems.

» Humans are inhabitants of a global ecosystem; biological networks intersect with those built by humans.

» Earth's natural systems are sustainable, finding strength in diversity, recycling water and nutrients, and powered by energy from the sun.

Food Webs

A food web is a network of energy relationships

Main ideas:

» The sun is the ultimate source of energy for most ecosystems on Earth.
» Producers are organisms that turn energy from the sun into living matter through the process of photosynthesis.
» Within an ecosystem, consumers depend on producers as a food and energy source.
» Producers rely on the actions of some consumers and decomposers to help provide them with additional nutrients.
» Decomposers recycle waste from producers and consumers back into the ecosystem.

Take a closer look!

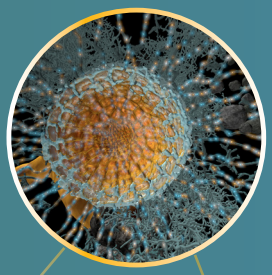
Learn about some of the organisms that are connected within a food web.

Douglas-fir

Pseudotsuga menziesii

Some of the tallest on Earth, these trees grow up to 250 feet in old-growth forests, rising above other trees to absorb more of the sun's energy.

Food web role: Producer
Distribution: Northwestern United States



Coccora

Amanita calyptroderma

Wrapping around root tips and pushing into the space between the tree's cells, this fungus provides minerals and nitrogen that support the tree's growth. In exchange, the tree provides the energy-rich sugars that the fungus needs to survive.

Food web role: Decomposer
Distribution: Western United States

Life is connected

Widely separated ecosystems are linked by air and waterways

Main ideas:

» Living things can transform the global water network over time.

» Many species follow migration paths through either air or water. These migrators are living links between far away places, carrying seeds, nutrients, and microorganisms on their long-distance travel routes.

Take a closer look!

Learn about a food web involving one of these global migrators.

Blue whale

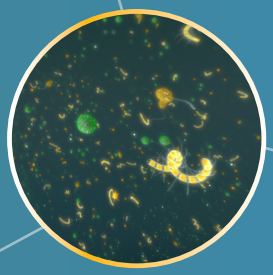
Balaenoptera musculus

Each year, these migrators travel thousands of miles from tropical waters where they mate and give birth to the frigid Arctic and Antarctic oceans to feast on krill and small fish.

Food web role: Secondary consumer

Phytoplankton

Various species



Dependent on the sun's energy for photosynthesis, these microscopic drifting organisms depend on a change in season to trigger their productivity.
Sun striking the cold, nutrient-rich waters of the North Pacific in springtime causes phytoplankton populations to thrive, providing more food for krill and small fish. Whales come to the Arctic waters to take advantage of this productivity.

Food web role: Primary producer

Human Impacts

Human activity has transformed the planet by connecting, and often weakening, ecosystems in new ways

Main ideas:

» Human activities introduce new species to local ecosystems, sometimes with great consequences.

» The innovation of agriculture has shifted land from wild to cultivated, unraveling natural networks that have evolved over millions of years.

Take a closer look!

Learn about how some organisms and habitats have been impacted by humans.

Asian clam

Corbicula fluminea

This invasive species likely arrived in North America with Asian immigrants in 1924 as a food source. The Asian Clam can produce both sperm and eggs, meaning that a single individual can seed an entire population. When clam populations boom, nutrient levels in the water increase, causing algal blooms. Algal blooms can cause the "death" of a lake by decreasing the amount of light available to aquatic plants. Lake Tahoe in California is currently in danger due to Asian Clam invasions.

Origin: Russia and Greater Asia
Range: Increasing, found in at least 40 of 50 US states and the District of Columbia

Coho salmon

Oncorhynchus kisutch

Many salmon populations are considered either extinct or critically endangered. While it's hard to pinpoint any single factor, hydropower dams may be partially to blame. The dams block spawning migrations of Coho adults, who come to adulthood in the ocean, but return to their inland river birthplaces to spawn.

Origin: North Pacific Ocean and associated coastal rivers inland
Range: Decreasing, currently considered endangered along much of coastal California and Oregon

Sustainable earth systems

Earth's systems are naturally sustainable and efficient in the absence of humans

Main ideas:

» Without large-scale human impacts, predators keep prey populations under control and protect biodiversity.

» Natural food webs include recycling of nutrients back into the system nothing is wasted.

» Humans are part of the global ecosystem, but some of our actions as consumers of energy and resources greatly hasten the rate of change of our environment.

» Endangered organisms can respond to human efforts to rebalance ecosystems, and human beings can make choices to better preserve biodiversity.

Take a closer look!

Learn about organisms exemplifying the sustainability of Earth's systems.

Brown pelican

Pelacunus occidentalis

Threatened by pesticides like DDT and dieldrin, the brown pelican was placed on the Endangered Species list in the early 1970s. After use of these pesticides was banned, the population bounced back, becoming of 'Least Concern' in 1988, and being removed entirely from the list in 2009.

Diet: Fish
Distribution: Coastal areas of North, Central, and South America

Purple sea urchin

Strongylocentrotus purpuratus

These subtidal sea urchins congregate and travel in large groups. In the absence of predators they can clear a kelp forest entirely. Fortunately, otters feed upon the urchins, which helps control the population and keep the kelp forest ecosystem intact.

Diet: Algae, Giant kelp
Distribution: Eastern edge of the Pacific, from British Columbia to Mexico

Related to *Habitat Earth*

algae	plant-like organisms that mostly grow in water and lack true roots, stems, and leaves
biodiversity	the different kinds of plants, animals, and other organisms in an area
biome	a region of land with a certain climate and certain forms of vegetation
climate change	the change in temperature, precipitation, or wind patterns, among other factors, that occurs over several decades or longer
consumer	an organism that feeds on plants or animals
crustacean	a group of mostly aquatic organisms that have a hard exoskeleton and an open circulatory system, including crabs, lobsters, crayfish, shrimp, krill, and barnacles
ecosystem	a community of living organisms and the physical environment with which they interact
environment	all of the living and non-living factors that act on an organism and influence its survival and development
food web	the network of relationships by which organisms get and give energy by eating or being eaten
fungi	a group of organisms, including molds, mushrooms, and yeast, that get their energy from breaking down dead organic matter, such as plants or animals

hyphae	the underground network of fungus
invertebrate	an animal that lacks a backbone or spinal column
invasive species	an organism that is not native and can cause harm to the ecosystem to which it has been introduced by outcompeting native species for space and resources
keystone species	an organism whose interaction with the physical environment and/or other organisms plays such a crucial role that removal from the ecosystem would cause drastic change to the system as a whole
mutualism	a relationship between two distinct species in which both benefit in some way
native species	a species that naturally occurs within a region, either having evolved in that region or arrived and becoming established in that region without human assistance
photosynthesis	the process by which plants use carbon dioxide and energy from the sun to build sugar
phytoplankton	plant-like ocean dwelling microorganisms that carry out photosynthesis (get their energy from sunlight)
producer	an organism that is able to create its own food, usually from the sun

Science Behind the Scenes

Building the digital kelp forest

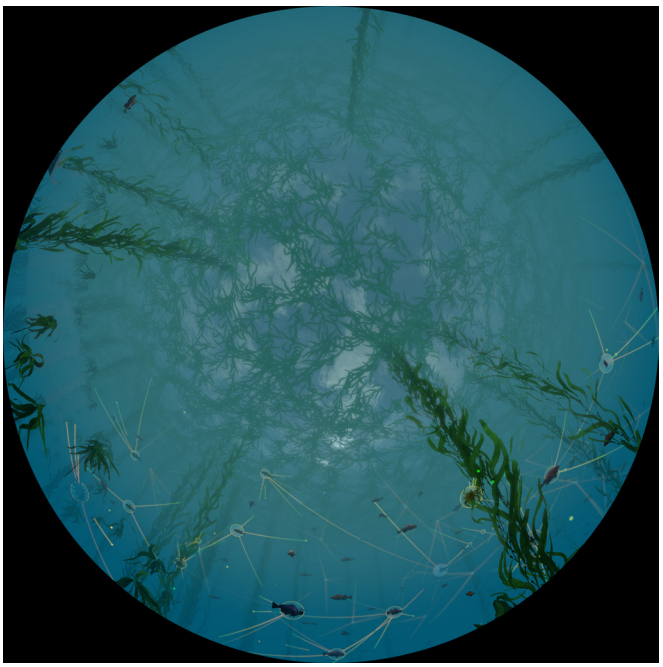
» **Have you ever wondered how the planetarium animations are made?**

Translating scientific data into a compelling narrative is difficult. Making it both understandable and visually stunning is even tougher, but that's exactly what the Visualization Studio team at the California Academy of Sciences loves to do.

This team of digital artists used their formidable technical skills, combined with more than 20 research data sets and specimens from the Academy's natural history collection, to produce *Habitat Earth*. We can get a glimpse into the scale of their process by looking at just one habitat highlighted in the show: the digital kelp forest.

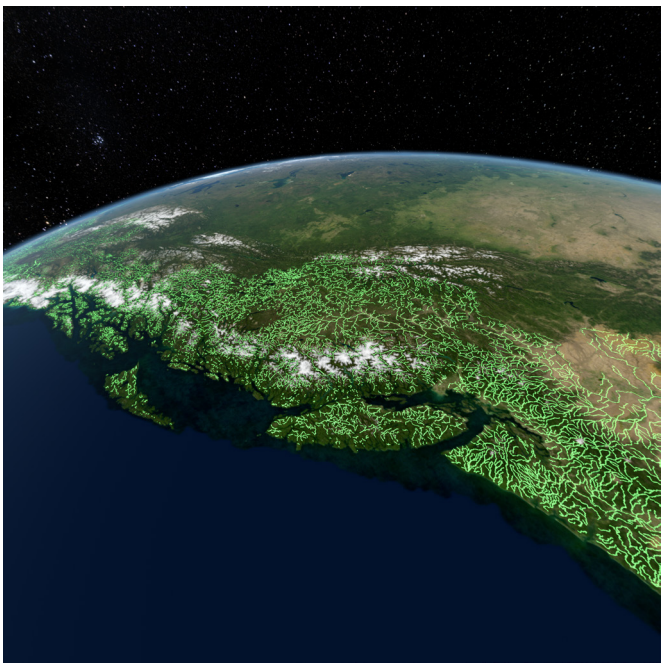
Creating the kelp forest entailed a combination of large and small tasks, including scanning specimens of giant kelp; photographing abalones, sea stars, and urchins to develop 3D digital models; and creating a motion algorithm to make the kelp 'sway' underwater.

And this is not a fictional sea floor. The kelp forest was built using tomographic data (a process that uses penetrating waves to determine water depth) from Whaler's Cove, a popular dive site near Point Lobos State Natural Reserve on the California coast. They used all of this data to stage less than 3 minutes of footage—less than 10% of the entire show.

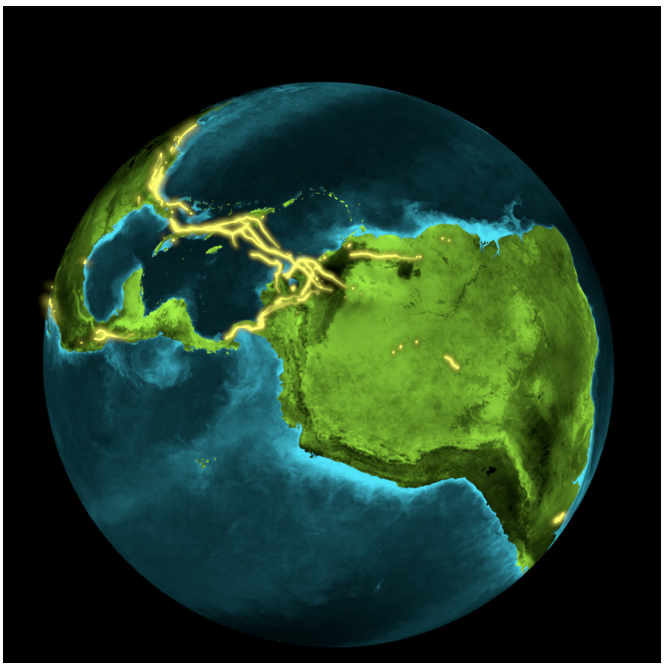


Species of the kelp forest are immersed in a complex food web, which links producers, consumers, prey and predators.

This digital kelp forest was reconstructed from 3D scans of real specimens and ocean depth data near Whaler's cove off the California coast.



Rivers and streams along the Pacific coast in which salmon populations have benefitted local ecosystems.



Bird migrations follow the seasonal abundance of food seen in this global productivity visualization.

The rest of the show is similarly detailed. The artists used data from many other sources, including: river and stream data from the US Geological Survey, Coho salmon data from the Canadian Department of Natural Resources, and blue whale migration data from the Marine Mammal Institute, to name a few. The level of accuracy and attention to detail gives the show a depth much greater than is immediately apparent, and can send us along a new trajectory.

"When scientists publish their findings, it's often the beginning of a conversation with the greater scientific community," says production coordinator Shauna Lacoste. "I like to think that releasing this show to the public is the beginning of a conversation with our viewers about how humanity can protect and enhance the ecosystems of our planet."

Specimen Spotlight

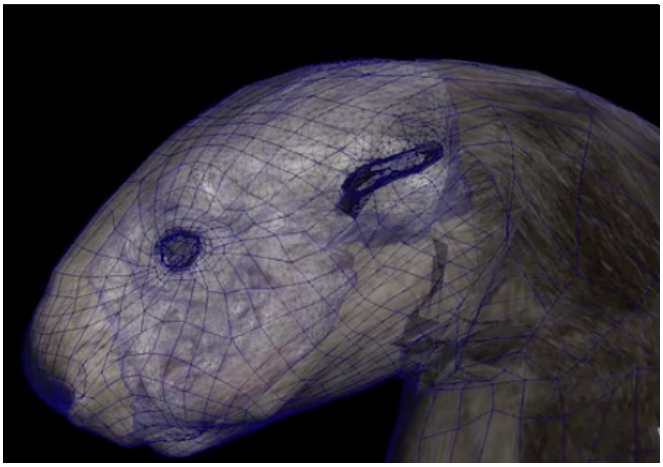
Sea Otter (digital version)
Enhydra lutris

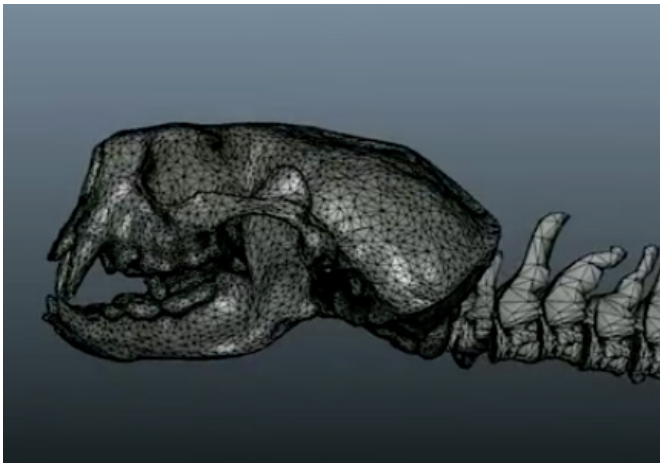
Here's something you probably didn't know: anyone can purchase digital models of otters online. On the website Turbosquid, there are digital models of people, cars, animals, and even background scenery for sale. It's a bit like the 'eBay' of the animation world.

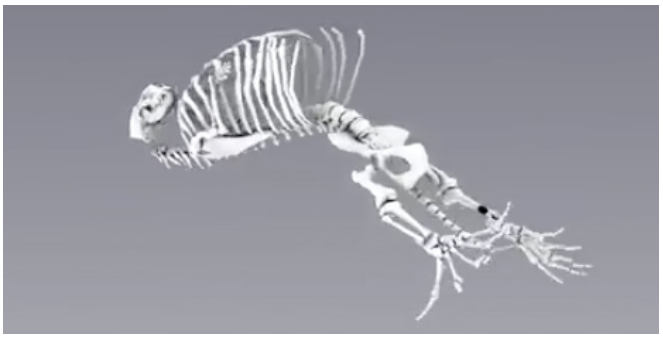
But when the Visualization Studio at the California Academy of Sciences began creating the sea otter in the *Habitat Earth* show, they found that the model of the sea otter they had purchased was not cutting it. The head wasn't the correct shape, the fur was the wrong color, and it was simply the wrong species. They needed a California sea otter (*Enhydra lutris*). Fortunately, the Visualization Studio is just a few feet away from one of the largest natural history specimen collections in the world, so the artists began looking for inspiration there.

First they selected a sea otter skull from the Academy's collection. They did a 3D scan of the skull and converted it to a digital image. Then, they inserted the skull onto the original otter animation.

Computer models are actually thousands of polygons stitched together to approximate a shape, and at nearly 150,000 individual shapes, this digital otter was no exception. Once the team had inserted the scanned skull into the existing model, they had to re-position all of the cranial polygons on the digital skull, to ensure its scientific accuracy.







The next task was to create an accurate pelt for the otter. The California sea otters that populate the kelp forests off the Pacific coast have distinct fur coloration. Since the specimen collections at the Academy include otter pelts, it seemed natural to use them as texture reference. They scanned, digitally refined, and wrapped the texture around the body of the digital otter.

The final step was to give the otter the ability to move realistically. To attain the desired level of accuracy and detail, including twitching whiskers and swishing tails, the animators referenced hours of dive videos of otters from both above and below the water's surface, and documented otter behavior and anatomy on film and in the wild.

"Building an animation rig that could mimic the gracefulness, agility, and charisma of the sea otter was definitely the hardest part," says animator Ken Ackerman, "but it was also the most fun."

Suggested Activities to Download

Download these activities from our website to enrich your field trip experience.

» **Connected Experience:** Carbon Cycle Poster (suggested grades 3–8)
www.calacademy.org/educators/lesson-plans/carbon-cycle-poster
En Español:
www.calacademy.org/educators/lesson-plans/cartel-del-ciclo-del-carbono
Cantonese:
www.calacademy.org/educators/lesson-plans/碳循環海報
Working in groups, students can create simple illustrations of how carbon flows between the biosphere, hydrosphere, and atmosphere and how human activity can contribute to climate change.

» **Connected Experience:** Carbon Cycle Role Play (suggested grades 4–12)
www.calacademy.org/educators/lesson-plans/carbon-cycle-role-play
En Español:
www.calacademy.org/educators/lesson-plans/cartel-del-ciclo-del-carbono
Cantonese:
www.calacademy.org/educators/lesson-plans/碳循環角色扮演
In active demonstration, students will model the carbon cycle and consider ways in which human actions play a role.

» **Anytime Lesson Plan:** Global Climate Change and Sea Rise (suggested grades 3–8)
www.calacademy.org/educators/lesson-plans/global-climate-change-and-sea-level-rise
In this data-driven group activity, students use modeling to consider glaciers and icebergs and determine which causes a rise in sea level when they melt.

» **Anytime Lesson Plan:** Amazon Water Cycle Role Play (suggested grades 4–8)
www.calacademy.org/educators/lesson-plans/amazon-water-cycle-role-play
Explore the various processes of the water cycle in a creative role-play activity involving movement, sound, and props to aid comprehension.

Be sure to review more of our teaching resources online!
www.calacademy.org/educators/teaching-resources

» **Pre-, during-, and post visit activities:** short, lively activities to focus your class trip.

» **Anytime lesson plans:** Full-period lessons to integrate into your yearly curriculum.

» **Connected experiences:** Activity combinations that extend the museum visit into the classroom.

Next Generation Science Standards

Crosscutting Concepts

Energy and Matter

Cause and Effect

Systems and System Models

Disciplinary Core Ideas

Life Science

LS2 Ecosystems: Interactions, Energy, and Dynamics

LS4 Biological Evolution: Unity and Diversity

Earth and Space Science

ESS2 Earth's Systems

ESS3 Earth and Human Activity

GRADE 3

» **Life Science**

LS4.C: Adaptation

For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.

LS4.D: Biodiversity and Humans

Populations live in a variety of habitats, and change in those habitats affects the organisms living there.

GRADE 4

» **Earth and Space Science**

ESS2.E: Biogeology

Living things affect the physical characteristics of their regions.

GRADE 5

» **Life Science**

LS2.A: Interdependence Relationships in Ecosystems.

The food of almost any kind of animals can be traced back to plants. Organisms are related in food webs. Organisms called decomposers break down dead organisms, recycling some materials back into the soil. A healthy ecosystem is one in which multiple species are able to meet their needs, and newly introduced species can damage the balance of an ecosystem.

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die.

» **Earth and Space Science**

ESS3.C: Human Impacts on Earth Systems

Human activities have had major effects on the land, vegetation, streams, ocean, and air. But individuals and communities are doing things to help protect Earth's resources and environments.

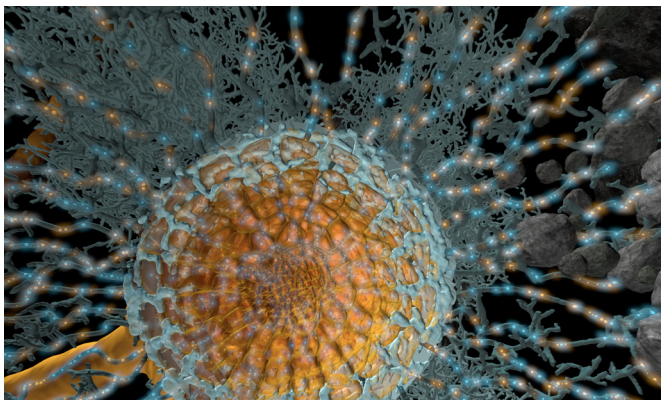
Guiding Questions and Answers

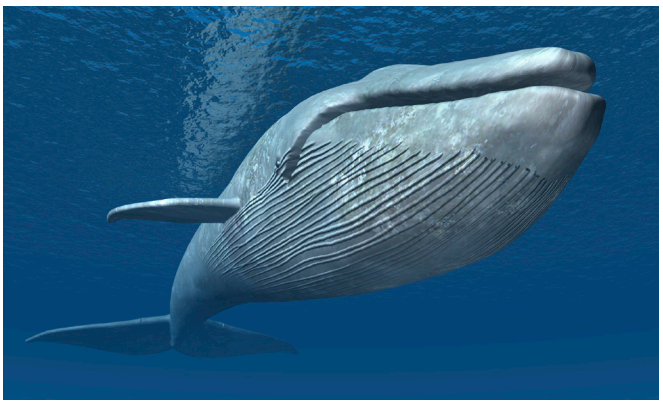
Use these questions to get students thinking about the *Habitat Earth* show.

» **What role do decomposers like fungi and bacteria play in an ecosystem, and why is it important?**
Decomposers, unlike producers, don't make their own food. They break down dead or decaying plants and animals, sometimes finishing the job begun by scavengers. The nutrients that decomposers put back into the ecosystem are essential to the survival of many producers. In *Habitat Earth*, we witnessed fungal hyphae participating in this process by exchanging minerals and nutrients for energy-rich sugars with roots of the Douglas-fir.

» **Describe the relationship between the seasons and the migration of the Blue Whale.**
The Blue Whale migratory cycle begins in tropical, warm waters, where they give birth to their young. In the early spring, the combination of increasing solar energy and nutrient-rich, cool water causes the population of phytoplankton to thrive in Arctic and Antarctic oceans. This thriving population causes the population of fish and krill, which are phytoplankton predators and Blue Whale food sources, to thrive as well. The Blue Whale travels to these cool waters to eat the plentiful food in the spring and summer, and returns to tropical oceans in the winter months.

» **Describe the paths that water might take to get from the soil to the clouds.**
Some of the water in the soil is "pumped" up by the roots through the tree, ultimately making it to the leaves, where it escapes from tiny pores. Some of the water evaporates from the soil surface. Water from both sources collects into clouds. This water will eventually fall back to the surface of the earth as rain (precipitation).

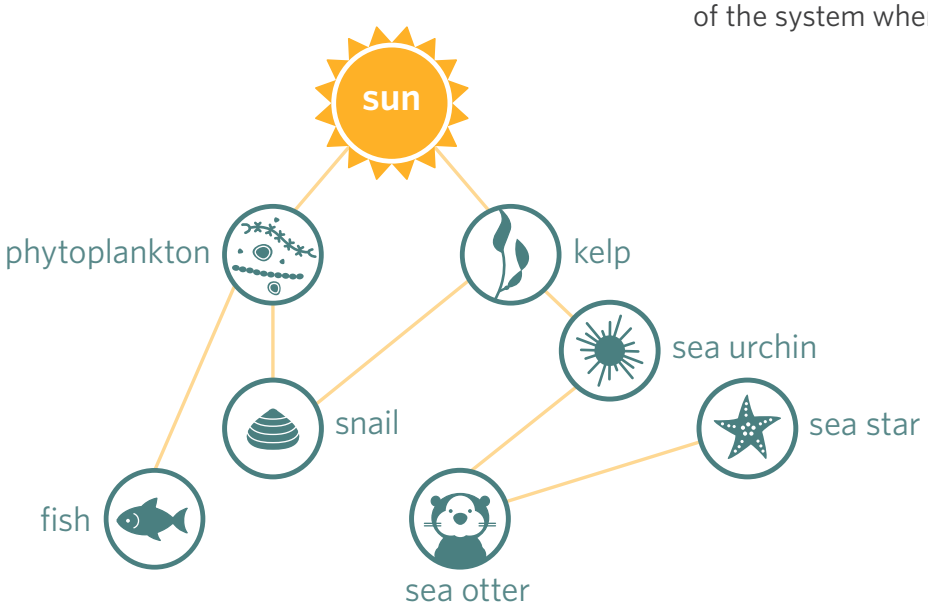




Guiding Questions and Answers

» **Do you have a favorite organism from the show? Pick one living thing and describe or draw how it is connected to others via a food web.**

The ultimate energy source for most food webs on Earth is the sun. Producers harness the sun's energy, transferring it to primary consumers when they are eaten. The food web expands as secondary consumers eat primary consumers. Below are two examples of food webs that you saw in the show!



» **When an organism dies, it becomes food for something else. How does this demonstrate the natural sustainability that exists within Earth's natural ecosystems?**

An organism consuming another organism represents a transfer of energy. When an organism is eaten, the consumer then transfers that energy to other parts of the ecosystem by being eaten or producing waste. Decomposers break down waste and dead organisms. As a result, this turns energy into heat that fuels the decomposition process and recycles nutrients like minerals and nitrogen back into the system to support the growth cycle of producers. In this natural system, there is zero waste. All of the energy and nutrients of a living organism are used by other parts of the system when it dies.

Habitat Earth

Global Environmental Literacy Initiative, major funding provided by PISCES FOUNDATION