
ARCTIC CIRCLE
AMAZON RAINFOREST
BY RACHEL IGNOTOFSKY
GREAT BARRIER REEF
THE WONDROUS WORKINGS OF
PLANET EARTH
UNDERSTANDING OUR WORLD AND ITS ECOSYSTEMS
DROP OF WATER
AFRICAN SAVANNA
SAHARA DESERT
ENGLISH GARDEN
TREE STUMP
U.S.A. DESERT


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TEN SPEED PRESS
CALIFORNIA | NEW YORK

Published in the United States by Ten Speed Press, an imprint of the Crown Publishing Group, a division of Penguin Random House LLC, New York.
www.crownpublishing.com
www.tenspeed.com



Library of Congress Cataloging-in-Publication Data
Names: Ignotofsky, Rachel, 1989- author.
Title: The wondrous workings of planet Earth : understanding our world and its ecosystems / Rachel Ignotofsky.
Description: First edition. | New York : Ten Speed Press, [2018] | Audience: Age 10-17. | Includes bibliographical references and index.
Identifiers: LCCN 2018006572
Subjects: LCSH: Biotic communities—History—Juvenile literature. | Ecology—Juvenile literature.
Classification: LCC QH541.14 .I36 2018 | DDC 577.8/2—dc23
LC record available at https://lccn.loc.gov/2018006572

Hardcover ISBN 9780399580413
Ebook ISBN 9780399580420

v5.3.1
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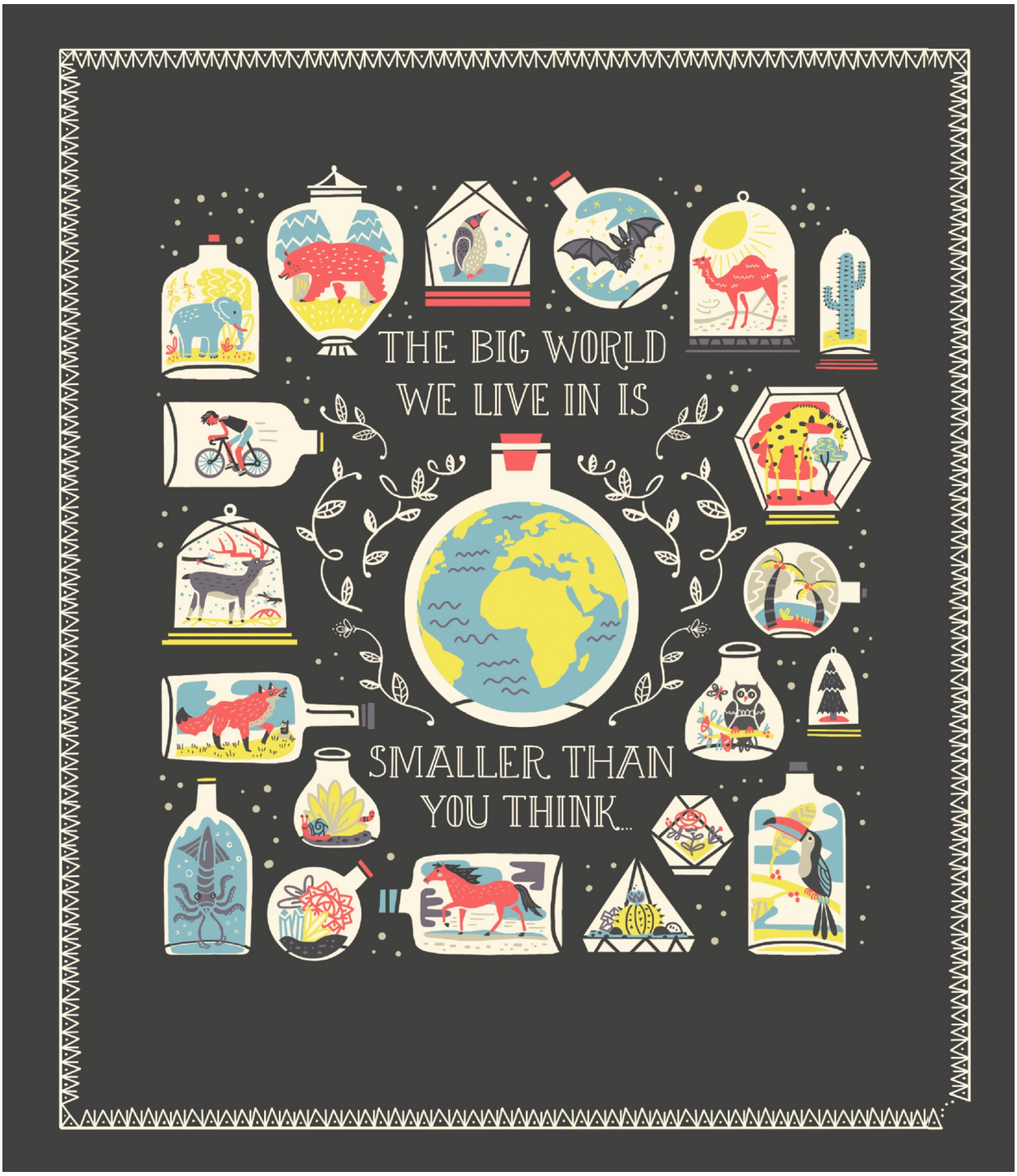

THE BIG WORLD
WE LIVE IN IS
SMALLER THAN
YOU THINK...

# INTRODUCTION

As you read this page, a jaguar is on the hunt in the Amazon rainforest, a coral reef teems with life, and a bike messenger in New York City is riding with a bagel in hand. These all might seem like unrelated events, but in fact, all living things have more in common than you think.

For starters, we all live on planet Earth. Together, plants, animals, and people spin through outer space, protected only by a thin layer of atmosphere. Second, everything on Earth (And I mean everything! Your dog, car, spaghetti dinner, and even you!) is made up of atoms. Last, all living things—no matter how small or big, whether it is a plant turning sunlight into sugar or a person eating a sandwich—build their bodies and get energy from their food. Every living thing is dependent on the earth's limited resources, and each other, for survival. To see just how much we are connected, we need to understand the earth's ecosystems.

Exactly how life on our planet works is a complicated question—the world can feel so large. What if you could comprehend the complex workings of a massive forest as easily as you could learn how to care for a houseplant? What if our whole planet was as easy to understand as a specimen in a bottle or a globe on a desk? You could watch the winds blow nutrient-rich dust from the Sahara across the Atlantic Ocean, where it fertilizes the Amazon rainforest. Those same trees in the Amazon release massive amounts of oxygen into the air. Those oxygen molecules mix with the atmosphere, which is then breathed by animals and people all around the world. The story could continue without end. In this book, we'll take a close look at how some of our world's largest—and smallest—ecosystems work, and how the natural world fits together to support life on Earth.

Looking at planet Earth you will also see people. Throughout human history, we have transformed the landscape in both good and bad ways. You will see people taking care of the land they live on, like shepherds in the Scottish moors digging ditches to keep the bogs moist. You'll see how people build in ways that take wildlife into account; in Kenya, people construct underpasses beneath highways so that elephants can continue

their annual migrations across the grasslands. You will see scientists, governments, and communities come together to create protected areas that preserve nature. However, you will also see how humans have used the land in ways that hurt the natural world.

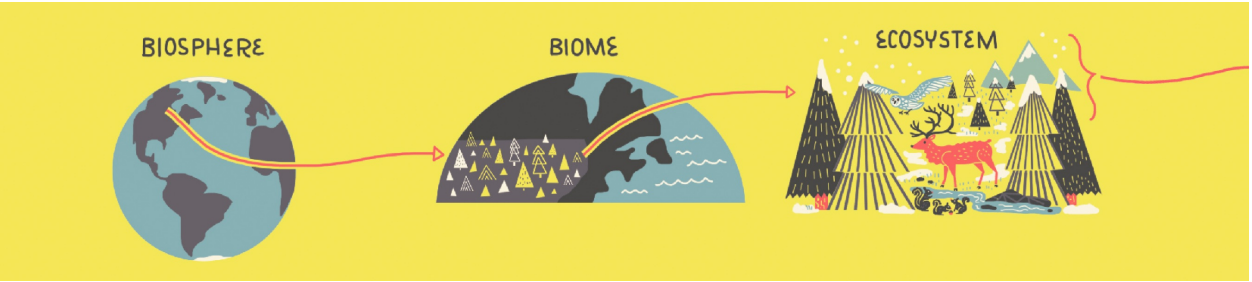
Humanity's biggest challenge is learning to use our resources responsibly. As there are more and more people living on Earth, it becomes a smaller and smaller place. Farms need to be bigger, and cities need to keep growing. But as we continue to build, we cannot afford to disrupt the natural benefits that Earth's irreplaceable ecosystems provide. Irresponsible mismanagement of land and the rapid overuse of our resources result in pollution, climate change, and the destruction of our important ecosystems, which in turn make it harder for humans—and all other life on Earth—to thrive.

The first step to protecting our planet is to learn more about it. With a true understanding of the natural world, we can take from the earth without destroying it. Together we can find new ways to farm, generate energy, and invent new materials to build with. But we cannot expect people to care for our planet if they cannot care for themselves. Often, poor communities depend on harmful or illegal practices like poaching or lumber exploitation. By addressing poverty and creating better ways to farm and build, we can give all people the means to preserve our earth.

Our planet is the only home we have. It is precious and needs our care. The power to protect our earth rests with each of us. You could say that the world's future is truly in the palms of your hands.

# LEVELS OF ECOLOGICAL ORGANIZATION

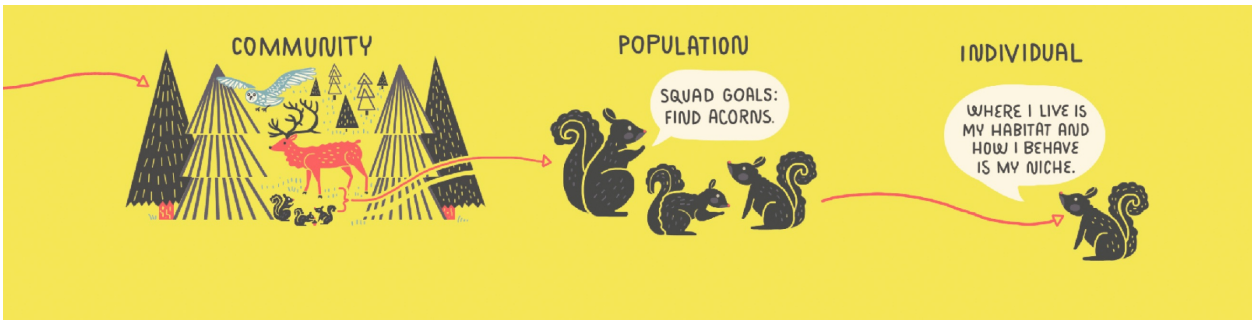
It is a great big complicated world out there! You can study the entire planet as a whole or study the habits of just a single organism. The *levels of ecology* put it all into context. The largest level is the biosphere, which includes everywhere life is found on Earth. With every level of ecology down from the biosphere, we zoom in and look at sequentially smaller and more specific parts of the world. The smallest level of ecology is an individual living thing; for example, just one single squirrel. The levels of ecology are like Russian nesting dolls, with each level fitting inside the next largest level.




**BIOSPHERE**: Everywhere life on Earth is found.

**BIOME**: A region defined by a specific climate (its temperature and precipitation) and certain types of animals and plants that have adapted to survive and thrive in that specific climate.

**ECOSYSTEM**: The interactions between all the living organisms and their nonliving environment in a certain place.



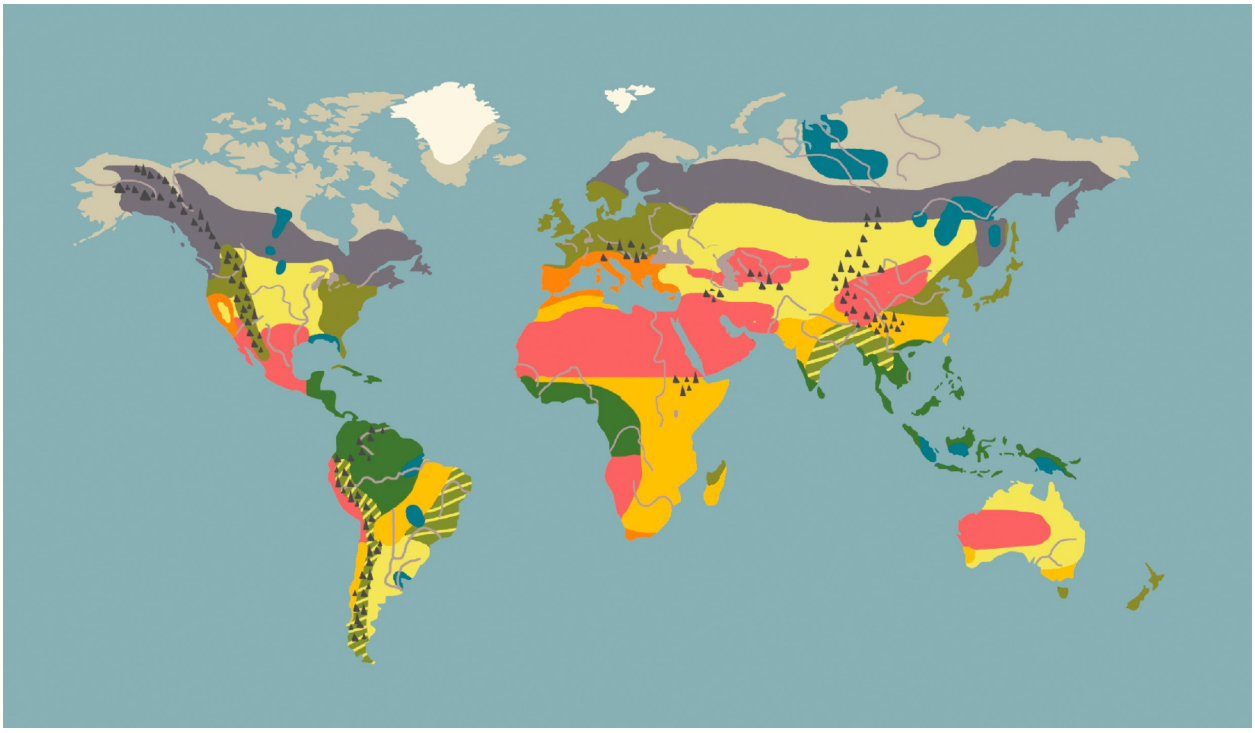

**COMMUNITY**: All of the living beings within an ecosystem, such as plants, fungi, animals, and bacteria. Does not include the air, dirt, water, or other nonliving things.

**POPULATION**: A group of individuals of the same species that live within the same community.

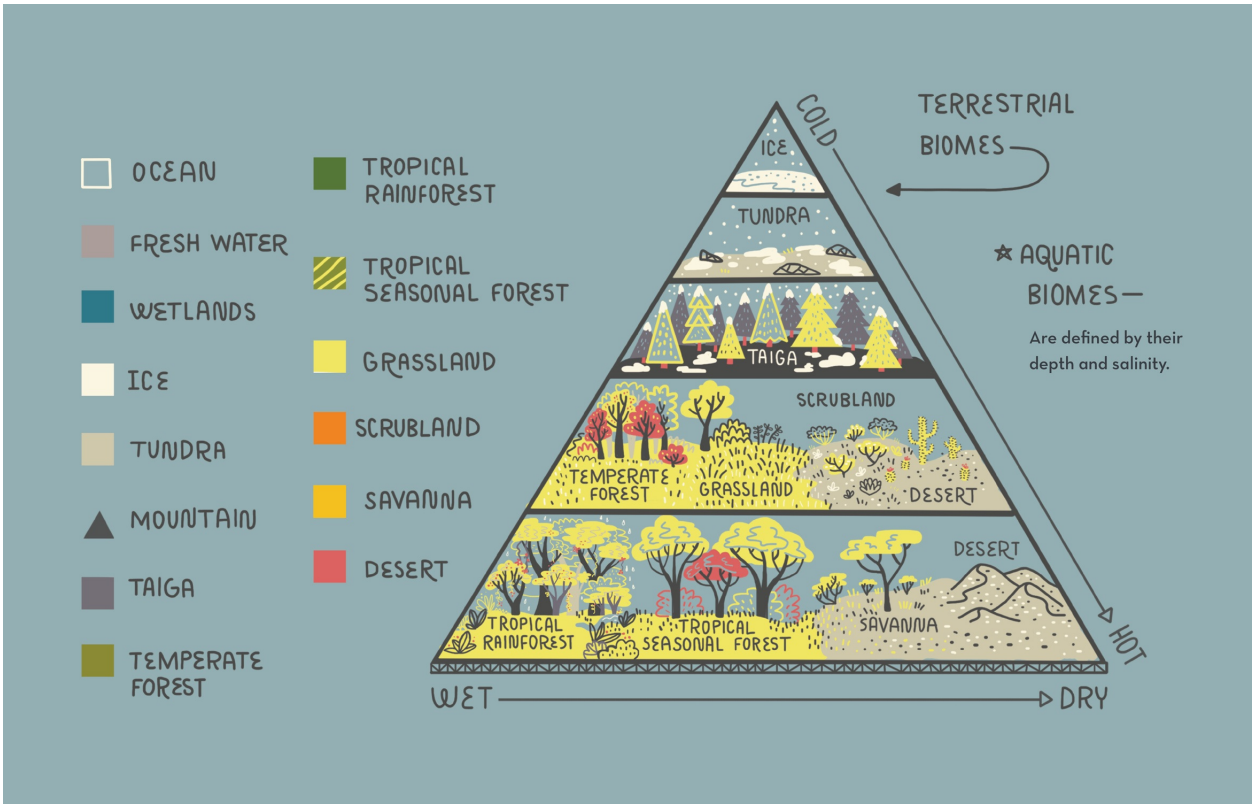
**INDIVIDUAL**: One specific living organism.

# BIOME MAP

Biomes are simply a way to classify and describe general parts of the planet. Each biome is determined by its temperature and precipitation and the living things that have evolved in that climate. There are two main types of biomes: terrestrial and aquatic. Ecologists have further broken down those two types into more specific classifications. Biome maps can be divided up in many different ways and allow us to understand the similarities between places on opposite sides of the world.



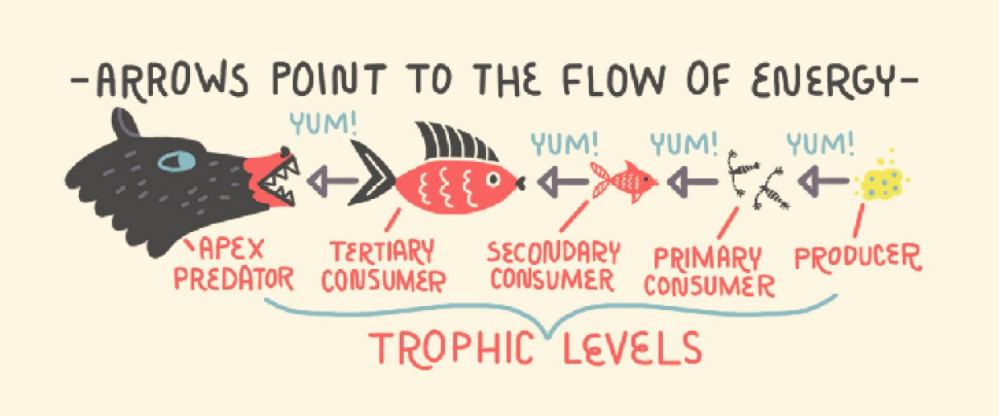
CITIES—Although cities, towns, and suburbs are not considered biomes, humans have transformed the earth so much that we are now in a new geological era called the Anthropocene epoch.


OCEAN
FRESH WATER
WETLANDS
ICE
TUNDRA
MOUNTAIN
TAIGA
TEMPERATE FOREST
TROPICAL RAINFOREST
TROPICAL SEASONAL FOREST
GRASSLAND
SCRUBLAND
SAVANNA
DESERT
COLD
TERRESTRIAL BIOMES
ICE
TUNDRA
TAIGA
SCRUBLAND
TEMPERATE FOREST
GRASSLAND
DESERT
DESERT
TROPICAL RAINFOREST
TROPICAL SEASONAL FOREST
SAVANNA
HOT
WET
DRY
AQUATIC BIOMES
Are defined by their depth and salinity.

# WHAT IS AN ECOSYSTEM?

Not even a lone wolf is a "lone wolf." Every organism on the planet is dependent on others to live. Through ecology, the study of ecosystems, we can begin to understand how we rely on the natural world. Ecosystems can come in many sizes, from a large forest to a tiny puddle, and through the study of ecosystems we begin to understand how living organisms in a certain place interact with each other (Who eats what? Who will compete with whom and for what resources?). We can also understand how these living things interact with the nonliving parts of their environment (like the soil, the temperature, the air, and the water).

Interactions between wildlife and their environment provide us with important natural services. Ecosystems large and small are responsible for breathable air, fresh water, protection from natural disasters, fertile soil, and of course food! By understanding ecosystems we can see how energy from the sun flows through the food web, and how the cycle of life, death, and decay allows nutrients to be reused. Only when our ecosystems are intact can the natural world continue to seamlessly do the hard work of sustaining life on planet Earth.




**TROPHIC LEVELS**: An organism's position in the food web, and how far away it is from the original source of energy (the sun), starting with producers and typically ending with apex predators.

**WHO EATS WHAT**: Producers make their own food from solar energy.

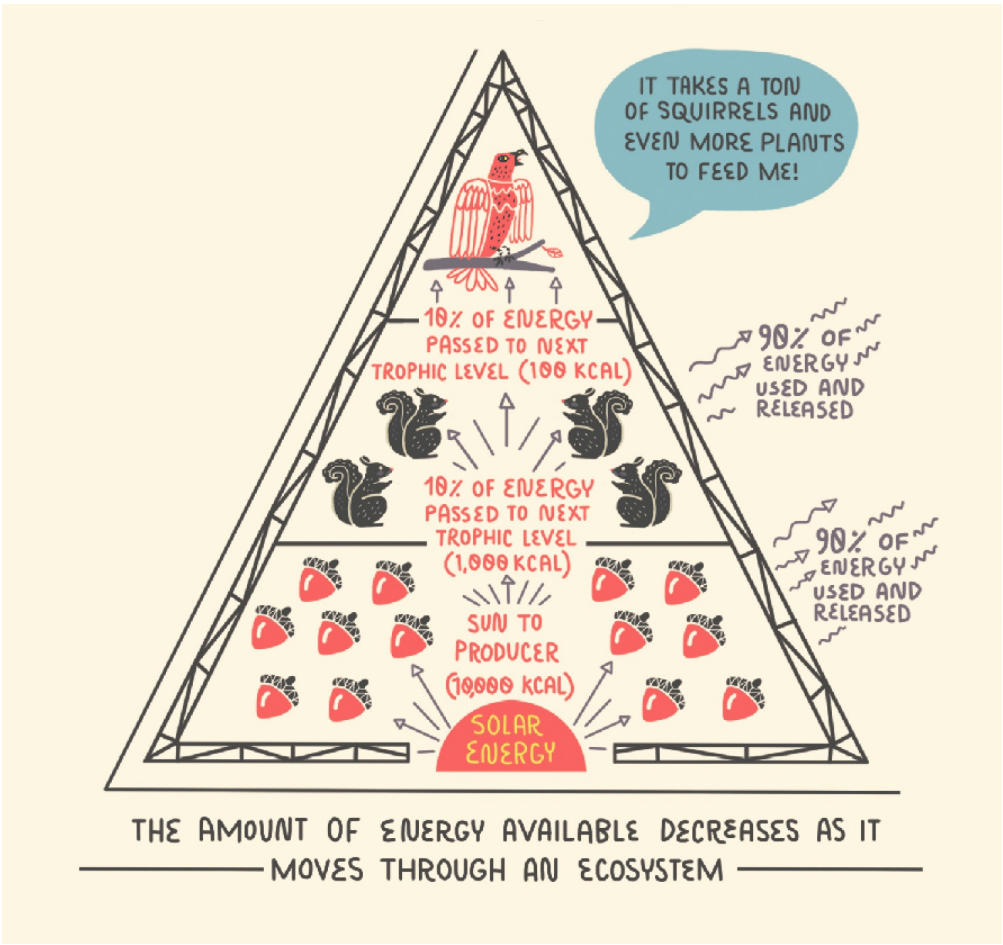
Herbivores eat only plants. Carnivores eat only other animals. Omnivores eat both plants and animals. Decomposers eat waste and dead organisms.

FOOD WEB: The mapping of the flow of energy. Who eats what and who gets energy from whom. Arrows point to who is enjoying a tasty meal, which is the direction energy is moving.

# THE FLOW OF ENERGY

Matter—which makes up our bodies and everything else—can never be destroyed or created. It cycles, transforms, and is constantly reused. Energy works differently. New solar energy constantly flows into our planet's ecosystems and is then used up and lost forever in the form of heat. Living things don't just eat each other to get the vital nutrients they need to grow strong. Food also is about gaining energy. Almost all of the energy for life originally comes from the sun. Plants and algae (also known as producers) can turn sunlight into sugar through a process called photosynthesis. Sugar is a form of chemical energy that is stored. During the complicated process of cells doing work, energy is released and lost as heat. Plants use around 90 percent of the original stored energy that they make. (Living takes work!) Only about 10 percent of the original sunlight energy remains stored as sugar. When a plant is eaten, this stored sugar energy begins its own journey through the food web.

Producers are at the bottom of a food web and hold the most stored energy. As you move up the food web—from producers to primary and secondary consumers and so on—more of that original energy is used up and less energy as a percentage of food mass is passed along. That means that an apex predator, which is at the top of a food web, needs to eat much more than a primary consumer to get the same amount of energy.


IT TAKES A TON OF SQUIRRELS AND EVEN MORE PLANTS TO FEED ME!
10% OF ENERGY PASSED TO NEXT TROPHIC LEVEL (100 KCAL)
90% OF ENERGY USED AND RELEASED
10% OF ENERGY PASSED TO NEXT TROPHIC LEVEL (1,000 KCAL)
90% OF ENERGY USED AND RELEASED
SUN TO PRODUCER (10000 KCAL)
SOLAR ENERGY
THE AMOUNT OF ENERGY AVAILABLE DECREASES AS IT MOVES THROUGH AN ECOSYSTEM


Taxonomic ranking helps scientists classify and identify different species. Scientists include every single living thing that has ever existed on Earth, which allows us to see how life on Earth has evolved and what different species have in common—even if they have been extinct for thousands of years or live on opposite sides of the world!

# LEVELS OF CLASSIFICATION

DOMAIN
(EUKARYA)

KINGDOM
(ANIMALIA)

PHYLUM
(CHORDATA)

CLASS
(MAMMALIA)

ORDER
(PERISSODACTYLA)

FAMILY
(EQUIDAE)


GENUS
(EQUUS)

SPECIES
(ZEBRA)

# THE MAIN DOMAINS

## BACTERIA

SINGLE CELL ORGANISMS WITH NO DEFINED NUCLEUS

## ARCHAEA

SINGLE CELL ORGANISMS WITH NO DEFINED NUCLEUS & DIFFERENT BIOCHEMISTRY THAN BACTERIA.

## EUKARYA

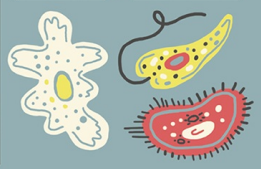
ORGANISMS THAT HAVE CELLS WITH A NUCLEUS

### ANIMALIA

### PLANTAE

### FUNGI

### PROTISTA



# HOW LIVING THINGS INTERACT

You may have seen a lion chase a zebra in a TV documentary, but that is just one way animals interact with each other. Competing for food and resources, finding a place to call home, and reproducing are some of the main priorities for all species. To do so, animals, bacteria, and plants have evolved to interact in many different ways to survive. These interactions help to maintain a balanced and healthy ecosystem.


PREDATION
ONE SPECIES EATS THE OTHER.
YIKES!
YUM
PARASITISM
ONE SPECIES GAINS BY HARMING THE OTHER SPECIES.
YUM!
OW!
YES! SPREAD MY POLLEN!
MUTUALISM
BOTH SPECIES GAIN SOMETHING FROM EACH OTHER.
COMMENSALISM
ONE SPECIES GAINS AND THE OTHER IS UNAFFECTED.
MINE!
MINE!
INTERSPECIFIC COMPETITION
DIFFERENT SPECIES COMPETING FOR THE SAME RESOURCES.
FREE RIDE!
RESOURCE PARTITIONING
TWO SPECIES INDIRECTLY COMPETE FOR THE SAME RESOURCE BY DEVELOPING DIFFERENT NICHES OR BEHAVIORS.
INTRASPECIFIC COMPETITION
*THE SAME SPECIES COMPETING FOR THE SAME RESOURCES.

# WHAT MAKES A HEALTHY ECOSYSTEM

Floods! Tornadoes! Fires! Disease! The animals and plants in any ecosystem have to deal with a lot of challenges. A healthy and intact ecosystem is adaptable and can bounce back from terrible natural disasters, changes, and challenges.

## BIODIVERSITY

A biodiverse ecosystem is home to many different types of animals, plants, and other living things. Biodiversity is the most important factor in having a strong and healthy ecosystem. When an ecosystem is biodiverse, wildlife have more opportunities to obtain food and shelter. Biodiversity also means a more complex food web, and more "paths" for matter to cycle, decompose, and create top soil for new plant growth.

Different species also react and respond to changes in their environment differently. For example, imagine a forest with only one type of plant in it, which is the only source of food and habitat for the entire forest food web. Now, there is a sudden dry season and this plant dies. Plant-eating animals completely lose their food source and die out, and so do the animals that prey upon them. But, when there is biodiversity, the effects of a sudden change are not so dramatic. Different species of plants respond to the drought differently, and many can survive a dry season. Many animals have a variety of food sources and don't just rely on one plant. Now our forest ecosystem is no longer doomed!

Changes, disturbance, or even disasters in nature are inevitable. Some disturbances will deeply affect an ecosystem and can thin out or kill off a species of microbe, plant, or animal. But an ecosystem with intact

biodiversity will have many other species that can survive, allowing the ecosystem as a whole to bounce back. The less biodiversity there is, the weaker an ecosystem is.

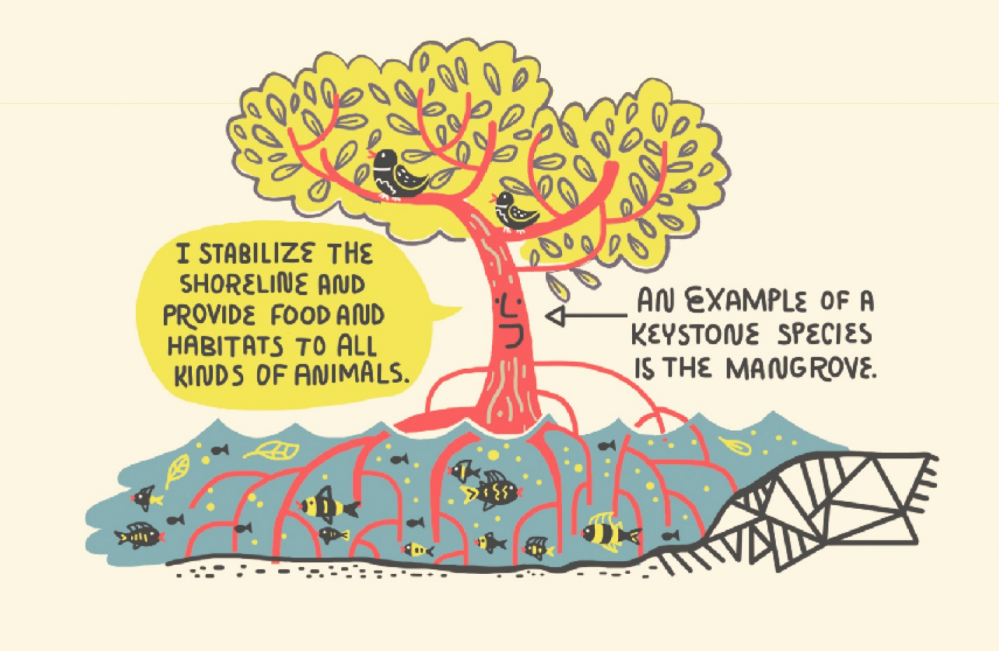

## NICHE

A living thing's role in an ecosystem—what its habitat is, and how it gets food, reproduces, and interacts with others—is its niche. If two different species have the same niche, then they are in direct competition. As in any competition, only one can dominate, and the losing species will die out if they do not change or adapt.


## KEYSTONE SPECIES

Certain ecosystems have a type of animal or plant that almost the entire community depends on directly or indirectly. If a keystone species

population is reduced or compromised, it could mean the end of an entire ecosystem. It is important for us to identify and protect these important keystone species.

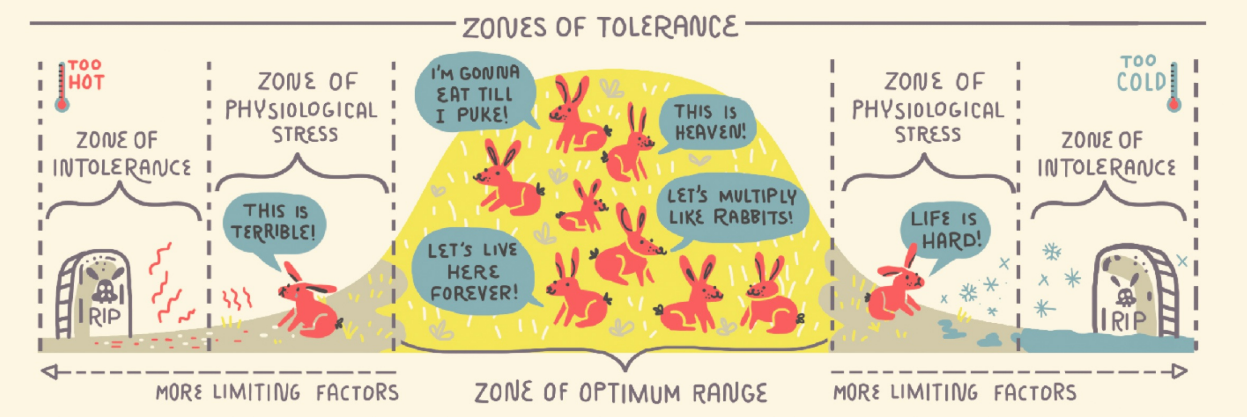



## SPECIES EVENNESS

What would happen if there were more wolves than rabbits in the forest? The wolves would eat all the rabbits before the next generation of rabbits could be born. Species evenness between predator and prey stops this from happening. If any living thing higher on the food chain outnumbers its food source, then a whole species could be eaten to extinction. By measuring species populations, ecologists can make sure that an ecosystem is balanced and intact.

Animals on the same trophic level also need to have species evenness between each other. If there are too many rabbits in an ecosystem, there may not be enough grass for other primary consumer species to survive. Also, if a disease (like rabbit fever) hits and there is only one species (rabbits in this case) on a trophic level, then all of the larger predators will die out too, because they have no other food source. Understanding species populations lets people hunt in ways that actually benefit an

ecosystem. Maintaining species evenness is crucial to maintaining biodiversity.




If there are too many limiting factors in an ecosystem—like predators, lack of resources, bad weather, or disease—then a population will die out completely. If there are not enough limiting factors and life becomes too easy for a species, then a population will boom out of control. This can lead to one species outcompeting all other living things until the biodiversity of the region is destroyed and resources are overused or even depleted.

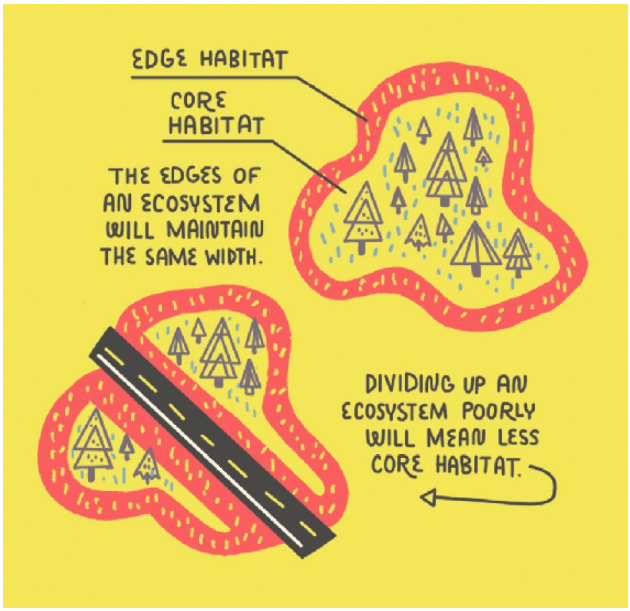
## EDGES

The edges of an ecosystem are just as important as its core parts. The area where two distinctly different biomes or ecosystems blend together is called an "ecotone."

You may have seen an ecotone where a forest blends into grassland, or where the bank of a river divides the water from the land. These ecotones blend two different biomes together but also act as a border, repelling and attracting different types of animals. Ecotones protect the mainland from erosion, protect core ecosystems from invasive species, and provide certain animals with unique resources. Often ecotones are the perfect places for hiding, reproducing, or protecting baby animals before they fully mature and enter their main habitat.

Some animals and plants have evolved to live only in or very close to

ecotones. They are called “edge species.” The other species that can live only in the core of an ecosystem depend on the edge as a border. All core ecosystems are surrounded by some kind of ecotone or edge region. When people construct roads or buildings without considering the crucial edges of ecosystems, they can shrink and damage the core wilderness more than they intend.

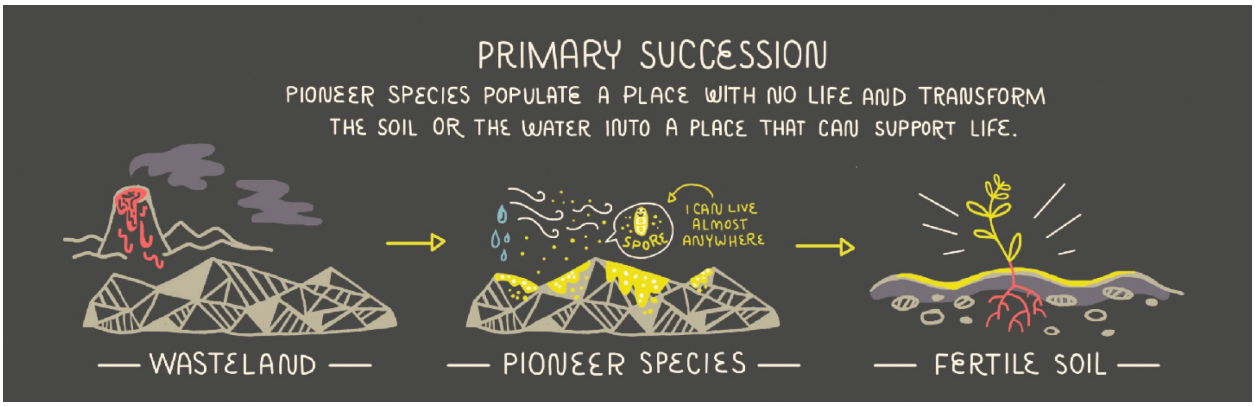



Change can be good! From the time life began on planet Earth, there have been many changes. The earth has had many eras with different dominant species. From the mass extinction of the dinosaurs to the building of massive cities, life finds a way to adapt to even the most dramatic changes. Primary succession is the way plants colonize and create soil from barren wastelands; secondary succession is how ecosystems adapt to small- and medium-size disturbances in their environment.

Small natural disturbances sometimes can actually create stronger and more resilient ecosystems. For example, a small- or medium-size wildfire will destroy a part of the forest. The burned area becomes a new microclimate for other smaller plants. New grasses, wildflowers, and bushes will grow over the area, creating new types of habitat. This allows for more biodiversity (a variety of wildlife) throughout the forest, which makes for a more resilient ecosystem. Some ecosystems have even evolved to depend on these kinds of intermediate disturbances, such as wildfires, floods, or seasonal frost.

Big or small, disturbances are inevitable for all ecosystems. Disturbances can be as small as a truck parked on a lawn, or as destructive as the volcanic Permian-Triassic extinction event, which killed over 70 percent of life on Earth about 250 million years ago. As far as we know, life has always bounced back from such disturbances—the only difference is how long it takes to recover. The greater the disturbance, the longer it takes for life to return. Sometimes recovery can take millions of years.

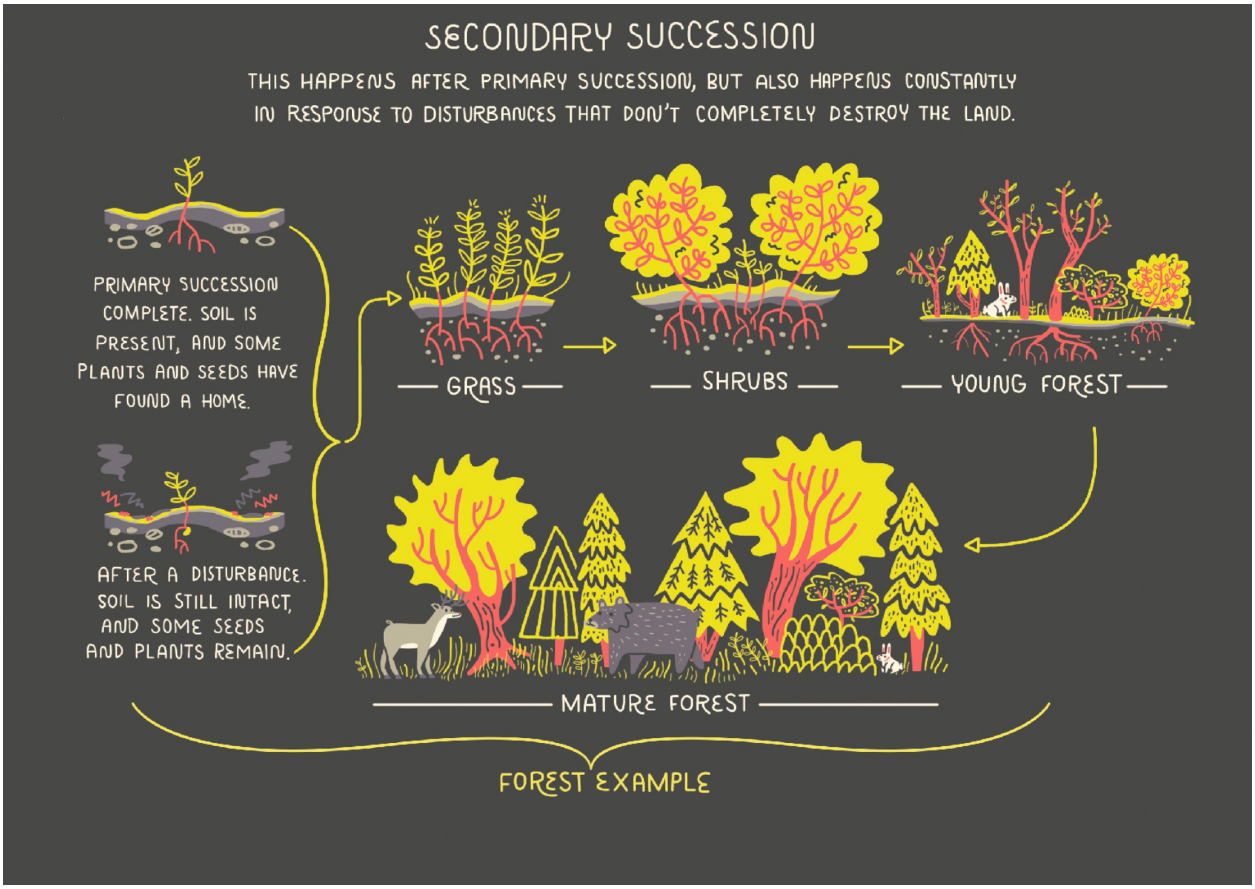

The expanding human population has been hard on our planet—the increase of pollution and the expansion of cities are transforming the earth in ways that are causing animal and plant species to go extinct at a rapid pace. Some scientists think that this human transformation of the land will be the next great extinction level event for many species. We share the planet with wildlife, and as humanity continues to build, we need to be conscious of the disturbances we impose on other species.




**WASTELAND**: A volcano erupts, a meteor hits, or land is paved over. Now there is a lifeless environment. Life can return quickly or it can take hundreds to millions of years.

**PIONEER SPECIES**: Weather like rain normalizes the land. The wind brings hearty bacteria and microscopic plants, and spores like those of lichen, moss, and algae. They live and die, and over time, soil begins to form.

**FERTILE SOIL**: Barren rocks are broken down by time, and the life cycle of these pioneer species begin to make fertile soil where small plants can begin to grow.


SECONDARY SUCCESSION
THIS HAPPENS AFTER PRIMARY SUCCESSION, BUT ALSO HAPPENS CONSTANTLY IN RESPONSE TO DISTURBANCES THAT DON'T COMPLETELY DESTROY THE LAND.
PRIMARY SUCCESSION COMPLETE. SOIL IS PRESENT, AND SOME PLANTS AND SEEDS HAVE FOUND A HOME.
AFTER A DISTURBANCE. SOIL IS STILL INTACT, AND SOME SEEDS AND PLANTS REMAIN.
GRASS
SHRUBS
YOUNG FOREST
MATURE FOREST
FOREST EXAMPLE

# MICROECOSYSTEMS

By zooming in and out to examine ecosystems of all sizes, we can better understand how our natural world works. Large ecosystems are often made up of many smaller communities and ecosystems that sometimes even have their own microclimates. The living and nonliving things that share these microhabitats may interact with life from the larger ecosystems that they are also a part of. For example, a pond, which is an enclosed ecosystem on its own, also provides drinking water and food to animals that are a part of a larger forest. Small ecosystems make larger ecosystems more stable by creating far more resources and more biodiversity. Here are two examples of microecosystems.


A ROTTING LOG
CARPENTER MOTH
LICHEN
DOWNY WOODPECKER
WOOD
TERMITE
CARPENTER MOTH CATERPILLAR
DRY ROT FUNGUS
CENTIPEDE
OYSTER MUSHROOM
CARPENTER ANT
BARK BEETLE
SAP
APHIDS
HONEY-DEW
BACTERIA

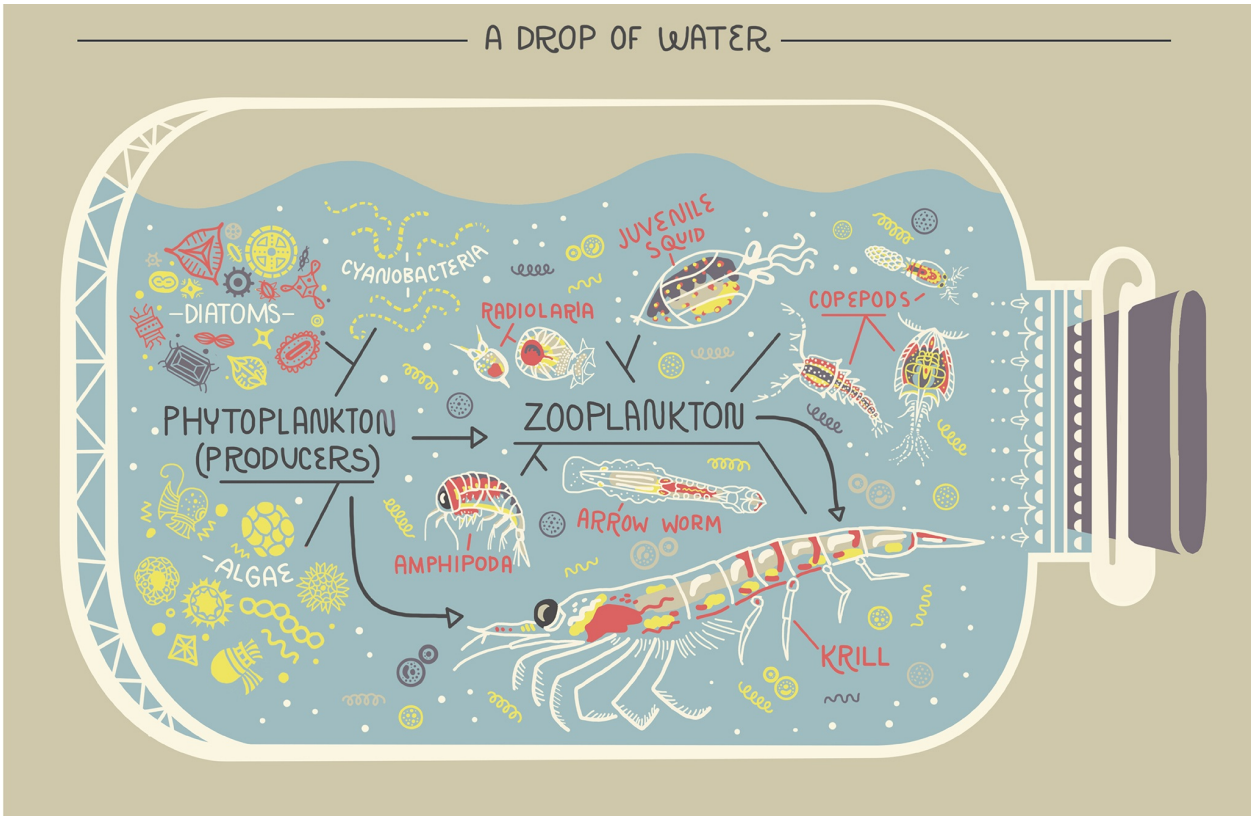

A POND
MOSQUITO
DRAGONFLY
CATTAIL
DUCK
WATER LILIES
FLY
PRODUCERS
ALGAE AND PHYTOPLANKTON
FROG EGGS
FROG TADPOLE
FROG
NEWT
ZOOPLANKTON
POND SNAIL
MINNOW
PONDWEED
WATER BEETLE
LEECH

# MICROSCOPIC ECOSYSTEMS

Scientists estimate that there are over a trillion species of microbes on Earth. Just look at a drop of water under a microscope, and you will see a whole world teeming with life. Microbes are everywhere, floating all around us; on our skin, our food, and the dirt on our shoes; and in the air we breathe. But don't get grossed out; we need microbes more than they need us. We rely on these tiny creatures to sustain all life on Earth, from creating the air we breathe to the food we eat.

Microscopic plants called phytoplankton are the basis of the marine food web—all life in the ocean depends on them. In turn, plant life in the ocean generates over half of all the oxygen on the earth (the rest comes from terrestrial plants). As if that was not enough, microbes are also important decomposers that turn dead plants and animals into fertile soil. In this new soil, new plants grow, which in turn sustain animal and human life. Microbes and bacteria are key for the cycling of vital nutrients like carbon, nitrogen, and phosphorus throughout the global ecosystem. Without these microbes, there would be no life on Earth!

Bacteria and other microbes are often the first type of life that can colonize inhospitable areas, turning depleted wastelands into lush ecosystems that can support more life. Ecologists can use their knowledge of microorganism ecology to help revitalize areas that seem to be barren. Microorganisms may seem like they are in a world of their own, but our world would not exist without them.


A DROP OF WATER
DIATOMS
CYANOBACTERIA
RADIOLARIA
JUVENILE SQUID
COPEPODS
PHYTOPLANKTON (PRODUCERS)
ZOOPLANKTON
ALGAE
AMPHIPODA
ARROW WORM
KRILL

# THE SOIL


PLANTS (PRODUCERS)
FUNGUS
SNAIL
SOWBUG
SHREDDERS ARTHROPODS
DECAYING MATTER
MILLIPEDE
SOIL
WATER
MITE
ROOTS
EARTHWORM
EARTHWORM SOIL MOVER
PREDATORY NEMATODE
FUNGI- AND BACTERIA-EATING NEMATODE
ROOT-EATING NEMATODE
PHOSPHORUS
NITROGEN
CARBON
BREAKS DOWN
FUNGUS
DECAYING MATTER
PROTOZOA
BACTERIA


North America extends from freezing and icy Greenland to warm and lush Panama. This continent has been called "the New World," and its history and legacy have shaped the path of human history.

The first people to live in North America were Asiatic people, over 10,000–20,000 years ago. Many archeologists have found evidence that a large nomadic tribe traveled on foot over an ancient (now nonexistent) bridge of land that connected Siberia to North America. Over thousands of years and many generations, a population of people spread from the tip of the Arctic Circle all the way down to South America, creating many different nations, cultures, and tribes along the way. Only a few of these once-numerous indigenous communities still exist today. In the 1500s there was a wave of exploration from the European continent, led by Portugal and Spain. In fact, the name "America" came from the Italian explorer Amerigo Vespucci, who was part of the first wave European exploration. This new "discovery" for Europe was followed by the conquest and colonization of North America and violent subjugation of its indigenous people. With these human invaders also came new species of bacteria, animals, and plants, which transformed and in many cases destroyed certain ecosystems. The negative effects of colonization are still felt today by the surviving indigenous communities.

The New World offered opportunities to colonizing Europeans away from the strict class system of the "Old World." With them came not only invasive species but also drastic changes in the types of agriculture production of the land. From the 1700s to today, waves of immigrants

have traveled to North America in search of opportunity, bringing plants and animals from their old homes with them. Although the introduction of new wildlife can cause great harm and unbalance an ecosystem, sometimes introducing a new species can provide solutions to big problems. For example, horses and wheat were brought to the Americas from Europe and Asia. These animals and plants were used for transportation and agricultural purposes and became an integral part of the landscapes, cultures, and economies of various North American regions. North America continues to be a home for new immigrants from all over the world and has become a beautiful melting pot of cultures.


THE GRAY WHALE MIGRATES FROM THE WARM LAGOONS OF MEXICO TO THE ARCTIC CIRCLE EACH YEAR.
GREENLAND
UNITED STATES
ALASKA RANGE
MACKENZIE MTS.
COAST MTS.
CANADA
LAKE SUPERIOR IS THE LARGEST FRESHWATER LAKE ON EARTH.
WATER
WETLANDS
ICE
TUNDRA
TAIGA
TROPICAL RAINFOREST
TEMPERATE FOREST
GRASSLAND
SCRUBLAND
DESERT
MOUNTAIN
SIERRA NEVADA
ROCKY MOUNTAINS
UNITED STATES
APPALACHIAN MTS.
BAHAMAS
DOMINICAN REPUBLIC
CUBA
PUERTO RICO
JAMAICA
HAITI
MEXICO
SIERRA MADRE
BELIZE
HONDURAS
GUATEMALA
EL SALVADOR
NICARAGUA
PANAMA
COSTA RICA
CHINAMPA (FLOATING GARDENS) IS A SUSTAINABLE AZTEC FARMING METHOD, STILL USED IN PARTS OF MEXICO.


GREAT HORNED OWL
APEX PREDATOR
MOUNTAIN LION
PRODUCER
COASTAL REDWOOD TREE
COASTAL REDWOOD TREE
DOUGLAS FIR TREE
OMNIVORE
AMERICAN BLACK BEAR
YELLOW-CHEEKED CHIPMUNK
SALMON
ACORN
PRIMARY CONSUMER
BLACK-TAILED DEER
ROOSEVELT ELK
LICHEN
FALLEN REDWOOD TREE
STRIPED SKUNK
INSECTS
GRASSES
LICHEN
ALGAL CELL
FUNGAL HYPHAE
TURKEY TAIL MUSHROOM
DECOMPOSERS
SHAGGY MANE MUSHROOM
SWORD FERN

# ECOSYSTEM OF THE REDWOOD FOREST

In the world's tallest forest, trees the size of skyscrapers are bathed in dense fog near the ocean. In the redwood forest, the coastal redwood tree can grow over 300 feet high and live over 2,000 years. They are relatives of the same trees that lived during the Jurassic period, 160 million years ago. As American author John Steinbeck wrote, "[Redwoods] are not like any trees we know; they are ambassadors from another time."

Redwoods are one of the most resilient species on Earth, able to withstand both floods and fires. Redwood trunks contain so much water that they can survive being burned. This comes in handy, because moderate fires actually help other types of trees—such as firs, spruces, and western hemlocks—compete and flourish. In the redwood forest, small fires help maintain biodiversity and prevent larger catastrophic fires from igniting later.

Although redwood trees are very resilient, they can only survive in a very specific cool and wet environment. Coastal redwoods grow along a narrow strip of land on the Pacific Coast of North America, where the ocean creates precipitation and fog. Plentiful rain leads to flooding that strips nutrients from the soil. On the forest floor, insects and decomposers like fungi and mosses revitalize the soil by breaking down burned trees and dead plants and animals. Through decomposition, this ecosystem is hard at work creating new topsoil, and the results are beautiful. Careful fire management, support, and protection from the U.S. national park system allow visitors to continue to enjoy these ancient forests.

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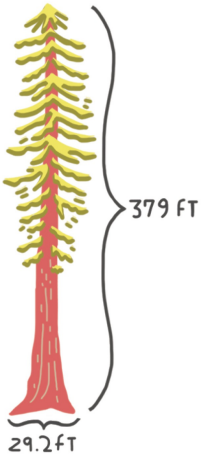
## BIGGEST BENEFITS

Dense forests worldwide **absorb carbon** from the atmosphere and **create oxygen.** But redwood forests absorb carbon at a heroic rate. Large coastal redwood trees grow quickly and store up to **three times more carbon** in their trunks than most other types of trees. With an increase in carbon dioxide

pollution from cars and factories, it is more important than ever to preserve redwood trees.

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One **redwood tree** grows at a rate of over five cubic feet a year (equal to 3.2 million pencils).

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Redwood trees have **basal burls,** knotty growths filled with seeds. When the main trunk of a tree is damaged, these dormant seeds begin to sprout a new tree.

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In the late 1800s and early 1900s, a few coast redwoods and giant sequoias (an inland species) had tunnels cut into them so that tourists could drive through them! Some of these **"tunnel trees"** are still around, but cutting through a redwood always results in its eventual death.

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You can see **seals, sea lions, dolphins,** and **whales** off the coast of the redwood forest.

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**Native Hawaiians** used fallen redwood logs that drifted from the coast of California to make 100-foot-long canoes.


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## GREATEST THREAT

Although most of the redwood forest is protected, the forest is still threatened by **bad lumber practices** and **encroaching cities.** Edge ecosystems act as watersheds and shield the forest from extreme flooding. When trees are removed and surrounding ecosystems are disturbed it can hurt the whole forest. Ecologists are working to restore impacted parts of Redwood forests while not interfering with natural disturbances like small wildfires that are good for it.


MIGRATORY BIRD
SANDHILL CRANE
AMERICAN BISON
AWOOOOOO
COYOTE
GRASS
PRONGHORN
WESTERN MEADOWLARK
BLACK-TAILED PRAIRIE DOG
BURROWING OWL
APHID
PRODUCERS
BUFFALO GRASS
BIG BLUESTEM GRASS
GRASS
WOLF SPIDER
PURPLE CONEFLOWER
GRASSHOPPER
MICROBES
FUNGUS
DECOMPOSERS
WORM
STOLEN PRAIRIE DOG NEST
OWL EGGS

ECOSYSTEM OF THE

# NORTHERN GREAT PLAINS

"There is so great a charm in absolute solitude, in the wild, lonely freedom of the Great Plains, that often I would make some excuse and go off entirely by myself." This is how U.S. President Theodore Roosevelt described the Great Plains of the central United States. His appreciation of and respect for the natural world led to the establishment of the U.S. National Park System. The Great Plains may seem like just a quiet expanse of flat grassland, but it is actually a wilderness teeming with life. Snakes, gophers, and insects battle it out in the underbrush while birds soar above. These native grasses are the basis of an ecosystem that has some of the most nutrient-rich soil in the world. These plains used to support massive herds of bison and elk, with an abundance of wildlife that rivaled that of the African savanna (see this page), but much has changed over the last 200 years.

As human populations grew larger in the 1800s, so did their use of the fertile Great Plains for farming, herding, and hunting. With any rich resource often comes the overuse and destruction of that resource. Bad farming practices combined with drought led to the devastating Dust Bowl of the 1930s. When this decade-long drought ended, drastic intervention was needed for the soil to bounce back. Much of the Great Plains is still used for farming today. The natural life cycles of native grasslands create rich soil and the grasses' long roots lock in moisture to prevent droughts. When farmers preserve native grasslands, they can use these natural benefits to help prevent another Dust Bowl from happening again.

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## BIGGEST BENEFITS

The long roots of the Great Plains' native grasses can absorb up to **eight inches of rainfall!** This prevents floods during rainy seasons. Water stored in these roots keeps the soil moist during the dry seasons. The life cycles of grassland wildlife create naturally nutrient-rich soil that is perfect for

supporting farming and livestock. When farmers keep native grasslands as a part of the agriculture fields, they use less water and chemical fertilizers on their crops.


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The **pronghorn** of the Great Plains is the fastest animal in North America and can run at speeds of up to 55 miles an hour.

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Has one of the largest **wind farms** in the world.

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In the 1890s, the **60 million bison** that lived on the plains were nearly driven to extinction by over-hunting. Luckily, from about a thousand remaining bison, conservationists were able to bring them back, and today half a million bison still roam the plains.

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**The Greater Sage-Grouse** is known for its dramatic courtship displays. A large population of sage grouse indicates that the entire ecosystem is intact and healthy.


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Nine million acres of the North American plains are managed by **Native American tribes,** many of whom are helping to restore the land through their own ecological initiatives.

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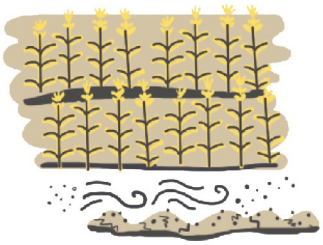
## GREATEST THREAT



Despite President Roosevelt's wish to preserve nature, the Great Plains is one of the **least-protected ecosystems on Earth.** More and more of the plains are being used for unsustainable large-scale monocrop farms (which grow just one type of plant) that destroys biodiversity. Poorly planned building on the plains threatens wildlife migration routes and habitats. Sustainable farmers, ranchers, conservationists, and Native American tribes are doing what they can to preserve the ecosystems on their land by **expanding protected areas** and **restoring** what little native grassland is left.


RACCOON
ROSEATE SPOONBILL
IGUANA
GREAT EGRET
PRODUCER
RED MANGROVE
APEX PREDATOR
AMERICAN ALLIGATOR
AMERICAN CROCODILE
FISH NURSERY
LONGNOSE GAR
SEA TURTLE
DEAD LEAVES
MANGROVE SNAPPER
FISH EGGS
DEAD LEAVES
CRAYFISH
PRAWN
SEA GRASS
POLYCHAETE WORM
CRAB
MOLLUSKS
AMPHIPOD

# ECOSYSTEM OF THE FLORIDA MANGROVE SWAMP

It is not hard to get lost in the swamps of a mangrove forest—visitors often have to canoe through a tight maze of tangled mangrove tree roots and branches. These roots and branches may seem like a big mess, but they are what make this ecosystem so successful and important.

Mangroves are found in tropical regions worldwide. The Florida mangrove forest is an edge ecosystem (an ecotone) in between the salty Atlantic Ocean and the shallow freshwater "river of grass" known as the Everglades. Mangroves are types of shrubs and trees that grow in brackish coastal water and are uniquely able to filter out salt to create their own fresh water. Mangroves provide habitat for numerous animals, and their dense root systems act as a physical barrier that protects Florida's coastal land from erosion and storms.

If all that wasn't enough to earn mangroves MVP status, their leaves are also the basis for the entire ecosystem's food web, making them a keystone species. Bacteria and baby crustaceans break down their floating leaves in the water, attracting large animals, birds, and (of course) large predators. White pelicans and egrets perch in the mangrove branches, while alligators and crocodiles float below, staying perfectly still until their next meal swims by. This ecosystem truly shows how one kind of plant can transform an entire coastline!

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## BIGGEST BENEFITS

Mangrove forests **protect the coastal land from erosion** and storms, and are

important homes for **marine and intertidal species,** including endangered species like the **Florida manatee,** the **American crocodile,** and the **Key deer.** The mangrove forest acts as nursery to many marine animals before they are mature enough to swim into the ocean—the roots protect developing eggs and young fish and crustaceans from prey. This makes them a vital resource for commercial fisheries in the Gulf of Mexico.


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Mangrove leaves **taste salty** because they "sweat out" some of the salt that the trees absorb from the water.


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Southern Florida is the only place on Earth where both **crocodiles and alligators** live in the same area.

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**Iguanas** are not native to Florida but can be found hanging out all over the mangrove swamp.


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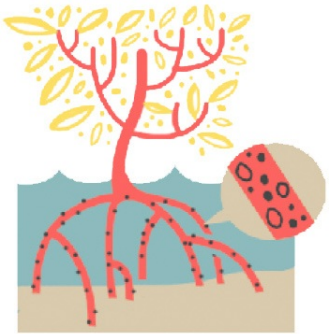
Mangroves have special breathing tubes called **lenticels** on their roots; these let them breathe underwater during high tide. Although plants "exhale" oxygen, they also need to consume some for cellular respiration.



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## GREATEST THREAT


Nearly half of the mangrove forests worldwide have been destroyed since the 1950s for firewood or have been cleared for construction. Mangroves are now a protected species in **Florida,** but are under continued threat in **Mexico, South America,** and **Asia.** The loss of these forests decreases the population of important aquatic animals that are part of larger ocean food web. International preservation groups are working to protect what is left of these important ecosystems.


APEX PREDATOR
RED-TAILED HAWK
MOTH
ELF OWL
JOSHUA TREE
PRICKLY PEAR CACTUS
KANGAROO RAT
CREOSOTE BUSH
KIT FOX
BAT
MOJAVE RATTLESNAKE
SECONDARY CONSUMERS
TORTOISE
PRODUCERS
ANTS
MILLIPEDES
SCORPION
DUNG BEETLE
COLLARED LIZARD
GRASSHOPPER
DECOMPOSERS

# ECOSYSTEM OF THE MOJAVE DESERT

The Mojave Desert in the southwestern United States has been described as otherworldly—dotted with strangely shaped red rocks and spiky Dr. Seussian Joshua trees, which don't grow anywhere else in the world. The Mojave was once the site of many ancient lakes and riverbeds, which have since dried up. Long ago these rivers and lakes carved what is now the deepest valleys in North America, right next to snowcapped mountains. They also left behind hidden underground water reservoirs and rich minerals that can be found throughout the desert.

During the rainy season, the Mojave is home to a limited variety of plant life, with cacti, shrubs, and colorful flowers flourishing. But in the summer, you can see why European settlers called it "the land that God had forsaken." This desert is home to the hottest, driest place on Earth: California's Death Valley. There, temperatures regularly reach 120°/49°F (hot enough to melt the sneakers right off your feet!) and it boasts the world record temperature of 134°F/57°C!

How can anything survive in such heat? Life depends on water, and desert plants and animals have adapted to survive on the occasional winter rainstorms and by finding underground aquifers. A few animals, like the kangaroo rat, do not drink water at all and get all their hydration from the leaves and seeds they eat. Meanwhile, other animals avoid the hot sun by leaving dens and burrows only at night, like a coyote or a jackrabbit. Although desert life can be hard, the Mojave Desert's unique elevations and hidden water sources makes it home to some of the most beautiful wildlife and landscapes in the world.

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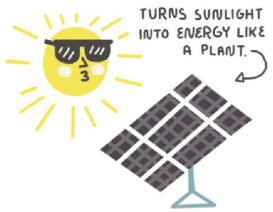
## BIGGEST BENEFITS

The Mojave Desert's generally sunny, cloudless weather and high elevation has made it home to one of the world's largest **solar energy farms.** Its ancient lake beds are a rich source of minerals like **salt, copper, silver,** and

**gold** that have been mined throughout history. The lakes also left an **underground water supply** that is one of the water sources for the surrounding communities and cities.

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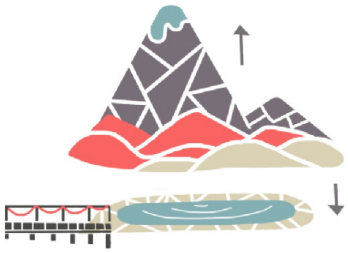
**Badwater Basin in Death Valley** is the lowest point in North America, at 282 feet below sea level. Extreme differences in elevation in the Mojave create dramatic contrast, with snowcapped mountains surrounding the basin.



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The mountains that surround the Mojave block almost all rain from reaching the desert. Scientists call this a **"rain shadow desert."**

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In the ecotone of the Mojave Desert and the Great Basin is the world's rarest fish. **The Devils Hole pupfish** is found only in **Devils Hole,** an aquifer so deep that earthquakes on the other side of the world cause the water to ripple.

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The **desert tortoise** stores water in its bladder during the rainy season and uses it to survive the dry parts of the year. (Like a camel, but slower!)

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So-called **"sailing stones"** are found in parts of the Mojave. They leave trails across the flat surface of dry lake beds, seeming to have moved on their own. When conditions are right, thin ice sheets break apart and are blown by the wind, pushing the rocks across the clay lake beds.


## GREATEST THREAT

When an area has valuable natural resource, even if that resource is as limited as water in the desert, there is the threat of people overusing it. Surrounding cities have been **draining the aquifers** of the Mojave, depriving wildlife that depends on that water and causing the desert floor to slowly sink. More and more of the desert is also being used as **garbage landfill space.** To help preserve the desert, we need to be more mindful of how we use water in our cities and think about what we throw away in our daily lives.


The driest desert and the largest rainforest in the world can both be found on the same continent: South America. This landmass is defined by its backbone, the Andes, which is the longest mountain range in the world!

The glaciers high in the Andes provide water to the mighty Amazon basin and its hundreds of connecting rivers. The Amazon basin supports tropical agriculture like cacao and coffee and is a major source of the world's lumber. The Andes also shield the western deserts of South America from rainfall. The arid heat of those deserts has exposed minerals, especially copper, that are mined to this day as one of Chile's largest exports. Southeast of the mountains are the fertile grasslands of the Argentine Pampas, where agriculture produces wheat, soy, and cattle.

The natural bounty of the Andes made it one of the six cradle civilizations where the environment and natural resources allowed ancient nomadic humans to settle down, farm, and create cities for the first time. The earliest civilization in the Americas, called the Norte Chico, was located in what is now Peru. Norte Chico's first city was built over 5,500 years ago, a few hundred years before the first pharaoh was crowned in ancient Egypt. People began to cultivate crops like squash, beans, and cotton—beginning humans' transformation of the South American wilderness. Today, South America is home to many cultures as diverse as its natural landscapes. Resources, minerals, and food produced in South America are exported and enjoyed all over the world. But with this comes a danger of overusing the land. Right now, the world's largest rainforest is

shrinking. With our knowledge of ecology, we can use both new and traditional techniques to take from the land while preserving its vital ecosystems.


VENEZUELA
GUYANA
SURINAME
FRENCH GUIANA
COLOMBIA
ECUADOR
PERU
ANDES MOUNTAINS
BRAZIL
BOLIVIA
CHILE
PARAGUAY
ARGENTINA
URUGUAY
FALKLAND ISLANDS
WATER
WETLANDS
TROPICAL RAINFOREST
SAVANNA
GRASSLAND
TROPICAL SCRUB
DESERT
MOUNTAIN
TROPICAL SEASONAL FOREST
ANGEL FALLS IN VENEZUELA IS THE TALLEST WATERFALL IN THE WORLD!
MOST OF THE WORLD'S COFFEE COMES FROM BRAZIL!
ECUADOR IS THE FIRST COUNTRY EVER TO GRANT RIGHTS TO NATURE IN ITS CONSTITUTION. THIS MEANS LAWYERS CAN DEFEND ECOSYSTEMS' "RIGHT TO EXIST, PERSIST, MAINTAIN AND REGENERATE ITS VITAL CYCLES."


LEAF
CANOPY
TOUCAN
SLOTH
UNDER-
STORY
SECONDARY
CONSUMERS
JAGUAR
SPIDER
MONKEY
MANGO
MACAW
HELICONIA
PLANT
HUMMINGBIRD
PRIMARY
CONSUMER
TAPIR
PRIMARY
PRODUCERS
FOLIAGE
SHRUB
LAYER
LEAF
FOREST
FLOOR
BACTERIA
DECOMPOSERS
FUNGUS
ANACONDA

# ECOSYSTEM OF THE AMAZON RAINFOREST

The Amazon is the world's largest rainforest, and it is the densest and richest place for life on Earth. Covering two million square miles across eight different countries (60 percent of which is in Brazil), the massive jungle has been nicknamed "the green ocean." The Amazon is home to 10 percent of all the known species in the world. Glowing insects, exotic dancing birds, flesh-eating fish, tiny pygmy sloths—you name it, you will find it in the Amazon.

The Amazon's millions of different plants and animals must compete for resources. Plants fight to break through the shady jungle canopy for sunlight; some plants have evolved to grow not in soil, but instead on top of trees as tall as skyscrapers. Competition for food sometimes results in specialized evolution, where a new species emerges with a super-specific niche. The sword-billed hummingbird's beak is longer than its entire body, so it can feed from only certain types of long tubular flowers that are impossible for other hummingbirds' bills to reach (which means no sharing).

Life here is fueled by the Amazon River, one of the longest rivers on Earth. Fresh water also comes from above. During the six-month rainy season, over 200 billion metric tons of rain floods an area of the forest floor larger than the entire United Kingdom. During this season, fish and even dolphins swim through the jungle. This water sustains the massive numbers of trees that are crucial to creating oxygen and regulating the whole planet's climate. The Amazon absorbs over 2.4 billion metric tons of carbon each year. Rainforests produce about 20 percent of the world's oxygen. This is why the Amazon rainforest is nicknamed "the Lungs of the Planet."

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## BIGGEST BENEFITS

The huge density of plants in the Amazon influences global carbon and water cycles, **creating oxygen** and **regulating the weather** patterns and climate for the **entire world.** Thirty million people (including 350 indigenous tribes and ethnic groups) living in the jungle and the surrounding cities depend on the jungle for food and jobs.


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There is so much food in the Amazon that animals can eat enough to grow to huge sizes, like the **capybara,** the world's largest rodent.

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During the rainy season, **freshwater Amazonian manatees** will leave the rivers and graze in the flooded forest.

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The forest canopy is so thick with leaves that only a small amount of light breaks through, leaving the forest floor in **nearly perpetual darkness.**

---

The Amazon is home to one of the rare freshwater dolphins called the **pink Amazon River dolphin.**

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**Jaguars** regularly hunt crocodiles and many think the original Tupi name for Jaguar (*îagûara*) directly translates to "he that kills with one leap."

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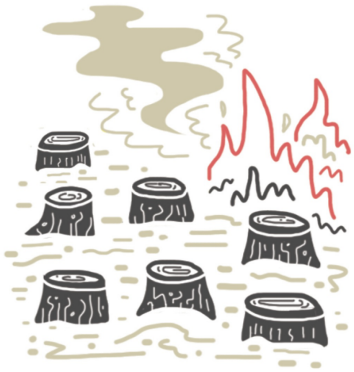
## GREATEST THREAT



New, poorly planned infrastructure, including the construction of **massive new dams,** break up the river systems that are crucial to life in the rainforest. Unsustainable and illegal **logging** also puts the jungle at risk. **Fires** are burned in the forest to remove trees and make space for cattle, releasing millions of tons of carbon into the atmosphere annually, which contributes to global warming. Indigenous communities like the **Asháninka** are working with conservationists to protect the rivers and the jungle. The Amazon rainforest is crucial to the **entire planet's health,** and it is critical to combat deforestation.


FLAMINGO
VICUÑA
PAJA BRAVA GRASS
-DIATOMS-
SPECIAL ALGAE & PHYTOPLANKTON
SUPER ACIDIC SALTWATER LAKE
SALT
SCORPION
SOUTHERN VISCACHA
CULPEO FOX
COPIAPOA CACTUS
LEAF-EARED MOUSE

# ECOSYSTEM OF THE ATACAMA DESERT

The last time it rained in parts of the Atacama Desert was before humans began to record history in writing—that is how dry it is. The only places on Earth with less rainfall are the very tips of the North and South Poles. Located on the Pacific coast west of the Andes, this desert is unusally high above sea level and is shielded from rain by the Andes mountains, giving it a unique climate and landscape. The Atacama Desert is filled with bright red canyons, stark white salt flats, and the most beautifully clear sky in the entire world. Although life struggles to survive in this harsh climate, a small number of plants and animals have adapted to call this "alien" landscape home.

The Atacama's closeness to the ocean causes fog zones known as "fog oases" or *lomas*, where the steep coastal cliffs and hills can catch moisture from the clouds that roll off of the Pacific Ocean. This small amount of water is the most moisture that parts of the Atacama will ever see. Yet it's enough to sustain some scrub plants and many types of birds like the Peruvian song sparrow and Pacific blue-black grassquit, and small mammals, like viscachas (a rabbit-like rodent) and foxes. As it gets even drier, only a scarce cactus, vulture, mouse, or scorpion can be found. South of the Chilean city Antofagasta, the terrain becomes a sea of red rocks, looking more like Mars than Earth. In some parts of the Atacama, farthest away from the fog, the climate is so dry even bacteria struggle to live. The heat that makes life so hard also creates clear, cloudless skies and a crystal-clear view of the Milky Way that can be seen with the naked eye at night. Some say this night sky is one of the desert's greatest natural resources.

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## BIGGEST BENEFITS

The Atacama Desert's uniquely high elevation, clear skies, and lack of light pollution make it perfect for **researching stars.** This desert is home to the

largest international astronomy project on Earth: a group of **radio telescopes** called The Atacama Large Millimeter/submillimeter Array. The telescopes' delicate long-wavelength readings give scientists detailed images of faraway stars and a better understanding of our universe.

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Even though it has not rained for centuries in the Atacama, its ancient lakes are still evaporating, creating huge **salt lakes** and **salt flats.** The largest salt flat in Chile is found in the Atacama Desert.

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Large flocks of **flamingos** eat algae that grows in the shallow water in the Atacama' salt flats. (A flock of flamingos is called a "flamboyance"!)

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NASA tested the **Mars Rovers** in the Mars-like landscape of the Atacama.

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**The Valle del Arcoíris** (Rainbow Valley) is named for its naturally occurring brightly colored rocks; the **Valle de la Luna** (Valley of the Moon) has stone and sand formations like those on the moon.


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Home to many large active **volcanoes,** including the famous **Licancabur.**

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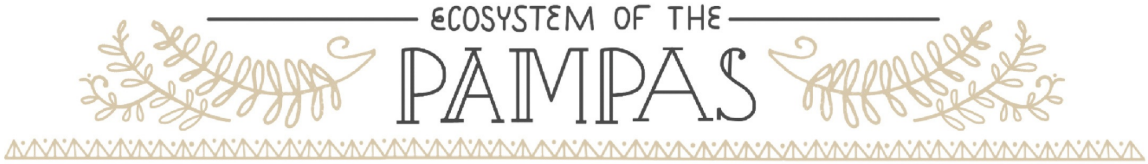
## GREATEST THREAT

As towns and cities grow near the desert so does the amount of **artificial light in the night sky.** This light pollution can confuse and disrupt nocturnal animals. It's important that new construction is done in a way that is sensitive to the ecosystem's needs. By installing special types of lights and enforcing light pollution regulations, we can preserve the desert's most amazing natural resource: the clearest view of the night sky to be found on Earth.


CAMPO FLICKER
GUANACO
GREATER RHEA
LOCUST
GRASS
APEX PREDATOR PUMA
GRASS
PAMPAS FOX
PAMPAS MEADOWLARK
PATAGONIAN HARE
BEETLE
GRASS
BIG HAIRY ARMADILLO
PRODUCER PAMPAS GRASS




The gauchos ride across a seemingly endless expanse of grass. For over 200 years, these South American cowboys have managed sheep, cattle, and horses in the Pampas, using the same techniques and traditions. The rolling hills of the Pampas are dotted with shrubs and trees and watered by lagoons and rivers. All that grass flourishes in the humid climate and heavy rainstorms called *pamperos*.

The native grasses and plants, like *flechillar*, have supported native wildlife like the guanaco (a wild llama) and the pampas deer, long before cattle were brought to the region. In the mid-1800s the Spanish colonized South America and brought along the domesticated horses and cows that now dominate the countryside. Much like grasslands all over the world, the ecosystems and landscape of the Pampas have been transformed by ranching and farming.

Although the Pampas seems huge, covering parts of Argentina, Uruguay, and Brazil, it is not an inexhaustible resource. Overuse of the land for farming and unsustainable grazing practices have made the Pampas ecosystem one of the most endangered in the world. When grassland doesn't have enough time to bounce back after animal grazing, soil erodes more quickly, making it harder for plants to grow. The gaucho has always been a symbol of the Pampas, but as the grassland's ecosystem becomes more endangered, so does the gaucho way of life. Right now scientists, gauchos, and private landowners are working together to create and implement new grazing and farming techniques that minimize environmental impact. Through proper management, the land can continue to be used for many generations.

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## BIGGEST BENEFITS

The grasslands of the Pampas are a valuable part of Argentina's economy

and a center of agriculture in South America. **Rich soil** and **abundant grasses** make it great for growing crops and grazing herd animals like cattle. As farming and ranching expand it is important to keep native grasslands partially intact, because they naturally help prevent desertification and floods.


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The Pampas is home to the **greater rhea,** an emu-like bird that runs in a zigzag when chased.

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The **guanaco's** thick, luxuriant eyelashes help protect their eyes from dust.


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**Buenos Aires,** Argentina's most populous city, is located in the Pampas.

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Baggy pants worn by the gauchos are called ***bombachas***.


## GREATEST THREAT

The **unnecessary draining** of vital grassy wetlands, **overgrazing** of farm animals, and the **destruction of native grassland** to make room for new unsustainable farms threaten the Pampas ecosystem. All of these activities increase **soil erosion,** making new grass harder to grow. To feed our ever-expanding human population, we need to find the balance between large-scale farming and sustainable techniques that keep the grasslands intact.


GLACIER
SCAVENGER
ANDEAN CONDOR
ALPINE GRASSLAND
3,000 M – 4,800M
PUYA
ALPACA
GIANT HUMMING-BIRD
GRASS
LLAMA
CHINCHILLA
CLOUD FOREST
800M – 3,500M
YELLOW-TAILED WOOLLY MONKEY
MOTH
PALM LEAVES
FRUIT
ANDEAN TINAMOU
SPECTACLED BEAR
TROPICAL RAINFOREST
500M – 1,500M
GLASS FROG
COMMON TREE BOA
DART FROG

# ECOSYSTEM OF THE TROPICAL ANDES

The Earth's surface is always moving. Over long periods of time, tectonic plates under the continents and oceans shift and collide. This is how the supercontinent Pangea started to break apart over 200 million years ago into the continents we have today. It is also how our greatest mountain ranges, like the Andes, were created. This 4,300-mile-long range, which stretches along the entire western side of the continent, is home to many of the tallest peaks in the Western Hemisphere. The three main climates of the Andes are dry, wet, and tropical. The tropical Andes are a huge biodiversity hotspot that follows the path of the mountains for 3,300 miles, from Venezuela to Bolivia.

The temperature in the tropical Andes gets colder as you climb into the mountains, causing climate fluctuations. These microclimates allow for many different types of niches and habitats for large amounts of diverse animals and plants. At 15,700 feet, the tropical Andes are covered in grasslands and snow. At lower elevations, starting at 11,500 feet, is the largest cloud forest in the world, its plants shrouded in fog. Lower still, at 4,900 feet, it begins to be warm enough for tropical rainforest wildlife to prowl the forest.

Climate is not the only factor that makes the this forest so diverse. Unlike a normal forest, the tropical Andes' forests are spread out across the mountains. Like on islands surrounded by water, certain wildlife species are unable to leave certain peaks. Many unique species of animals and plants can be found on only one mountain in the entire range.

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## BIGGEST BENEFITS

**Fifteen percent** of the world's known plant species can be found in the Tropical Andes. In just 2.5 acres of the tropical Andes are over 300 different flower species. The abundance of plants in this forest help to **create oxygen**

and absorb **5.4 billion tons** of carbon each year. That is equivalent to the yearly carbon emissions created by one billion cars.


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The **spectacled bear** found in the Andes got its name because its markings look like glasses. Its sounds—like **screeching** and **soft purring**—are very rare among bears.


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The Andes used to be the home of the **Inca Empire,** the largest civilization in the pre-Columbian Americas.

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**Potatoes** and **tobacco** both originated in the Andes and are now grown all over the world.

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The **yellow-eared parrot** is endangered, but with help of conservationists, the population has been increased to over 1,500 individuals.

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The tropical Andes have the greatest animal and plant diversity of all the world's designated biodiversity hotspots.

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## GREATEST THREAT

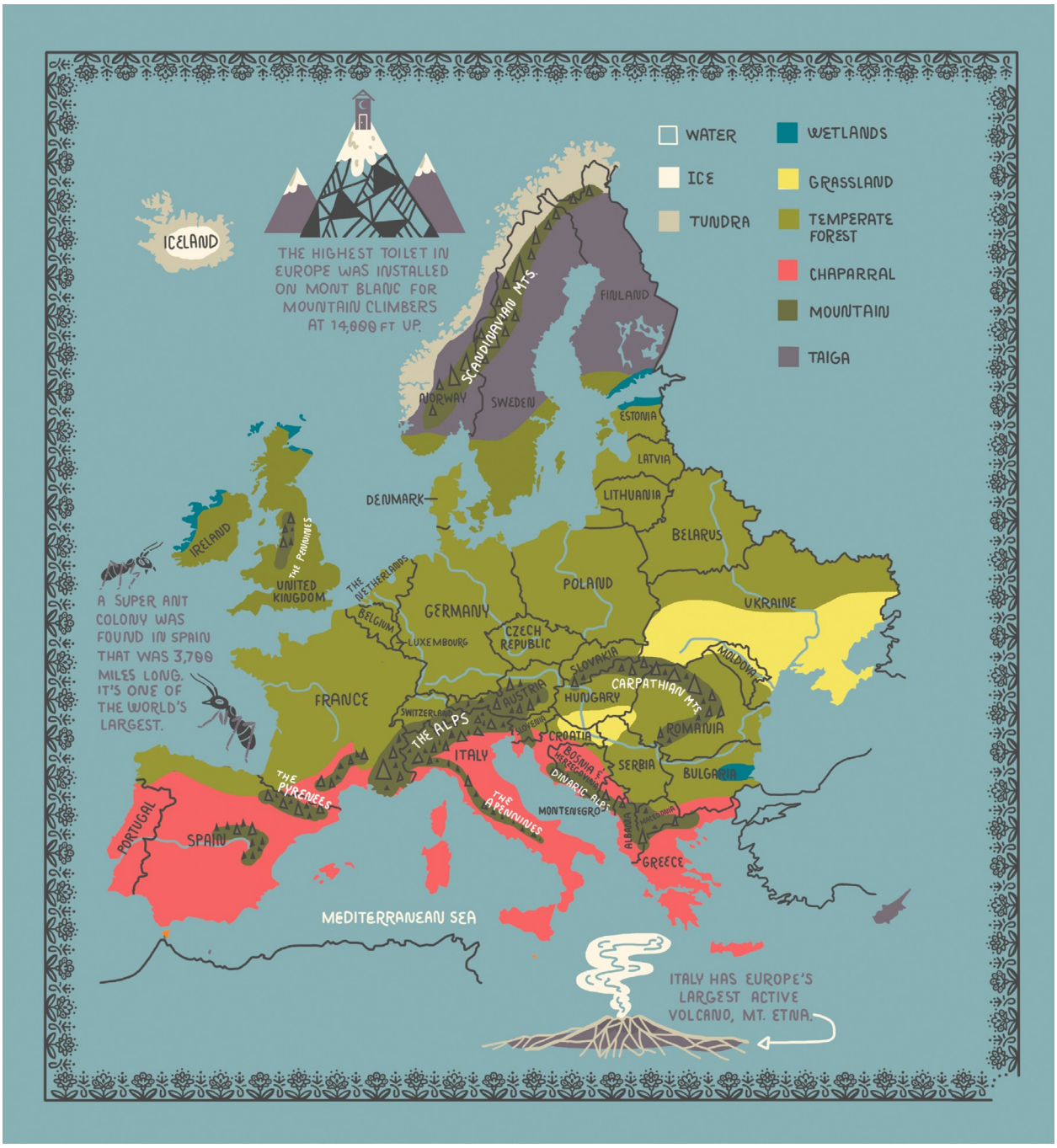
As the human population grows, so does the demand for **fuel, wood,** and **food.** As a result, the tropical Andes face **timber exploitation** and **illegal hunting.** This contributes to **deforestation** and puts animal species at risk. Unsustainable large-scale production of **cacao** and **coffee** in the region damages the soil and forces local communities to clear even more forestland to farm food they can actually eat. The region's poverty must be addressed to prevent illegal poaching and deforestation. When people have **food security,** they are better able to protect wildlife.


Many have said that Europe is more of an idea than a geographical place. It is on the same landmass as Asia, but its eastern border is undefined by any geological barrier. The "idea" of Europe was created by the ancient Greeks, who decided that two different sides of a narrow passageway called the Hellespont (now the Dardanelles) would be two different continents. The Europe-Asia border is an agreed-upon line that has shifted over time depending on the politics and cultural situations of a given time period. Europe is essentially a large peninsula with many islands filled with beautiful, diverse cultures, climates, and landscapes.

Europe is considered the "Old World," where western civilization began. From the Stone Age to the Industrial Revolution, Europe has changed the entire world on a massive scale. Ideas and art created during Greek antiquity and the European Renaissance still define the western world today. During the age of exploration and colonization, Europeans changed the human history of many other continents and cultures. In a race to create global empires, European kingdoms displaced and impacted huge numbers of people in other regions of the world. In addition, they took their native animals and plants all over the globe, and in turn brought species they found in their travels back to Europe—hugely impacting our global ecosystem.

In Great Britain during the eighteenth century, the Industrial Revolution brought about radical and irrevocable changes to how we use our

environment. New tools and inventions like steam engines, iron-making techniques, and the power loom changed how things were made. Assembly lines enabled mass production of goods. All over Europe, people left a life of farming to work in these new factories. Instead of people locally making their own clothes or tools, such goods were mass-produced and could be traded on a global scale. A rise in coal- and steam-powered engines greatly expanded global transportation. The Industrial Revolution transformed the way humans live and do business. More importantly, it redefined our relationship with the natural world.


WATER
ICE
TUNDRA
WETLANDS
GRASSLAND
TEMPERATE FOREST
CHAPARRAL
MOUNTAIN
TAIGA
ICELAND
THE HIGHEST TOILET IN EUROPE WAS INSTALLED ON MONT BLANC FOR MOUNTAIN CLIMBERS AT 14,000 FT UP.
SCANDINAVIAN MTS.
FINLAND
NORWAY
SWEDEN
ESTONIA
LATVIA
LITHUANIA
BELARUS
DENMARK
IRELAND
THE PENNINES
UNITED KINGDOM
THE NETHERLANDS
BELGIUM
LUXEMBOURG
GERMANY
POLAND
CZECH REPUBLIC
SLOVAKIA
VKRAINE
MOLDOVA
CARPATHIAN MTS.
HUNGARY
AUSTRIA
SWITZERLAND
THE ALPS
FRANCE
SLOVENIA
CROATIA
ROMANIA
SERBIA
BULGARIA
BOSNIA & HERZEGOVINA
DINARIC ALPS
MONTENEGRO
ALBANIA
MACEDONIA
GREECE
ITALY
THE APENNINES
THE PYRENEES
PORTUGAL
SPAIN
MEDITERRANEAN SEA
A SUPER ANT COLONY WAS FOUND IN SPAIN THAT WAS 3,700 MILES LONG. IT'S ONE OF THE WORLD'S LARGEST.
ITALY HAS EUROPE'S LARGEST ACTIVE VOLCANO, MT. ETNA.


SPHAGNUM (PEAT MOSS)
DEAD VEGETATION
PRESSURE AND HEAT
PEAT FORMS
GROUND-WATER
RED DEER
MERLIN
BOG
BADGER
EGGS
MOUNTAIN HARE
GRASS
SKYLARK
PEAT MOSS
RED GROUSE
WORM
PRODUCER
HEATHER
EMPEROR MOTH
DRAGONFLY
BUMBLEBEE
VERTIGO SNAIL
COTTON-GRASS
SNIPE

ECOSYSTEM OF THE

# MOORLAND OF THE BRITISH ISLES

"Dark against the evening sky, the long, gloomy curve of the moor, broken by jagged and sinister hills" is the landscape that set the scene for Sir Arthur Conan Doyle's famous novel *The Hound of the Baskervilles*. The iconic moors of the British Isles have inspired many great authors.

While this wet and hilly landscape may seem like a pure wilderness, in fact it was created by people. Although some of the moorland is a naturally occurring treeless bog, there is evidence that much of it was once an ancient forest. Many of those trees were cleared by ancient humans during Mesolithic times, and by doing so they created this new ecosystem. The moors are still used by people today to graze farm animals and hunt wildlife. Now the moors are preserved through a rich tradition of land management. Selective and targeted game hunting and managed wildfires help preserve the diverse patchwork of young and old ecosystems. This makes sure that the grasslands have a healthy regrowth period and remain viable for future grazing.

The Moorlands have many bogs—wetlands rich in peat, a thick mud-like substance. Peat is the first stage in the formation of coal. Over time, dead plant matter builds up in the bottom of a bog. They don't completely decompose, but instead create peat. The deeper the peat, the more carbon-rich it is. All of that carbon packed into peat makes it a source of energy, helping fires to burn longer. Bogs also contain mosses called sphagnum, which keep the peat from being washed away. Sphagnum also naturally filters the water, creating cleaner fresh water for all! Wet bogs contribute to the carbon-rich soil that fuels this entire grassland ecosystem.

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## BIGGEST BENEFITS

People and animals depend on the moors as the foundation of their **food**

**supply.** The bogs supply clean **drinking water** and provide rich **grazing** for flocks of sheep. The peatland that stretches across Europe is also an important **global carbon sink.** Carbon sinks naturally store carbon in places other than our atmosphere and are an important part of the carbon cycle.


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**Birds** from all over the world migrate to the moors, such as the **barn swallow,** which migrates every year from Africa.

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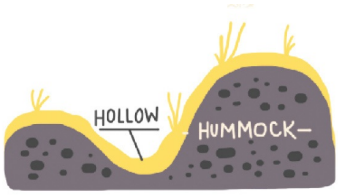
Peat bogs are "living landscapes," constantly forming new **hummocks** (small hills or mounds) and **hollows** (ditches or craters).

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**Grouse,** known as the king of game birds, is hunted when the population gets too big. This hunt is necessary to keep a balanced animal population, and game hunting gives rural communities another form of business, allowing them to continue to manage the moors.

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Peat bogs are found throughout Europe, and peat has been used as a fuel source since the Bronze Age. It is still used in parts of Europe, including Ireland and Finland.

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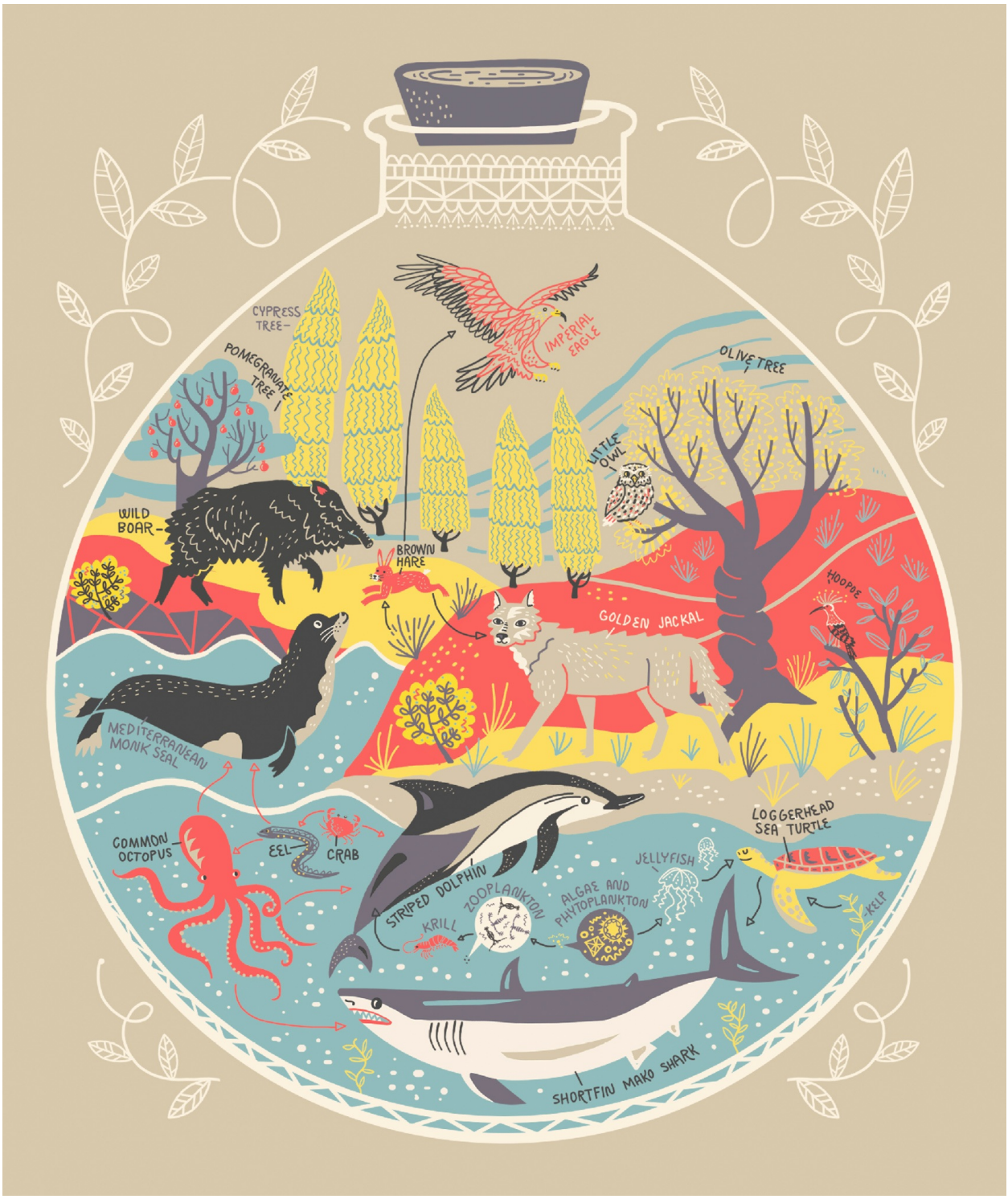
**Sphagnum moss** in bogs acts like a sponge and can **prevent harmful flooding** in nearby towns.

## GREATEST THREAT

**Overgrazing** and **poorly planned farming** have started to dry up the moors. **Global warming** is also causing more out-of-control wildfires. To combat this, conservationists and land owners are working to mindfully allow the wetlands to fill with water, sometimes helping the process along by digging ditches with explosives.


CYPRESS TREE
POMEGRANATE TREE
IMPERIAL EAGLE
OLIVE TREE
LITTLE OWL
WILD BOAR
BROWN HARE
HOOPOE
GOLDEN JACKAL
MEDITERRANEAN MONK SEAL
COMMON OCTOPUS
EEL
CRAB
LOGGERHEAD SEA TURTLE
JELLYFISH
STRIPED DOLPHIN
ZOOPLANKTON
ALGAE AND PHYTOPLANKTON
KRILL
KELP
SHORTFIN MAKO SHARK

# ECOSYSTEM OF THE MEDITERRANEAN BASIN

"The birthplace of western civilization" lies around the largest enclosed sea on Earth, the Mediterranean. The Mediterranean Basin encompasses twenty-four countries in Europe, the Middle East, and Africa. The sea seems unchanged by time, but in fact, it once dried up completely into a desert.

The amount of fresh water that the Mediterranean Sea receives from the surrounding rivers evaporates three times faster than it flows in. This makes the Mediterranean dependent on salty water flowing in from the Atlantic Ocean. Over six million years ago, tectonic activity caused the tips of Spain and Morocco to meet and fuse, cutting the Mediterranean Sea off from the ocean. The sun's heat worked quickly, and within only two thousand years, all the water in the Mediterranean evaporated, turning the sea floor into a desert. Eventually, another earthquake broke Spain and Morocco apart again, creating the Strait of Gibraltar, and the Mediterranean Sea was refilled. Today, underneath the island of Sicily, there is a massive underground salt mine of deposits left over from when the sea evaporated.

Fertile soil and a mild climate have allowed people to thrive in the Mediterranean Basin for more than 130,000 years. While its landscape may seem completely natural, it has been heavily shaped by people over thousands of years. Ancient humans transformed and cultivated the land to the beautiful, food-producing landscape we see today. The region is rich with crops such as grapes, figs, olive trees, lavender, and rosemary. With easy farming and abundant fishing, it is no wonder the Mediterranean has been called paradise! Easy living meant more time for the people of the ancient world to create art and spread ideas. The influence of these ancient civilizations is still felt throughout the world today!

## BIGGEST BENEFITS

There are over 22,500 plant species in the Mediterranean Basin, making it a **biodiversity hotspot!** The climate, vegetation, and great fishing made this region home to many great **ancient civilizations.** The **art, philosophy, government,** and **architecture** of ancient Greece and the Roman Empire still influence the art and culture in the western world today.

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There is so much salt underneath the Mediterranean Basin that miners have sculpted a **full-size underground church** made entirely of salt. We could mine it for **a million years** and not run out!


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In the basin lives the **Barbary macaque,** the only primate species in Europe.

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Home to the world's oldest sovereign state and constitutional republic, **San Marino,** which dates back to 301 CE.

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Ancient Greek stories like the ***Iliad*** and the ***Odyssey*** describe the Mediterranean as a **dark wine color.** Historians have tried to figure out what

this means; did the bright blue waters once look darker, or has human eyesight changed over time?


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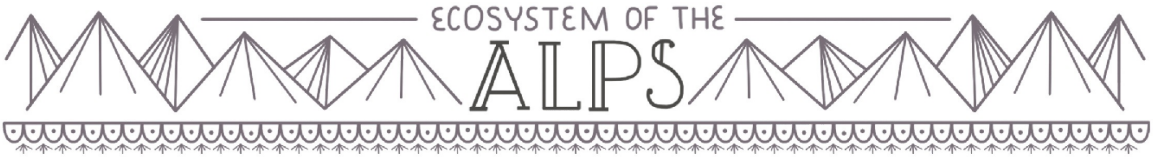
## GREATEST THREAT

The Mediterranean Basin is visited by over **200 million tourists** a year, who flock to beautiful locations like Nice, Barcelona, Sardinia, and Milos. This means that hotel **construction** and other **development** is a major issue. Very little of the Mediterranean Basin is protected and wildlife habitats are being destroyed. The sea is over-fished, and limited fresh water from rivers is overused. For centuries, the land of the Mediterranean has been managed by people without destroying it. Now countries in this region are coming together to try and prevent irresponsible land use.


GLACIAL ZONE
ALPINE ZONE — TREE LINE TO SNOW LINE
ALPINE IBEX
CHAMOIS
GRASS
MOSS
SUB-ALPINE ZONE 1,600M – 2,400M
GOLDEN EAGLE
SCAVENGER BEARDED VULTURE
ALPINE CHOUGH
ALPINE MARMOT
DWARF MOUNTAIN PINE
MONTANE ZONE 800M – 1,700M
APOLLO BUTTERFLY
PREDATORS
GRAY WOLF
EURASIAN BROWN BEAR
RED DEER
GRASS
COLLINE ZONE 500M – 1,000M




Some places are so big they are hard to understand. The massive mountain range of the Alps is one of them. The poet and physician Oliver Wendell Holmes said, "After looking at the Alps, I felt that my mind had been stretched beyond the limits of its elasticity, and fitted so loosely on my old ideas of space that I had to spread these to fit it." This beautiful mountain range, with slopes of colorful wildflowers and tall snowy summits, is the largest in Europe, spanning eight different countries, from Monaco to Slovenia.

Although the Alps' range is massive, its resources are not unlimited. Hunting and the expanding human population have caused large predators like bears, wolves, and lynx to become endangered. The resulting imbalance between predator and prey threatened the entire ecosystem. Conservationists and local governments created hunting regulations that protected these important large predators and allowed their populations to bounce back.

Millions of tourists travel to the Alps annually to see the majesty of the mountains, hike, ski, and perhaps let out a yodel. Although the Alps are still home to some of the largest stretches of untouched wildlife habitat in Europe, the density of human activity has also made it the most threatened mountain range in the world. Conservationists and local governments are acting now to preserve these important mountains and build in a way that won't disrupt nature.

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## BIGGEST BENEFITS

The Alps have been nicknamed **"the lungs of Europe"** because the massive forests and grasslands found throughout the range are huge oxygen producers. **Glacial melt** from the mountaintops feeds Europe's major rivers and seas. This fresh water also sustains the Alps' diverse wildlife and its

human population. Today around **20 million people** living in these mountains are dependent on an agricultural economy sustained in the mountains' pastures.

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Many farmers on the mountainside still use traditional, sustainable techniques that date back to the times of the **New Stone Age.**

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In the Alps, farmers now use **guard dogs** instead of guns to scare off large predators like **bears** and **wolves.** The dogs' loud barks prevent dangerous contact between people and animals, and prevent unnecessary wildlife deaths. This helps keep the ecosystem balanced by maintaining the necessary large predator population.


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Cold weather mountain plants have adapted to grow **long roots** that withstand harsh climate.

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Impressive feats of engineering have allowed **roads** and **tunnels** to be carved into the mountains, making the Alps one of the most accessible ranges on Earth.

## GREATEST THREAT

**Climate change** threatens mountain ranges all over the world including the Alps. As global temperatures rise, mountain **glaciers** melt, **avalanches** become more frequent, and cold-adapted animals continue to **migrate** farther up the mountains, displacing other wildlife in search of a cooler habitat. In the Alps, tourist-driven **overcrowding** and **traffic,** and **unsustainable farming techniques** are harming the wildlife and fresh water sources. Right now, conservationists and governments are identifying and protecting the parts of the Alps crucial for the health of the entire mountain range. There is also a rise in **eco-friendly tourism** and new sustainable architecture is being built.


Lions, tigers, and bears! (Oh my!) Asia is the largest continent on Earth, with an amazing diversity of ecosystems, from the burning hot deserts of the Middle East to the wet fertile grasslands of China. In the south, tropical monsoons soak India with rainfall for months at a time. In the north lies Siberia, a cold land of mostly frozen tundra. Asia is home to many mountain ranges, including the Himalayas, the world's highest. These mountains are so tall they block wind currents and create many different climates across central and Southeast Asia. They also act as a natural wall that has controlled animal migration and provided protection from outside invaders for ancient Asian empires.

Asia was home to some of the first human cradle civilizations in its river valleys: the Fertile Crescent of ancient Mesopotamia, the Indus Valley in ancient India, and the Yangtze River Valley in ancient China. As humans began to grow crops and transformed the landscape around them, the human population boomed, and civilization entered a new era. More advanced farming techniques meant less time spent searching for food and more time for thinking and inventing. Around 5,000 BCE Mesopotamia became home to several large civilizations and gave birth to inventions like the wheel, irrigation, domesticated animals, record keeping, and mathematics. Now Asia is the most populous continent on Earth, home to over half of the human population. Ecosystems in Asia have a huge impact

on the entire world. It is vital to protect its beautiful and important wildlife.


ASIA HAS THE TALLEST PEAK AND THE LOWEST POINT IN THE WORLD. MOUNT EVEREST REACHES 29,035 FT. (8,850 M) TALL, THE DEAD SEA IS 1,410 FT. (430 M) BELOW SEA LEVEL.
HOME TO THE TAJ MAHAL AND THE GREAT WALL OF CHINA, 2 OF THE WORLD'S 7 WONDERS.
RUSSIA
KAZAKHSTAN
MONGOLIA
ALTAI MOUNTAINS
GEORGIA
ARM.
AZ.
CASPIAN SEA
UZBEKISTAN
TURKMEN.
KYRG.
TAJIK.
TURKEY
CYP.
LEB.
ISRAEL
JORDAN
SYRIA
IRAQ
IRAN
AFGHANISTAN
PAKISTAN
KUW.
BAHR.
QATAR
UAE
SAUDI ARABIA
OMAN
YEMEN
NEPAL
BHU.
THE HIMALAYAS
INDIA
CHINA
N. KOREA
S. KOREA
JAPAN
TAIWAN
BANG.
MYANMAR
LAOS
VIETNAM
THAI-LAND
CAM.
PHILIPPINES
MALDIVES
SRI LANKA
BRUNEI
MALAYSIA
SING.
INDONESIA
EAST TIMOR
WATER
TUNDRA
WETLANDS
TAIGA
TROPICAL RAINFOREST
TEMPERATE FOREST
GRASSLAND
SCRUBLAND
DESERT
MOUNTAIN
ASIA IS THE BIRTH-PLACE OF MOST OF THE WORLD'S MAJOR RELIGIONS: BUDDHISM, CHRISTIANITY, HINDUISM, ISLAM, AND JUDAISM.


PRODUCERS
FIR TREE
SPRUCE TREE
GREAT GRAY OWL
REINDEER
SAXIFRAGA
(STONE-BREAKER)
LYNX
LICHEN
ERMINE
EAST SIBERIAN BROWN BEAR
TAIGA VOLE
MOSS
ARCTIC HARE
GRASS

ECOSYSTEM OF THE

# NORTHEAST SIBERIAN TAIGA

"The Land of Little Sticks" or "The Sleeping Land" were the first names for Siberia and the cold, dry, seemingly endless forest that makes up northern Russia. The taiga of Siberia is the largest unaltered forest of its kind in the world, spanning over 1.5 million square miles. Its hardy pine trees have adapted to grow in one of the coldest climates on Earth. The winter is long and bitterly cold (with lows dipping to -70°F/-56°C), with very little snowfall, and summers are brief but hot (with temperatures that reach an average of 60°F/16°C, thawing the snow). This cold weather makes Siberia home to the furriest animals on Earth. Ferocious lynx with fluffy spotted coats and the heavily furred and dangerous Siberian brown bear hunt small mammals such as hares.

The Siberian taiga butts up against the Arctic Circle, and most of the soil has been frozen for millennia. This permafrost makes growing crops almost impossible, but as climate change raises temperatures, the permafrost throughout the Arctic Circle has begun to melt for the first time. This melt is also rapidly releasing carbon and methane gases that have been safely stored in ice for thousands of years. As carbon and methane are released into the atmosphere, they contribute even more to global warming.

The Siberian taiga is one of the largest untouched wildernesses in the world. This massive evergreen forest is doing what plants do best: breathing oxygen into our atmosphere and creating a base for the entire furry food chain that calls this harsh, cold land home.

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## BIGGEST BENEFITS

This large, year-round forest is a **global carbon sink.** This means the forest is crucial in global absorption of CO2 from the atmosphere and the production of oxygen. The taiga helps to **regulate the global climate.** Siberia is also rich

in mineral resources like **coal, fossil fuels, iron,** and **gold.**


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Many rocks in the Siberian forest are **volcanic** and date back to the **Permian–Triassic period.**


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Worldwide, taiga biomes cover **17 percent** of the earth's surface.

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In the summer, **300 bird species** visit Siberia, but only 30 species remain throughout the cold Siberian winter.


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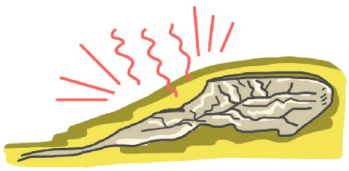
**The Batagaika crater,** caused by melting permafrost, is the largest of its kind. In local folklore it's considered a gateway to the **underworld,** due to the strange noises that emanate from it.



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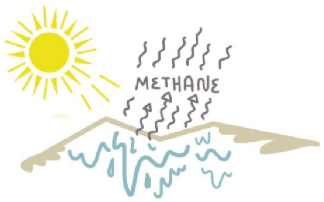
Melting **permafrost** is revealing the fossils of prehistoric **woolly mammoths** and ancient bacteria.

## GREATEST THREAT

**Global warming** is causing the **permafrost** to melt, releasing stored greenhouse gases into the atmosphere. The abundance of trees in Siberia has led to **excessive logging** without **replanting. Coal mining** and excessive **fur trapping** also threaten Siberia's wildlife.





BLACK MANGROVE PRODUCER
SIAMANG
DATES
STORM'S STORK
APEX PREDATOR TIGER
ASIAN TAPIR
GRASS
MUD CRAB
SALTWATER CROCODILE
SPOT-BILLED PELICAN
SHRIMP
FALSE GHARIAL
MULLET

ECOSYSTEM OF THE

# INDOCHINA MANGROVES

Along the coastline of Southeast Asia are the tangled roots of the mangrove forests. Mangroves are uniquely evolved to grow in between fresh and salty ocean waters, with root systems able to filter out salt. Living between ecosystems, they are an important ecotone and have protected the coastlines of Thailand, Cambodia, Vietnam, and Malaysia. Their branches and roots create natural barriers for storms, stop tidal erosion, and create a maze-like refuge for many animals. Mangroves are also an important breeding ground and nursery for baby marine life and an essential part of the marine ecosystems throughout the Pacific and Indian Oceans. A Thai fisherman on the Andaman Coast said it best: "If there are no mangroves, then the sea will have no meaning. It is like having a tree without roots, for the mangroves are the roots of the sea."

These important mangrove forests were almost completely destroyed during the Vietnam War. Large portions of the forests on the central coastline of Vietnam were decimated by tanks driving through them and exposure to napalm and Agent Orange, a biochemical weapon made from the same ingredients as herbicide (weed killer). It destroyed parts of the mangrove forest and surrounding ecosystems and farms throughout Vietnam and Korea. Herbicides are also harmful to people in large doses, causing cancer, birth defects, and genetic disorders that can affect future generations. The effects of Agent Orange are still felt by millions today, but there is hope. Now conservationists are making huge strides in the reforestation of this area, and there is new life in this once damaged land.

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## BIGGEST BENEFITS

Mangrove forests serve as **natural barriers** that protect the shoreline from **storms** and **erosion.** Although no mammals are native to the Indochina mangrove forest, many depend on the trees as a daily hunting ground. Many

**fish** and **crustaceans** use submerged mangrove roots to lay their eggs, since it is the perfect place for baby fish to grow and hide.

Many lizards depend on the mangrove forest including the **monitor lizard** and the **false gharial,** which looks like a crocodile.

Some of the world's rarest water birds are found in Indochina mangroves, including the **white-winged wood duck** and the **spot-billed pelican.**

The Indochina mangrove forest is a part of a larger network of many different mangrove-based ecosystems that stretch all the way from Thailand to Australia. Many fish born in the mangroves go on to populate the **Great Barrier Reef.**

Enjoy shrimp cocktail? Thank the mangroves! Massive amounts of **shrimp** come from fisheries in **Vietnam** that directly benefit from the coastal mangrove forest.

Young **tapirs,** found in the mangrove forest, have white stripes and dots that help them hide. After around seven months, they will lose their baby fur and their markings.

## GREATEST THREAT

Many people wrongly think that Indochina mangroves are useless, and they will clear them for new buildings and farm development. In Thailand, half of the country's mangroves have been cut down to create **charcoal.** Additionally, **explosives** and **dragnets** are sometimes used in fishing practices near the mangroves, which damages the trees and wildlife, especially juvenile marine animals.


ARGALI
SCAVENGER
CINEREOUS VULTURE
GREAT BUSTARD
SEDGE
WHITE-TAILED GAZELLE
GRASS-
PRZEWALSKI'S HORSE
OMNIVORE
RACCOON DOG
FRUIT
COUCH GRASS
BEETLE
CATERPILLAR
EARTHWORM
LONG-EARED HEDGEHOG
MONGOLIAN MARMOT
CORSAC FOX
MARMOT DEN

# ECOSYSTEM OF THE EASTERN MONGOLIAN STEPPE

The Eastern Mongolian Steppes are home to the world's largest intact temperate grasslands. While grasslands all over the world are shrinking at an alarming rate, over a million white-tailed gazelles roam freely in Mongolia. Mongolia is slightly smaller than Alaska and a large part of it is covered by rolling hills, grassy plains, and soggy wetlands. With clear skies about 250 days a year, the region has earned its local nickname, "The Land of the Blue Sky." But this mostly-flat land is unprotected by the surrounding Altai mountains, making it open to the extremes of the seasons. The summers on the grassland are warm and see massive amounts of fast-growing grass. Winter on the steppes is brutally windy, with temperatures below freezing. Throughout Mongolia, temperatures can drop to an extremely cold -40°F/C—it is so harsh that there is a special Mongolian word for it: *zud*.

The Eastern Mongolian Steppes are a UNESCO World Heritage Site because of their pristine and vast wilderness and abundance of unique wildlife. In these grasslands you can find animals like the chubby raccoon dog, the elegant corsac fox, and the endangered Przewalski's horse. The reason the steppes' grassland is still intact is thanks to the Mongolian people and their traditional land management. Mongolia is still mostly undeveloped, so many of its citizens depend on the health of the land and have prioritized the care of it. In fact, in the twentieth century, the number of people living as traditional nomadic herders in Mongolia increased. One of the world's largest wildernesses exists today thanks to the Mongolian people and the important relationship they have with the steppes.

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## BIGGEST BENEFITS

The largest intact temperate grasslands in the world support an entire country. The Mongolian economy is based on the production of **meat, wool,**

and **cashmere** from domesticated herd animals. The national government enforces restrictions on hunting and promotes the preservation of **traditional land steward techniques** to keep the grasslands intact and plentiful.

Many Mongolian farmers still live in **yurts** and wear traditional herding clothes.

Mongolia's **native wild horses** were nearly wiped out due to illegal hunting and competition with livestock.

The Eastern Mongolian Steppes are part of a larger **5,000-mile-long grassland** biome that stretches across Asia from Ukraine to China.

Mongolia is home to the **argali,** the world's largest mountain sheep.

## GREATEST THREAT


**Cashmere,** which comes from **goats,** is one of Mongolia's most lucrative exports. But large populations of these goats can be destructive to the landscape. When they graze, they eat the roots as well as grass, which can destroy entire pastures, leaving sand dunes (which can't be farmed) in their place. Herders are working with conservationists to graze their goats in **more strategic and sustainable ways.** If they are successful, the overgrazed grasslands will grow back in about ten years. But the demand for cashmere keeps growing. Even in the most rural places, farming, agriculture, and development need to be done with conservation in mind.


GLACIER
MONTANE GRASSLAND 3,002M–4,998M
HIMALAYAN TAHR
SNOW LEOPARD
GRASS
PIKA
TEMPERATE CONIFEROUS FOREST 2,499M–4,206M
BAMBOO
TAKIN
LEAVES
RED PANDA
MUSK DEER
TEMPERATE BROADLEAF & MIXED FOREST 2,011M–2,987M
GOLDEN LANGUR MONKEY
FRUIT
RUFOUS-NECKED HORNBILL
FERN
ORCHID
TROPICAL & SUB-TROPICAL BROADLEAF FOREST 502M–1,005M
ASIAN ELEPHANT
WILD BOAR
BENGAL TIGER
WORM
BULBS
GRASS

ECOSYSTEM OF THE

# HIMALAYAN MOUNTAINS

"Himalaya" means "abode of snow" in Sanskrit, and the world's tallest mountains have been the basis of myth and legend throughout Asia. In the twentieth century, the Himalayas became a point of conquest for climbers to reach the top of the mountain's peaks. But the Himalayas are more just an adventure destination.

The higher up the mountain range, the colder the climate gets. At the very top of the Himalayas are its glacier ice caps. Besides the North and South Poles, the Himalayan peaks hold the third-largest deposit of ice and frozen snow on the planet. As you descend to lower elevations, the temperature begins to warm and the ice and snow begin to melt, flowing into rivers.

Below an elevation of 16,400 feet is western alpine scrubland and montane grasslands. Here the elusive snow leopard hunts musk deer on the rocks. Another 3,000 feet lower, in the inner valley, lives the endangered red panda among pine and spruce trees. As you continue to descend, the climate becomes more tropical. At around 9,800 feet, the eastern forest is filled with huge oak trees, beautiful orchids, and 500 species of birds. Finally, at the base of the mountains, at an elevation of 3,300 feet and lower, the tropical broadleaf forest starts, where tigers and elephants are hidden by the dense foliage.

Although these mountainside terrains are very different, they often overlap. A mountain is a giant complex web of interaction from top to bottom, and each different ecosystem depends on its neighbors for survival.

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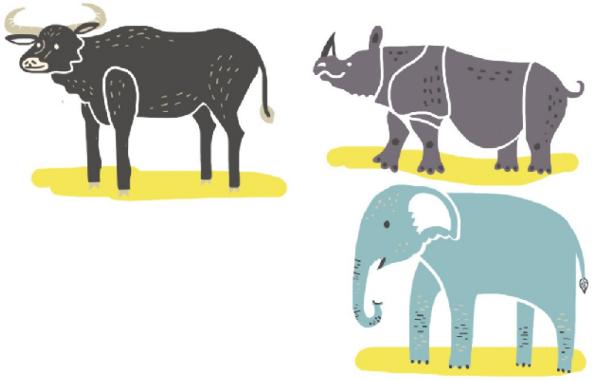
## BIGGEST BENEFITS

The huge **glaciers** of the Himalayan Mountains are the source of fresh water for most of Asia. The **snowcap melt** feeds three major Asian river systems: the **Indus,** the **Yangtze,** and the **Ganges-Brahmaputra.** The mountains also

create a huge **natural barrier** that affects the **climate** of the southern Asia. They physically block cold northern winds from reaching southern India in the winter, and block the southwestern monsoon winds, causing clouds to release most of their rainfall before reaching the north.

The Eastern Himalayas are home to Asia's three biggest mammals: the **Asian elephant,** the **one-horned rhinoceros,** and the **wild water buffalo.**



**Landslides, earthquakes,** and **avalanches** are common because the tectonic movement that created the mountains is still active in the area.

At **29,029 feet,** Mt. Everest is the **tallest mountain in the world.** It takes most climbers about **two months** to summit the mountain.

The first people to summit Mt. Everest were Sherpa mountaineer **Tenzing Norgay** and **Sir Edmund Hillary** in 1953.

## GREATEST THREAT

**Climate change** is causing a rapid melt of glacier mountain caps around the world. The glaciers of the Himalayans are melting at an alarming rate and this threatens the fresh water source that most of Asia relies on. Along with this, mountain forests are overused for **timber** and **grazing.** Farmers in the Eastern Himalayas are grazing animals in the mountain forests because of a lack of grasslands, but the forests cannot support this large number of farm animals. Conservation groups are working to protect the land while improving the livelihoods of the people who depend on agriculture in the mountains.

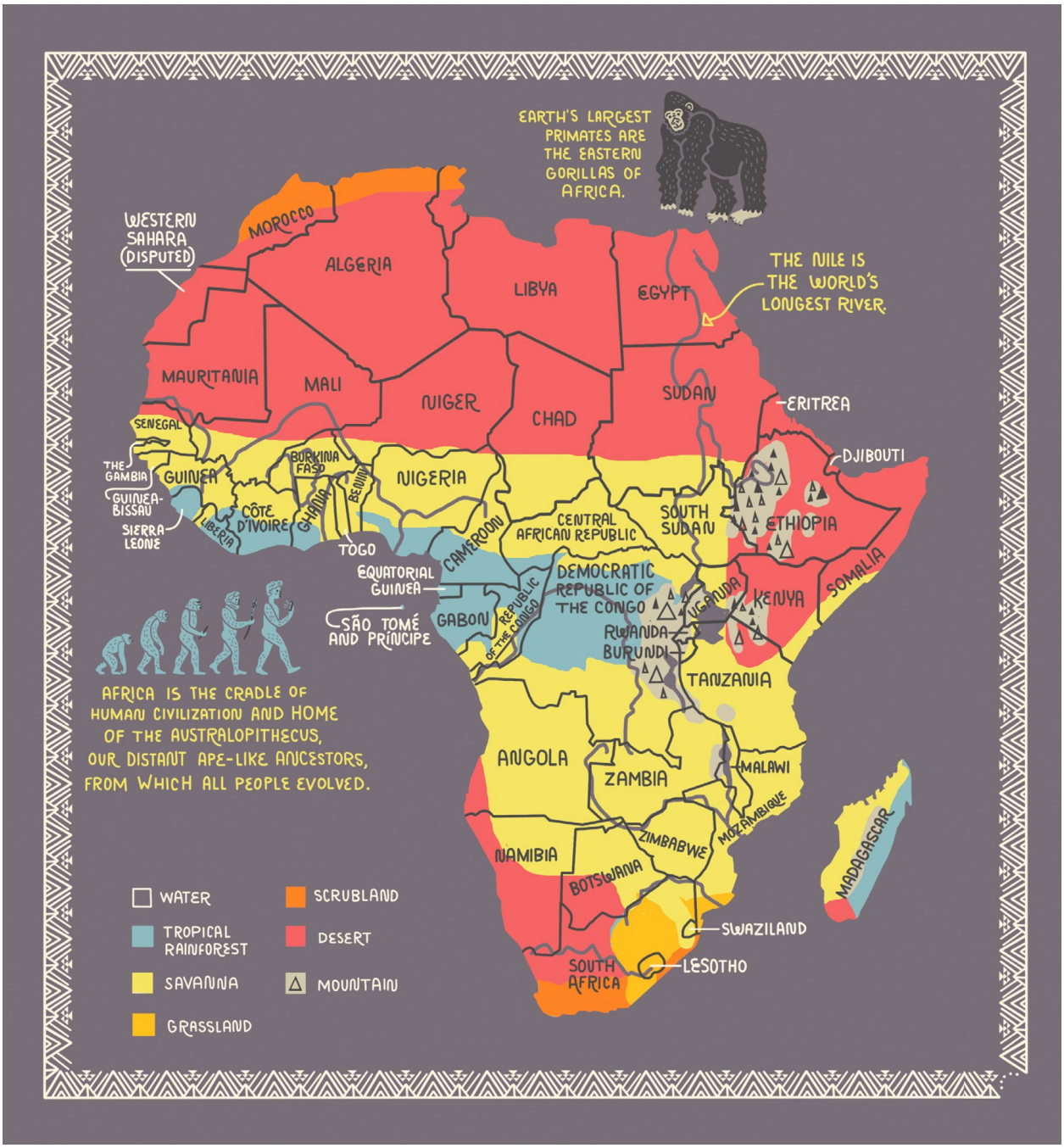

Africa is the original birthplace from which all humanity has descended. Over a period of six million years, humans have evolved from our ape-like ancestors into to the two-legged, big-brained *Homo sapiens* we are today. Fossils of our ancestors who lived from six million to two million years ago have been found only in Africa, and scientists believe that most of human evolution took place on this continent.

As Earth's second-largest continent, Africa contains some of its greatest wilderness. It is also a place of great contrast. Mighty gorillas roam the Congo, the second-largest rainforest on Earth. Camels traverse the sands of the Sahara, the world's largest hot desert. In another part of Africa, lions, zebras, and wildebeests travel across the Serengeti in one of our planet's most magnificent animal migrations.

Africa is known for its natural resources, like precious metals, gems, and metallic ores, which are mined and exported all over the world. From the 1600s to the 1800s, Europeans violently colonized the continent for land and resources, and it wasn't until the 1950s that the dismantling of colonial Africa began. As countries gained independence, there also came a fight for civil equality in many of these post-colonial states, such as the fight against the racist, segregated apartheid regime in South Africa. The history of colonialism has greatly affected the politics, land use, and borders of the 54 different countries that make up Africa today.

From Cairo to Cape Town, Africa is home to large cities and many

diverse cultures. While trade and the economy are strong in certain regions of Africa, many areas of this large continent are still underdeveloped. Some of the poorest countries in the world are in Africa, and with poverty comes illegal poaching, lumber exploitation, and the destruction of important ecosystems. The fight for our environment goes hand in hand with helping under-resourced communities create sustainable economies with access to education, energy, and food.


EARTH'S LARGEST PRIMATES ARE THE EASTERN GORILLAS OF AFRICA.
WESTERN SAHARA (DISPUTED)
MOROCCO
ALGERIA
LIBYA
EGYPT
THE NILE IS THE WORLD'S LONGEST RIVER.
MAURITANIA
MALI
NIGER
CHAD
SUDAN
ERITREA
DJIBOUTI
SENEGAL
THE GAMBIA
GUINEA
GUINEA-BISSAU
SIERRA LEONE
LIBERIA
CÔTE D'IVOIRE
BURKINA FASO
GHANA
BENIN
TOGO
NIGERIA
CAMEROON
CENTRAL AFRICAN REPUBLIC
SOUTH SUDAN
ETHIOPIA
SOMALIA
EQUATORIAL GUINEA
SÃO TOMÉ AND PRÍNCIPE
GABON
REPUBLIC OF THE CONGO
DEMOCRATIC REPUBLIC OF THE CONGO
UGANDA
KENYA
RWANDA
BURUNDI
TANZANIA
AFRICA IS THE CRADLE OF HUMAN CIVILIZATION AND HOME OF THE AUSTRALOPITHECUS, OUR DISTANT APE-LIKE ANCESTORS, FROM WHICH ALL PEOPLE EVOLVED.
ANGOLA
ZAMBIA
MALAWI
MOZAMBIQUE
ZIMBABWE
NAMIBIA
BOTSWANA
MADAGASCAR
SWAZILAND
LESOTHO
SOUTH AFRICA
WATER
TROPICAL RAINFOREST
SAVANNA
GRASSLAND
SCRUBLAND
DESERT
MOUNTAIN


CANOPY
FRUIT
GORILLA
LEAVES
CHIMPANZEE
INSECTS
—UNDERSTORY—
CONGO PEAFOWL
PALM
AFRICAN FOREST ELEPHANT
GRASS
SHRUB LAYER
LEOPARD
OKAPI
DECOMPOSERS AND BACTERIA
FERNS
BUTTRESS ROOT
FUNGUS
— FOREST FLOOR —

# ECOSYSTEM OF THE CONGO RAINFOREST

The dense foliage of the Congo rainforest stretches westward from the center of Africa to the Atlantic Ocean, covering six countries. Gorillas, elephants, and buffalo can all be found among the massive trees and brush of this forest. The Congo is jam-packed with wildlife, and when so many animals and plants share space, competition for resources is inevitable.

In the crowded rainforests, plants vie for space, using a variety of adaptations to try to gain an edge. Some plants have poisonous sap that wards off predators. Others rely on animals like boars and monkeys to eat their fruit and then poop out the fruit's seeds on their travels, allowing the plant to spread throughout the forest. Other plants use their sharp thorns and strong vines to push and climb their way toward the sunlight. In only one hectare of land in the Congo forests there are over a thousand trees.

When there is dense forest spread over such a large area, the plants actually create their own weather systems. Trees release oxygen and water vapor in a process called "transpiration." That water vapor forms clouds and later comes back down as rain. In fact, 95 percent of the rain in the Congo rainforest comes directly from plant transpiration. Major rainstorms flood the forest floor, flowing into the thousands of rivers that weave through the jungle, creating powerful waterfalls and eventually reaching the Atlantic Ocean. The world depends on this powerful and wet ecosystem. A third of all of the oxygen on the planet is created by the world's tropical rainforests, and as the second-largest rainforest on Earth, the Congo has definitely earned its nickname, "the lungs of Africa."

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## BIGGEST BENEFITS

The Congo rainforest is home to over **75 million people** whose economy depends on its rich ecosystem. The dense trees regulate the weather and add

oxygen to the earth's atmosphere, which helps combat **carbon emissions.** The trees also **provide timber** that's used around the world. This rainforest is also home to many animals that can't be found anywhere else, like **bonobo apes** and **gorillas.**


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**Virunga National Park** in the Congo rainforest is the oldest national park in Africa, established in 1925.

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There is a glow on the forest floor of the Congo called **"chimpanzee fire"** by locals. It comes from a special enzyme produced by a fungus that eats dead leaves.

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Tourism to see **gorillas** raises money used to protect the rainforest and has created new economic opportunities for local communities.

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Its unique climate means that the Congo rainforest experiences more **lightning storms** than anywhere else on Earth; it is hit with 100 million bolts of lightning a year.

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**Forest elephants** create a network of pathways through the deep jungle to special clearings with small lakes where they hang out, socialize, and eat the salt that is deep under the mud.

## GREATEST THREAT

The **illegal poaching** of forest animals like gorillas, monkeys, and antelope for meat is pushing endangered animals to the brink of extinction. Conservation groups are working with the six countries of the region to end **harmful logging** of fuel wood and create more protected areas of rainforest. Some of Africa's poorest communities live in or near the rainforest, and when such communities experience economic stress, they turn to **poaching** and **unsustainable mining** or **logging. Addressing poverty** goes hand in hand with conservation. The jungle needs to be used in a way that preserves its resources for future generations.


UMBRELLA THORN
ZEBRA
GIRAFFE
PARASITES
TICKS
GRASS
CATTLE EGRET
ELEPHANT
APEX PREDATOR
LION
GRASS
SCAVENGER
STRIPED HYENA
OXPECKER
TICKS
CHEETAH
PRODUCER
RED GRASS
WILDEBEEST

# ECOSYSTEM OF THE AFRICAN SAVANNA

Have you ever heard the sound of a million wildebeests on the move? Or the roar of the lions that hunt them? The African savanna is home to one of the largest annual animal migrations in the world: 1.5 million zebras, elephants, gazelles, giraffes, and other herbivores migrate in search of fresh grass. Traveling in a giant 1,800-mile loop, these animals move through Tanzania and Kenya across the Serengeti Plains. Primary consumers are then followed by predators—cheetahs, lions, and hyenas that are on the hunt. Birds, insects, and lizards also take advantage of these migrations, catching bugs that live on these larger animals' hides.

The African savanna is a grassland specked with trees and covers about half of the continent. Savanna animals' lives are tuned to—and depend on—the wet and dry seasons. During the rainy season, large marshes are filled with hippopotamuses and marine birds. During the dry season, parts of the savanna burst into flame, with natural wildfires burning an area as large as Great Britain. These fires are a necessary part of maintaining the ecosystem, stimulating growth of new grass. Grazing animals—including the world's largest land mammal, the African elephant—move with the seasons. Female elephants travel in close-knit family groups led by the oldest female. Elephants are highly intelligent and remember the good spots for grazing and mud wallowing throughout their territorial ranges. This is just a few of the many animal wonders that can be spotted in the African savanna.

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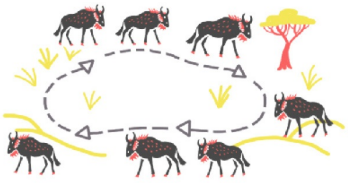
## BIGGEST BENEFITS

The African savanna is home to an impressive abundance of animals. In the geographical region of the Serengeti alone there are over **3,000 lions, 1.7 million wildebeests,** a **quarter of a million zebras,**

and about **half a million gazelles.** All of those animals generate a lot of poop, which naturally fertilizes the soil as they migrate across the savanna. Grasslands that support so much wildlife also provide for people, with nutrient-rich soil supporting farming and livestock grazing.

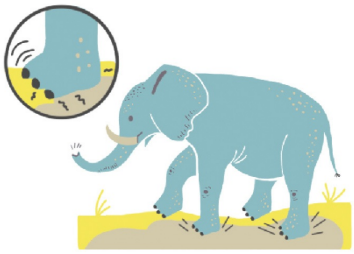
Parts of the Savanna are fertilized by **volcanic ash** from Africa's active volcanoes, like **Mt. Nyiragongo** in the Democratic Republic of Congo.

The **wildebeest migration** moves **clockwise** every year.



**Grant's zebras** don't sound like horses—they make dog-like barking sounds!


**Elephants** can feel vibrations with the soft, spongy tissue in their feet. They stomp the ground to warn other, distant elephants when a predator approaches.



A **cheetah** can run up to 70 miles per hour to catch its prey.

## GREATEST THREAT

**Illegal poaching** threatens endangered animals like African elephants and

black rhinoceroses. **Rising temperatures** caused by **global warming** prevent rainfall during the wet season and extend the dry seasons, making it harder for new grass to grow. In addition, **poorly planned construction** interrupts many animals' natural migration routes. Fortunately, the Serengeti National Park in Tanzania, continues to be protected, helping to maintain one of the greatest animal migrations in the world. But more work is needed to end illegal poaching and to protect the rest of the Savanna.


DATE PALM
OASIS
DESERT CROCODILE
SAND DUNE
CAMEL
DUNG BEETLE
CAMEL POOP
ROSE OF JERICHO
DEATH STALKER SCORPION
LOVEGRASS
MONITOR LIZARD
JERBOA
FENNEC FOX
SAHARAN SILVER ANT
SCAVENGERS
SAHARAN HORNED VIPER

ECOSYSTEM OF THE

# SAHARA DESERT

There once was a time when North Africa was teeming with life, rich with forests, lakes, and an abundance of animals roaming large, grassy fields. Now North Africa is dominated by the Sahara Desert, which covers a third of the entire continent. It often rains only once or twice a year in the Sahara, and that water quickly evaporates back into the air. Studded with sand dunes and dry, cracked rocks, the Sahara is vast, hot, and dangerous. The few animals that have adapted to live in this harsh environment are specialized reptiles, insects, and rodents that are mostly nocturnal and live underground, away from the ever-present sun. The silver ant is the only animal that can survive in the Sahara's mid-day heat, but it can endure only ten minutes before being cooked alive.

Most scientists believe that this once-lush area became a desert over 6,000 years ago, after a slight change in the tilt of the earth's axis. This change caused the sun to hit Africa at a new angle, raising the temperature and drying out the land. The change in climate was too quick for most plants and animals to survive. With no plants to create humidity, the desert continued to spread until it was the size of the United States. Now all that's left are petrified trees, stone artifacts, and ancient rock carvings that show the animals that once roamed North Africa. There are also rare oases left over from ancient lakes. But without many plants or animals to create soil, the desert continues to spread, which is exacerbated by dry seasons and poorly managed land. Conservationists are working together to fight further spread of desertification in the region.

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## BIGGEST BENEFITS

**Oases** allow human caravans to pass from one side of the Sahara to the other and provide food and water for many migrating birds, like **barn swallows.** The Sahara is also **rich in minerals** like **phosphates** and **iron ore,**

which are mined and exported all over the world. In the remains of what was once the largest lake in the world, there are still deposits of **dried algae and minerals.** These are blown by the wind across the ocean, all the way to South America, where they help to fertilize the **Amazon rainforest.**


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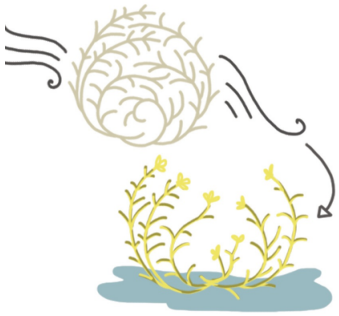
The resurrection plant called the **rose of Jericho** can remain dormant for years as dead-looking tumbleweed. If exposed to sufficient water, the plant unfurls, releasing its seeds before drying up again.



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**Oases** in the Sahara Desert can sustain **palm trees, ferns, fish,** and even **crocodiles** in the middle of the desert.

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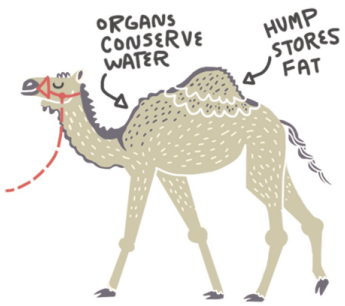
**Camels**, nicknamed **"the ships of the desert,"** can go without a drink of water for months at a time, but they cannot survive in the desert without a person to guide them to a well or an oasis.

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When **sand dunes** avalanche, they cause a hum that can be heard up to six miles away.


## GREATEST THREAT

**Desertification** and the ensuing expansion of the Sahara is an ever-present threat to the rest of Africa. In the **Sahel,** the transition area between desert and grassland, countries, ecologists, and local farmers are working to slow the spread. They are using indigenous **land management techniques** and **planting trees** among crops to create a farming network that **retains water** in the soil. This acts as a **natural barrier** that blocks the spread of the desert. Local communities are now using trees for fuel and lumber without killing them. Most of this work has been done in the **Zinder Valley** of Niger, which in 2004 looked the greenest it had in 50 years. Conservationists believe that if they scale up these techniques, they can prevent the spread of the desert throughout Africa.


KING PROTEA
SUGARBIRD
CAPE MOUNTAIN ZEBRA
CAPE IRIS
CHACMA BABOON
GRASS
FREESIA
ROCK HYRAX
GRUBS
AFRICAN LILY
AFRICAN PENGUINS
BENGUELA CURRENT
CAPE GANNET
AGULHAS CURRENT
DUSKY DOLPHIN
SARDINES
BRYDE'S WHALE

# ECOSYSTEM OF THE CAPE OF AFRICA

Colorful flowers bloom as far as the eye can see at the Cape of Good Hope on Africa's southern tip. One of the great floral kingdoms of the world, this small area is home to 8,500 different types of plants. Two very different ocean currents meet to create the weather that makes this ecosystem possible: the hot and powerful Agulhas Current from the Indian Ocean and the cold Benguela Current from the Atlantic Ocean. Ocean temperatures affect weather and what kind of animals and plants can live in an area. When two different and powerful water currents come together, they create a microclimate, which allows many different plants to live in one place. The cold Benguela Current creates a cool fog over the Cape's desert scrubland. Meanwhile, the hot Agulhas Current, one of the strongest currents in the world, moves the warm tropical waters and precipitation that contributes to summer rainfall on Africa's southeast coast. The Cape's plentiful plant life supports over 250 species of birds and mammals like Cape mountain zebras and Chacma baboons.

Currents are used by many animals to navigate the ocean. With warm water on one side of South Africa's Cape and cold water on the other, these waters support many different types of marine life from all over the world. Lots of fish means lots of food for ocean predators. There are so many fish that the Cape attracts the largest population of great white sharks in the world and "super-pods" of thousands of dolphins—all ready to grab a tasty meal. Without these two powerful currents, the tip of Africa would not have the biodiversity or beauty it is known for today.

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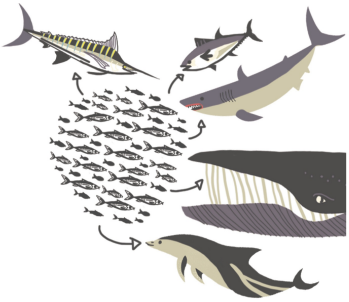
## BIGGEST BENEFITS

The Cape of Africa has been named a **World Heritage Site** by UNESCO because of its amazing **biodiversity.** The system of ocean currents brings plentiful marine life to the area, and is an important migration route for large ocean predators. This area is also an important source of commercial fishing for people in South Africa.

There are only six **flower kingdoms** in the world, and they are usually the size of continents. The Cape of Good Hope has so many flower species that it is considered a flower kingdom, even though it is only one-hundredth the size of the British Isles.

Giant schools of **sardines** swim to the Cape's coast on the cold **Benguela Current.** Wanting to avoid the warm water of the **Agulhas Current,** they get trapped between the two currents. This allows whales, sharks, dolphins, seabirds, and seals to prey on this ball of fish in a massive feeding frenzy.



The cold air of the Benguela Current supports unusual animals like **African penguins.**


**Monkey beetles** sleep inside of flowers to avoid the cool Atlantic night air.

## GREATEST THREAT

**Cape Town** is the second-largest city in South Africa, and as urban populations grow, so does the **construction of dams** that disrupt the natural flow of water and encroach on wildlife. More than 1,700 of the region's plant species are **endangered,** and 26 of its flower species have already gone **extinct.** To protect the area, conservation groups have worked with the local government to establish Table Mountain National Park and promote **ecotourism.**


Australasia is made up of the continent of Australia and its neighboring islands. It is part of the larger political and geographic region called Oceania, which stretches from West Papua to Hawaii. Australia, the largest landmass in this area, has been called "the last of lands," "the oldest continent," and "the last frontier."

Although this continent is not actually the oldest in the world, many of its rugged and beautiful landscapes seem untouched by time because of Australia's isolation. For 50 million years, the animals and plants on Australia have been separate from the rest of the world's landmasses. Surrounded by vast ocean like an island, wildlife was free to evolve and compete with each other in unique ways. Only Australia has mammals that lay eggs: the funny duck-billed platypus and four species of spiky echidna. Marsupials like the kangaroo and koala are abundant. Unlike other mammals, marsupials evolved to keep their developing young not inside their bodies, but in an external pouch. There are many odd-looking and interesting birds, like the colorful, dinosaur-like cassowary, which reminds many of a velociraptor because of its sharp claws and the skin-covered casque on top of its head.

Australia is famous for its outback, the mostly unpopulated wilderness

that contains the largest intact savanna in the world. But Australia is also home to lush coastal forests and coral reefs. When European colonization of Australia began in 1788, so too began massive deforestation of the continent. Logging of native forests continues in Australia, and many of its endemic animals, like the koala, are vulnerable because of unsustainable devolvement. Now conservation groups and ecologists are working hard to protect Australia's unique wildlife and environment.


ABORIGINAL FLAG
THE FIRST PEOPLE LANDED IN AUSTRALIA 50,000 YEARS AGO.
WHEN THE FIRST STUFFED PLATYPUS SPECIMEN WAS BROUGHT TO EUROPE IN 1798, PEOPLE THOUGHT IT WAS A DUCK BEAK SEWED ONTO A RAT AS A PRACTICAL JOKE.
PAPUA NEW GUINEA
SOLOMON ISLANDS
GREAT BARRIER REEF
VANUATU
FIJI
NEW CALEDONIA
AUSTRALIA
GREAT DIVIDING RANGE
KINGSTON
THE ICONIC KOALA LIVES IN AUSTRALIA'S COASTAL EUCALYPTUS FORESTS.
AUSTRALIA IS ONE OF THE WORLD'S LARGEST COUNTRIES, BUT IS THE SMALLEST CONTINENT.
TASMANIA
NEW ZEALAND
MOUNTAIN
SCRUBLAND
DESERT
TEMPERATE FOREST
TROPICAL SEASONAL FOREST
WATER
TROPICAL RAINFOREST
SAVANNA
GRASSLAND
THE LUSH GRASSLANDS OF AUSTRALIA ARE HOME TO SOME OF THE LARGEST SHEEP RANCHES IN THE WORLD.


APEX PREDATOR
WEDGE-TAILED EAGLE
EMU
RED KANGAROO
JOEY
GRASS
BANDICOOT
DINGO
TERMITE
FRILLED LIZARD
WALLABY
GOLDEN-SHOULDERED PARROT
KANGAROO GRASS
TERMITE MOUNDS
GRASS SEEDS

ECOSYSTEM OF THE

# AUSTRALIAN SAVANNA

The greatest intact savanna in the world is in the north of Australia. This savanna wilderness is vast, covering about a quarter of the continent but home to only an estimated five percent of its people. These lush grasslands are made up of six different savanna regions where some of the most unusual wildlife in the world are found.

Because Australia is separated from other continents by the ocean, its isolated wildlife have evolved in unique ways. Marsupials like red kangaroos and wallabies keep their developing babies close to them in an external pouch. These babies may poke their tiny heads out while their moms graze the savanna. The mysterious compass termites use grass to build gigantic mound structures as tall as a person that all eerily point on an exact north-south axis. One of Australia's best-known animals is the large flightless emu. Looking more like their dinosaur ancestors than most other birds, they stand six feet tall, hiss loudly at predators, and run across the grasslands at speeds of up to 30 miles an hour. The savannas have been named a "global ecoregion," because they give scientists an understanding of biodiversity on a global scale.

## BIGGEST BENEFITS

Grasslands around the world provide **rich grazing** and **farmland.** While an estimated 70 percent of global grasslands are giving way to human

development, the Australian tropical savanna remains mostly intact. This grassland provides **rich soil** for farming and some of the Australia's largest **cattle grazing areas.** The savanna also is home to many **aboriginal communities** who continue their rich cultural traditions and land stewardship today. The people who live on the savanna depend on the land for their livelihood.

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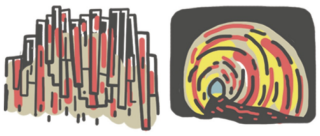
Ancient lava flow created the famous **Great Basalt Wall** and the hollow cave maze of the **Undara Lava Tubes.**



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The **Gouldian finch** of the Australian savanna is considered one of the most beautiful birds in the world.

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**Dingoes** are wild Australian dogs that prey on **rabbits, wallabies,** and even **kangaroos.**


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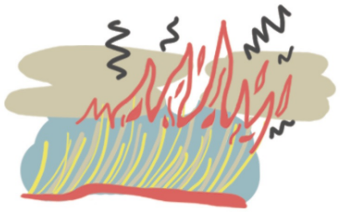
Groups of kangaroos are called "mobs." Female kangaroos are called **"flyers,"** males are called **"boomers,"** and babies are called **"joeys."**

---

Millions of years ago, ancestors of the **emu** could actually fly. Scientists think that after the dinosaurs became extinct, these birds had no real predators and access to more food. They started to grow in size and after many generations, evolution took its course and the birds became **too heavy to fly.**


## GREATEST THREAT



**Overgrazing** and **invasive animal species** harm the grasslands. But **global warming** is the greatest threat to the Australian savanna. Like all grasslands, these are expected to have cycles of natural wildfires. As global temperatures rise, dry seasons are extended. Longer dry seasons mean more dry grass, which acts as fuel for the **wildfires.** Large, out-of-control late-season wildfires are threatening grass and scrublands worldwide. Conservationists are working with aboriginal communities in Australia to manage the land to try to prevent late-season fires.


PRODUCER
MOUNTAIN ASH TREE
CLIMBING HEATH
MOSS
MACLEAY'S SWALLOWTAIL BUTTERFLY
HARD WATER FERN
WOMBAT
TASMANIAN ROSELLA
ECHIDNA
WORMS AND ANTS
TASMANIAN LAUREL
SPOTTED-TAIL QUOLL
PLATYPUS
ANNELID WORM
SHRIMP
SCAVENGER
TASMANIAN DEVIL
VELVET WORM
SLIME
CRICKET

# ECOSYSTEM OF THE TASMANIAN TEMPERATE RAINFOREST

Around 180 million years ago, dinosaurs ruled the earth on the supercontinent called Gondwana. Over time, Gondwana broke apart, creating Australia and the other continent and islands in the southern hemisphere. Many trees, mosses, and invertebrates that lived alongside the dinosaurs—called "living fossils"— are still found in Tasmania's forests today. The Tasmanian temperate rainforests are part of a UNESCO World Heritage Site because of their unique connection to the past.

Tasmania is a small island state of Australia, but despite its size, there are eight different biomes on the island. The quiet and cool rainforest covers 10 percent of Tasmania and is one of the most pristine, unchanged Gondwana wilderness regions in the world. Many of the flowers and trees, like the rare King's lomatia shrub, have grown in Tasmania for over 60 million years. Here, the Eucalyptus regnans (also known as mountain ash trees) grow up to 300 feet tall, rivaling the trees of the redwood forest. Soft green moss covers the forest floor, and coral-like blue and red fungus dots the landscape.

The rainforest is also home to ancient invertebrates like velvet worms, which have been around for 300 million years, predating the existence of insects on earth. They hunt in packs like wolves and capture their prey by shooting streams of sticky slime out of their faces! Tasmania is also home to some of the fluffiest and cutest marsupials—like the Tasmanian pademelon (which looks like a miniature kangaroo), the tiny spotted quoll, and of course, the famous Tasmanian devil. There is still much to be discovered in the Tasmanian temperate rainforest, and people are still encountering and naming new species of wildlife today!

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## BIGGEST BENEFITS

The large and dense trees of the Tasmanian temperate rainforest help to **create oxygen** and **precipitation** in the area. It is also home to unique natural resources like the **Huon pine tree,** which has golden yellow colored

lumber, and the **leatherwood plant,** which beekeepers depend on to produce special **leatherwood honey.**

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**Wombats** like building their homes near creeks in the rainforest and are famous for their **cube-shaped poop.**

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The **thylacine** (also known as the **Tasmanian tiger**) was the largest carnivorous marsupial, dating back 23 million years. Unfortunately, people saw them as a threat to livestock and hunted them to **extinction** in the 1930s.

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The **UNESCO World Heritage Site** covers 20 percent of Tasmania and is made up of 19 separate national parks or conservation areas.

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The famous **Tasmanian devil** got its name from its high-pitched screeches and growls.


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## GREATEST THREAT

Most of the Tasmanian temperate rainforest is protected, but an increase in **wildfires** caused by **climate change** and **over logging** of unprotected areas has threatened this ecosystem. Unlike redwood forests, this ecosystem cannot withstand fire. Studies show that forests logged within the past 40 years have more catastrophic fires than untouched forests do. This means it's critically important to maintain intact ecosystems surrounding UNESCO World Heritage Sites.

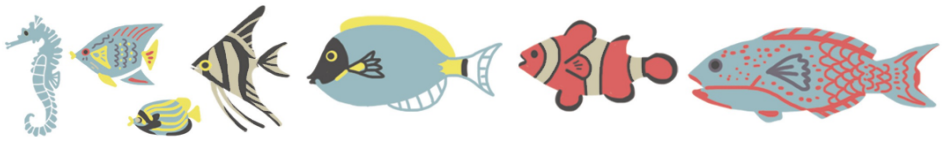

APEX PREDATOR
HAMMERHEAD SHARK
STINGRAY
GREEN SEA TURTLE
SOFT CORAL
SEAHORSE
OPOSSUM SHRIMP
BUTTERFLYFISH
RED-SPOTTED CORAL CRAB
CLOWNFISH
ZOOPLANKTON
PARROTFISH
CORAL TROUT
SEA ANEMONE
ALGAE
SURGEONFISH
CORAL POLYP
TENTACLE
ZOOXANTHELLAE
MOUTH
BASAL PLATE
SKELETON
BRAIN CORAL
OCTOPUS
CROWN-OF-THORNS STARFISH
SEA URCHIN
HARD CORAL

# ECOSYSTEM OF THE GREAT BARRIER REEF

In the turquoise waters off the eastern coast of Australia lies the world's largest living structure, the Great Barrier Reef. Three thousand coral structures have created a colorful colossus the size of Japan. The coral reef may look like a dazzling underwater forest, but it is actually made up of thousands of tiny animals called coral polyps. These polyps are clear, nocturnal, squishy creatures with tiny tentacles. Together, polyps secrete calcium carbonate to create the hard skeleton structure of the reefs.

Coral polyps have a codependent relationship with their food source, a microscopic algae-like organism called zooxanthellae, which live inside the polyps and perform photosynthesis. Through zooxanthellae, a coral gets energy, oxygen, and essential nutrients. These microscopic wonders also give the reef its distinctive bright colors.

The Great Barrier Reef comprises over 600 different types of corals, creating colorful tunnels and towers of various shapes and sizes. All of these nooks and crannies make inviting habitats for thousands of other marine plants and animals. Schools of tropical fish, sea horses, stingrays, sharks, whales, and even the seabirds flying above all depend on the Great Barrier Reef, making it the most biodiverse ecosystem in the whole ocean. In fact, reefs around the world make up only 0.1 percent of the ocean's ecosystems but support 25 percent of all marine life on Earth.



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## BIGGEST BENEFITS

Not only does the reef support thousands of plant and animal species, its ecological value is estimated at **$172 billion.** It acts as a **barrier** that protects

Australia from **storms** and **hurricanes,** and powers both **fishing** and **tourism** that help Australia's economy.

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The Great Barrier Reef experienced the worst **bleaching** ever recorded in 2016, and another large one in 2017.

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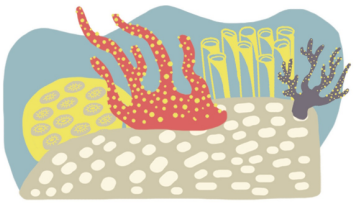
The Great Barrier Reef is on top of **limestone** that is actually **fossilized dead corals** from thousands of years ago.



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Along with the green coloring from **zooxanthellae,** the super-bright coral colors are caused by fluorescent protein pigments. The coral produce them when they are exposed to sunlight in order to to protect themselves **(like sunscreen!).**

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You can see the Great Barrier Reef from **space!**


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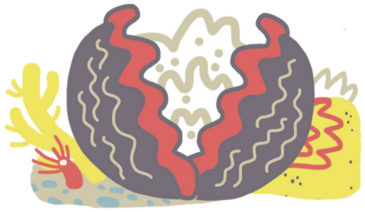
**Giant clams** can weigh up to 440 pounds and live for over 100 years.



## GREATEST THREAT

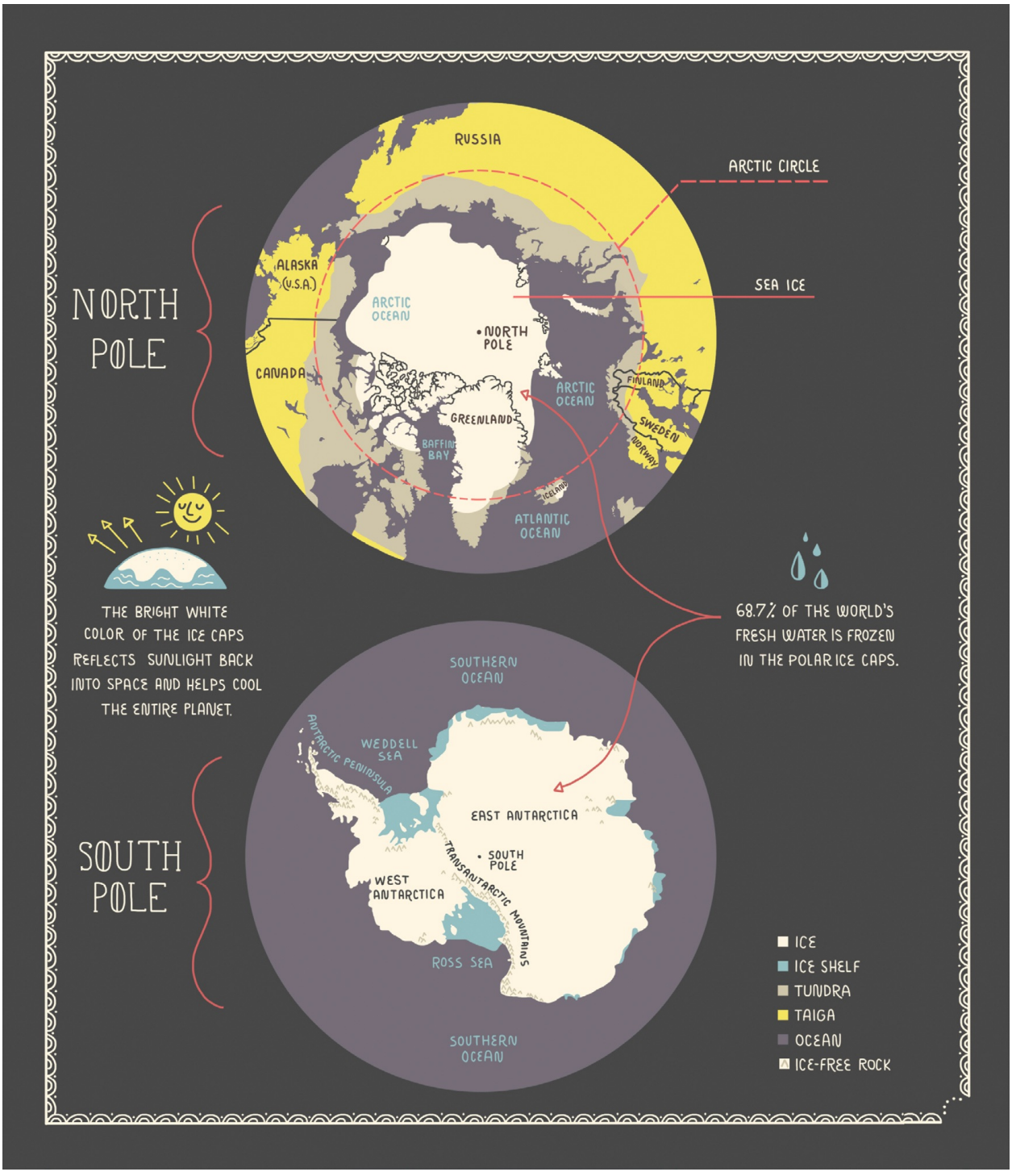
**Global warming** is causing the worldwide **bleaching** of coral reefs. As ocean temperatures rise, heat causes reefs' food supply, **zooxanthellae,** to release toxic amounts of **hydrogen peroxide.** This forces the corals polyps to release their now-toxic food supply. Without zooxanthellae the coral turns a **ghostly white color** in a process called **bleaching.** Coral can survive bleaching events only if the temperature cools down before the coral starves to death. If we take actions right now to slow the pace of global warming, we have a chance to protect the world's reefs.

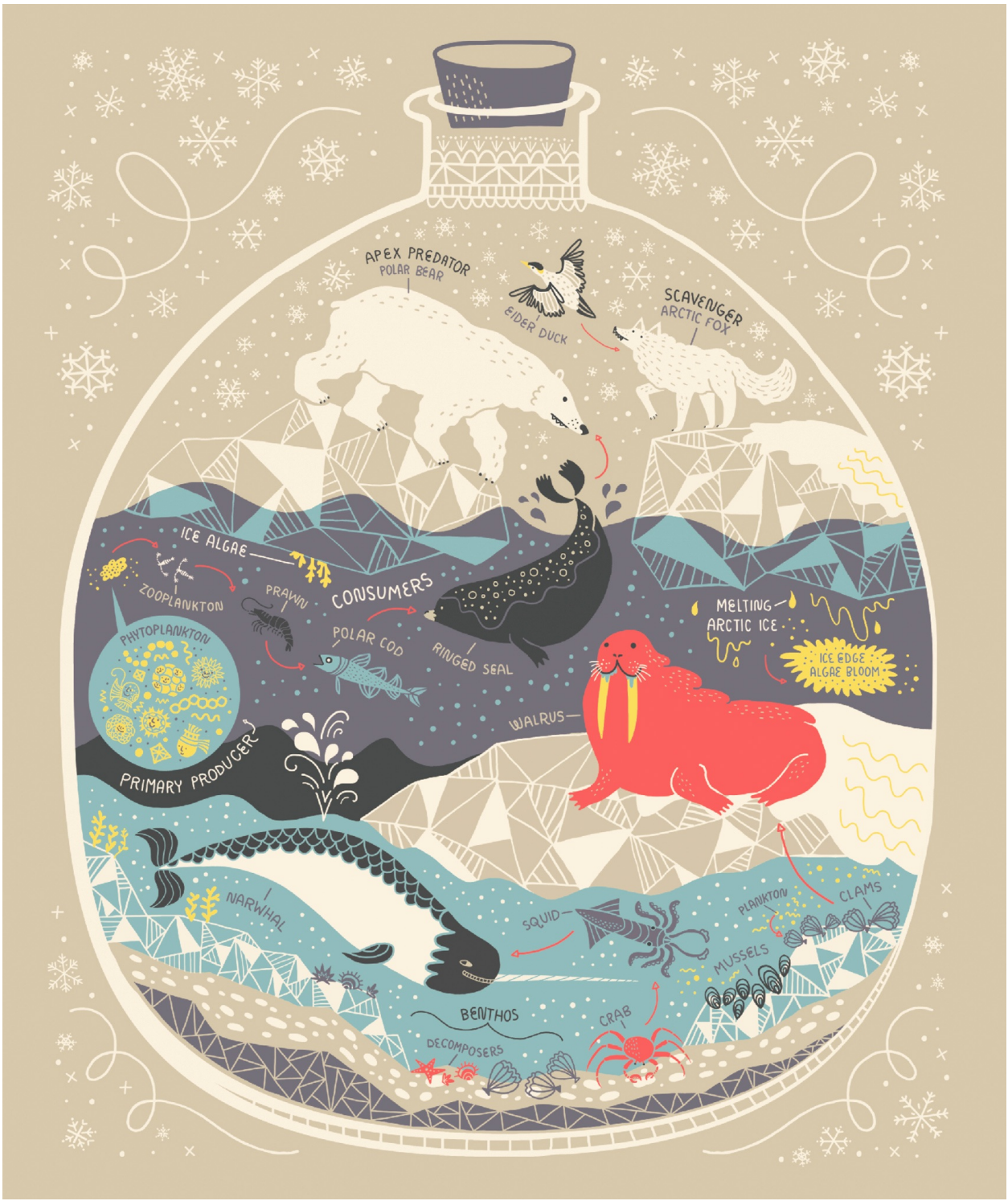

The North and South Poles are the farthest points from Earth's equator and some of the coldest places on the planet. Both experience perpetual darkness for half the year, and most of the sunlight that hits the polar ice caps is reflected back into space by the brilliant white of the snow. Despite these extreme conditions, the Arctic seas and the Antarctic tundra are home to many species of hardy wildlife.

The Antarctic South Pole is on a mountainous continent surrounded by ocean, while the Arctic North Pole is a frozen ocean surrounded by land. This makes temperatures in the South Pole much colder than those in the North Pole. The ocean water that makes up much of the Artic is warmer than its frozen ice cap and affects the Arctic's temperature. Meanwhile, the land continent of Antarctica is over a mile and a half above sea level. The higher the elevation, the colder the air gets, and Antarctica's elevation makes it the coldest place on earth.

Global warming is negatively impacting both of the poles. As oceans warm, the northern ice caps shrink more each year and the ice shelves of the Southern ice cap collapse. With smaller ice caps, less sunlight is reflected back into space, meaning even more of the ocean is exposed to —and absorbs—even more sunlight, contributing to the further warming of the ocean. The fresh water that was previously locked in large polar glaciers is melting into the ocean, causing global sea levels to rise. Scientists predict that this will affect global weather patterns and currents

of the entire ocean. It is our job to learn more about these changes in our world and work toward preserving the ecosystems of Earth.


NORTH POLE
RUSSIA
ARCTIC CIRCLE
SEA ICE
ALASKA (U.S.A.)
ARCTIC OCEAN
• NORTH POLE
CANADA
ARCTIC OCEAN
FINLAND
GREENLAND
SWEDEN
NORWAY
BAFFIN BAY
ICELAND
ATLANTIC OCEAN
THE BRIGHT WHITE COLOR OF THE ICE CAPS REFLECTS SUNLIGHT BACK INTO SPACE AND HELPS COOL THE ENTIRE PLANET.
68.7% OF THE WORLD'S FRESH WATER IS FROZEN IN THE POLAR ICE CAPS.
SOUTH POLE
SOUTHERN OCEAN
ANTARCTIC PENINSULA
WEDDELL SEA
EAST ANTARCTICA
• SOUTH POLE
TRANSANTARCTIC MOUNTAINS
WEST ANTARCTICA
ROSS SEA
SOUTHERN OCEAN
ICE
ICE SHELF
TUNDRA
TAIGA
OCEAN
ICE-FREE ROCK


APEX PREDATOR
POLAR BEAR
EIDER DUCK
SCAVENGER
ARCTIC FOX
ICE ALGAE
ZOOPLANKTON
PRAWN
CONSUMERS
PHYTOPLANKTON
POLAR COD
RINGED SEAL
MELTING
ARCTIC ICE
ICE EDGE
ALGAE BLOOM
WALRUS
PRIMARY PRODUCER
NARWHAL
SQUID
PLANKTON
CLAMS
MUSSELS
BENTHOS
CRAB
DECOMPOSERS

# ECOSYSTEM OF THE ARCTIC CIRCLE

In the northernmost part of the globe is the Arctic Circle. Although you can drive a truck over the northern ice cap, it is not land. It is actually thick frozen sea ice covered in blinding white snow. This white is so bright that it reflects 80 percent of the sunlight back into space. A lot of this sea ice stays frozen all year, but during the summer some of it melts away, revealing the Northwest Passage. This sea route is one of the most sought-after trading routes in the world, and disputes over rights to use it have created tensions between many countries.

Winters in the Arctic Circle can get as cold as -58°F/-50°C (*brrr!*), but despite the cold climate, the Arctic seas and the landmasses that surround it are teeming with life. The polar bear is perhaps the most iconic animal of the Arctic, living and hunting on the sea ice. But this apex predator is just the top of the food chain. From seabirds to sea lions, there is an abundance of animal life, like Arctic hares, puffins, and orca whales. Many use camouflage as a method for survival, like the Arctic fox, which is brown in the summer and grows a white coat in the winter to hide in the snow. Meanwhile, seals turn from white to dark brown as they mature so they can better hide in the dark ocean waters.

During the warm seasons, animals from all over the world migrate to the Arctic to feast on algae and phytoplankton blooms. From food to climate control, the Arctic Circle is one of the most important resources for preserving life on the entire planet.

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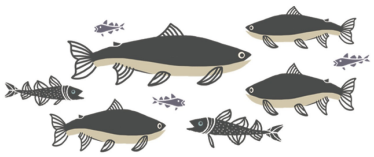
## BIGGEST BENEFITS



The Arctic Circle is abundant in marine life. All of that fish **provides food** not just for other animals but for people as well. Fish caught in the Arctic seas are eaten all over the world. The Arctic is also rich in **minerals**—beneath the ocean floor and surrounding frozen land is one of the

world's largest **oil fields** and 30 percent of the earth's total undiscovered **natural gas.** But the greatest benefit is likely the way the bright snow **reflects sunlight,** cooling the entire earth and regulating the global climate.

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The measurement of how much sunlight is reflected by the snow is called **"albedo."** This reflected warmth is so strong that it often looks like a **heat mirage.**

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**Gray whales** migrate from the warm waters of Mexico to the Arctic Ocean to feast on fish during the warm season's algae bloom.

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The **Northern Lights** in the Arctic (also called the **aurora borealis**) are caused by **solar winds** interacting with the North Pole's **magnetic field.**

---

**Polar bears** actually have black skin and transparent fur. Their hollow guard hairs reflect light and make them look as white as the snow around them.

---

Because of the tilt of the earth's axis, in the winter the Arctic experiences days of **24-hour darkness** (called **"polar nights"**) and days of **24-hour sunlight** in the summer (called **"polar days"** or **"the midnight sun"**).

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## GREATEST THREAT

**Global warming** is one of the greatest threats to our world, and the effects can be seen most dramatically in the Arctic. The amount of **sea ice** that

previously stayed frozen all year is shrinking. As global temperatures rise, fresh water that has been locked in **glaciers** for centuries is now melting into the ocean. This causes **sea levels to rise,** impacting islands and coastal cities. As the **ice caps shrink,** the planet will only get hotter. We need to act now to stop harmful $CO_2$ emissions, or one day we may well feel just like a polar bear floating on a shrinking iceberg.


ALBATROSS
CHINSTRAP PENGUIN
ADÉLIE PENGUIN
EMPEROR PENGUIN
ELEPHANT SEAL
MACARONI PENGUIN
CHICK
ADÉLIE PENGUIN
GLACIAL SQUID
KRILL
ALGAE AND PHYTOPLANKTON
ANTARCTIC SILVERFISH
COPEPODS
ANTARCTIC TOOTHFISH
LEOPARD SEAL
GLYPTONOTUS ANTARCTICUS
BENTHOS
SEA CUCUMBERS
KILLER WHALE
APEX PREDATOR
ANTARCTIC SCALLOP

ECOSYSTEM OF THE

# ANTARCTIC TUNDRA

When you think of a desert, you probably imagine a hot, sandy place with a dry climate. But the driest place on Earth also happens to be the coldest: the landmass of Antarctica, around the earth's South Pole. This barren landscape has been described as the end of the world, and while it's not a place that's hospitable to humans, its coast is teeming with life that depends on the changing of the seasons and the surrounding icy seas.

Over 170 million years ago, Antarctica was part of the supercontinent Gondwana, where dinosaurs roamed. Over millions of years Antarctica broke off, moving towards the pole and becoming the frozen continent we know today. Scientists recently discovered ancient tree fossils in Antarctica, meaning that a million years ago, Antarctica had forests whose trees evolved to withstand six-month periods of almost complete darkness. Fossils and deep underground water reservoirs give us glimpses of what ancient Antarctica looked like.

Today, Antarctica has become synonymous with penguins, from the stout macaroni penguin with its blond, bushy eyebrows to the large and noble emperor penguin. These distinctive flightless birds crowd the coastal regions, but they are only part of Antarctica's complex food web. Just as in the Arctic, frozen algae is the base of the Antarctica's food chain. In the summer, the ice melts and the phytoplankton blooms, which feeds massive amounts of krill. This attracts a migration of seabirds, seals, and whales, turning the Antarctic seas into a feeding frenzy of life.

Antarctica is owned by no country and has no permanent human residents, only tourists and research scientists who live there for limited periods. It is the world's most pristine wilderness; the first person to travel to the South Pole, Roald Amundsen, described the land as "a fairytale."

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## BIGGEST BENEFITS

The North and South Pole have a lot in common. Like the Arctic's **algae bloom,** Antarctica's provides the base of the food web for animals all over

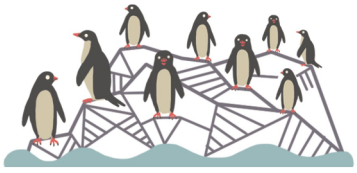
the ocean. And like the Arctic, its massive white surface **reflects sunlight** and heat back into space, helping to cool and regulate the planet's climate.

The **McMurdo research station** is the closest thing to an Antarctic town. Only about 4,000 scientists live in Antarctica during the summer and that number drops to about 1,000 in the winter.

In 1959, the **Antarctic Treaty** was signed, which states that the South Pole will be used only for peace and science, and that all discoveries will be shared freely. Fifty-three countries are now a part of the treaty.

Many **mosses** grow on rocks throughout Antarctica, but only three types of flowering plants can survive on the entire continent: **Antarctic pearlwort, Antarctic hair grass,** and **annual bluegrass.**

There are an estimated over six million **Adélie penguins** living in East Antarctica.



Since 1950, the Antarctic Peninsula has warmed by **half a degree Celsius every ten years.** This is much more rapid than the global average.

## GREATEST THREAT

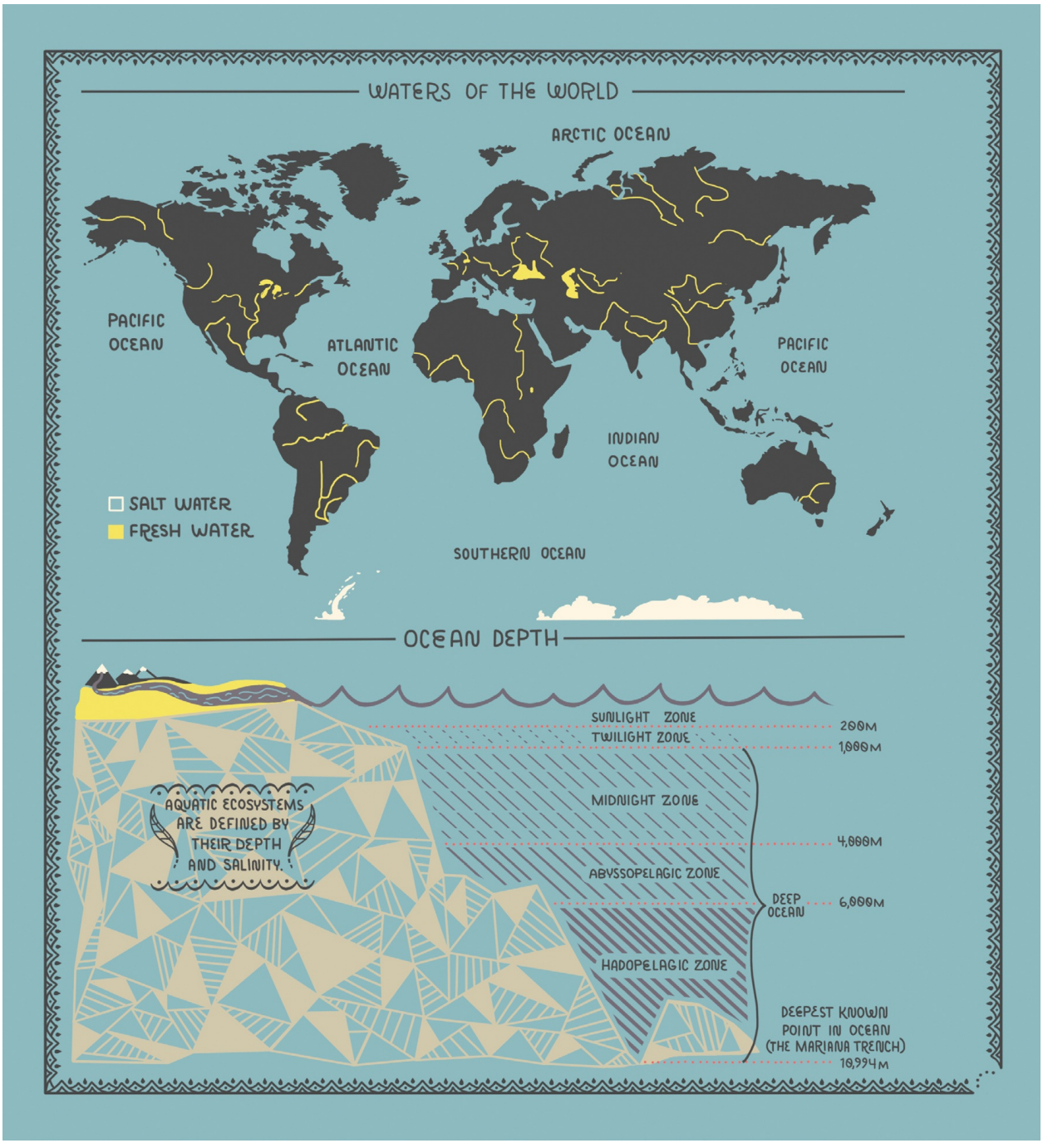
Even though no humans live full-time in Antarctica, people still have an impact on its ecosystems. **Global warming** is melting cracks in the Antarctic **ice shelf;** in 2017, a portion the size of Delaware broke away, forming one of the largest **icebergs** ever recorded; it is now floating and melting in the ocean. When ice breaks away, it makes the entire ice shelf unstable. If all of Antarctica's ice were to melt, scientists estimate that the seas would rise by up to **200 feet,** flooding coasts all over the world.


Have you ever spit off of a tall building or bridge? Cried during a sad movie? Drunk a cool glass of water on a hot day? Of course you have. Humans (and every animal and plant on Earth) constantly consume and excrete water. $H_20$ makes up 60 percent of the human body. The primordial waters of ancient Earth are where the first single celled–organism evolved. All living things depend on the cycling of water through our earth's ecosystems. Even in places where there seems to be no water, animals and plants wait for rare rainfall, find underground wells, or consume plants to get their fill. Marine biologist Sylvia Earle said, "Even if you never have the chance to see or touch the ocean, the ocean touches you with every breath you take, every drop of water you drink, every bite you consume. Everyone, everywhere is inextricably connected to and utterly dependent upon the existence of the sea."

No wonder aquatic ecosystems are some of the most valuable and productive resources in the entire world. The bounty of life found in the ocean feeds the world. All of those fish, plants, and marine animals are the basis of many of our global food webs. But it is not just a source of food—plants in our aquatic ecosystems produce over half of the oxygen in Earth's atmosphere. Water that evaporated from our oceans becomes the fresh water that falls as rain, even in some of the world's driest places. Without our oceans, we absolutely could not survive.

Although oceans, lakes, and other aquatic ecosystems may seem like endless resources, our world is much smaller than you may think. As

human populations grow, pollution and overfishing are destroying many of our important aquatic ecosystems. The water that flows throughout the world sustains life on this planet, and protecting it should be one of our highest priorities.


WATERS OF THE WORLD
ARCTIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
PACIFIC OCEAN
INDIAN OCEAN
SALT WATER
FRESH WATER
SOUTHERN OCEAN
OCEAN DEPTH
AQUATIC ECOSYSTEMS ARE DEFINED BY THEIR DEPTH AND SALINITY.
SUNLIGHT ZONE
200M
TWILIGHT ZONE
1,000M
MIDNIGHT ZONE
4,000M
ABYSSOPELAGIC ZONE
DEEP OCEAN
6,000M
HADOPELAGIC ZONE
DEEPEST KNOWN POINT IN OCEAN (THE MARIANA TRENCH)
10,994M


HUMPBACK WHALE
PHYTOPLANKTON
PRODUCERS
SUNLIGHT ZONE
KRILL
HERRING
ZOOPLANKTON
MACKEREL
BLUEFIN TUNA
COPEPODS
BOTTLENOSE DOLPHIN
ATLANTIC BLUE MARLIN
GREAT WHITE SHARK
APEX PREDATOR
TWILIGHT ZONE
SQUID
EEL
JELLY-FISH
BRISTLEMOUTH FISH

# ECOSYSTEM OF THE OPEN OCEAN

The open waters of the ocean have been called "the great blue desert." Where crowded coastal waters end, the open ocean begins, covering more than 70 percent of our planet's surface. Although open water forms the largest surface area on our planet, only 10 percent of marine species live there. Not many nutrients are found in the open ocean, because dead matter sinks to the ocean floor to decompose. What the surface does have, though, is hard-working microscopic algae called phytoplankton, which create oxygen through photosynthesis. They are the basis of almost the entire ocean's food chain. Occasionally, an upwelling or a storm will bring nutrients from the bottom of the ocean up to the surface, creating an algae bloom followed by a feeding frenzy for marine animals.

The animals that call the open seas home need to be powerful and fast. They travel from one end of the ocean to the other in search of food and mating grounds. Strong swimmers like whales, dolphins, and marine turtles navigate the oceans' currents, which act like underwater rivers. Underneath the ocean's surface is the dimly lit "twilight zone" where the animals have evolved to be stealthy. Diurnal (daytime) animals that live in this zone usually come to the surface to eat plants or scavenge. At night, twilight-zone predators will swim toward the surface to hunt their prey, usually luring them with fluorescent and bioluminescent markings.

The seas may seem endless, but they are not an inexhaustible resource. We need to take from our oceans responsibly if we hope to preserve them for the future.

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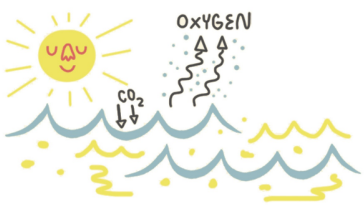
## BIGGEST BENEFITS

The open ocean is the beating heart of the entire world. The deep blue waters absorb over half of the sun's heat that hits the earth, and the **evaporation of sea water** is vital to creating rain that distributes fresh water worldwide. The different hot and cold



ocean currents also control **weather patterns** and climate for the entire planet. Most importantly, the water's surface supports **phytoplankton,** which produce over half of the atmosphere's **oxygen.**

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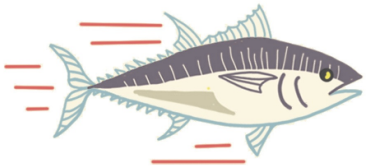
The **bluefin tuna** can accelerate as fast as a sports car and can reach speeds of 47 miles per hour.



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**Crustaceans** and **squid** in the open ocean have **clear bodies** that camouflage them to blend in with their environment.

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The **Great Pacific Garbage Patch** is an area of littered ocean about the size of Texas. Ocean currents between the United States and Japan consolidate the trash in one place, allowing it to pile up. This is one of many **"garbage vortexes"** throughout the ocean.

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Most of the animals that live in the deep ocean **never see land** in their lives.


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## GREATEST THREAT

**Pollution** of our oceans from **pesticides** and **oil spills** destroy ecosystems and

cause **dead zones** like the ones in the **Gulf of Mexico** and the **Baltic Sea.** Tons of **garbage** is thrown into the ocean each year, which kills marine life. **Overfishing** is also a major problem: right now, we are fishing the ocean at twice the level it can support. About 32 percent of the world's fisheries are over-exploited and being depleted of fish. However, we can change this through creating protected parts of the ocean, improving waste management, and enforcing sustainable fishing practices.


BLACK SEADEVIL ANGLERFISH
DUMBO OCTOPUS
BLUNTNOSE SIXGILL SHARK
VOLCANIC HOT SPRING VENTS
BARRELEYE
DEEP-SEA DRAGONFISH
BACTERIA AND ARCHAEA
VAMPIRE SQUID
TUBE WORMS
VENT MUSSELS
EELPOUT
VENT OCTOPUS
VENT CRAB
POMPEII WORM
FEATHER DUSTER WORMS

# ECOSYSTEM OF THE DEEP OCEAN

Imagine a place where the atmosphere is over 400 times heavier than it is at sea level. There is no sunlight, and strange creatures with sharp teeth, huge eyes, and glowing bodies float in the darkness. While this may sound like a place out of science fiction, it is right here on Earth, thousands of feet deep in the ocean. The "deep ocean" is the region 13,000 feet below the sea's surface, a depth where there is no sunlight. As the water gets deeper, additional water weight creates more pressure. Only special equipment and submarines can withstand this intense pressure without imploding, making the deep ocean one of the most unexplored places in the world.

Plants depend on sunlight for photosynthesis and are the base for most food chains. Therefore, in the past, scientists assumed that since there was no sunlight in the deep ocean, there could be no life. But in exploring the deep ocean, scientists have found that it is actually full of life. Hydrothermal vents on the sea floor spew minerals and energy from the earth's core. And microbes found in the deep ocean can turn minerals in the water into energy through a process called chemosynthesis. Marine animals at this depth have evolved to withstand the darkness, cold waters, and the intense pressure of the deep ocean. Giant tube worms and feather duster worms feed on vent microbes and are eaten by vent crabs. Other strange animals found in the world's deep ocean include the frilled shark (which is a "living fossil"!), the luminescent viperfish, and an animal with the biggest eye-to-body proportion, the vampire squid. Scavengers like the rattail fish and crustaceans called amphipods eat and decompose dead animals that sink to these depths. There is still so much to discover in the deepest parts of our earth.

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## BIGGEST BENEFITS

There are more **volcanic eruptions** on the ocean floor than anywhere else on Earth. Volcanoes thousands of feet underwater disperse **thermal energy** from

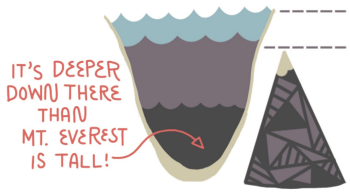
the earth's core all around the world, and contribute to the formation of **islands** and the ever-changing surface of the earth.

Every ten meters underwater adds another atmosphere of **pressure** to the ocean. That means most of the **ocean floor** has the equivalent of over **1,300** Earth atmospheres!

The **giant spider crab** is thought to be the largest arthropod on Earth.

Deep **underwater vents** spray out white wooly flocculent material, which means there is bacteria living under the earth's crust.

The **Mariana Trench** is the deepest known ocean depth, at 36,070 feet under water.




Constant **volcanic activity** means the ocean floor is always changing shape.

## GREATEST THREAT


**Overfishing** and destructive practices are harming our oceans, and the effects are in even the most remote depths. **Bottom trawling** is a fishing method that indiscriminately crushes everything in its path. This irresponsible practice destroys deep-sea corals and kills fish that we don't even eat, which in turn impacts whole ecosystems. There is **no regulation** in the deep seas, and **overfishing** is rampant. Commercial deep-sea fishing catches fish in spawning areas before they have a chance to reproduce. This means fewer fishing resources for humans in the long run.


HEADWATERS
(A RIVER'S SOURCE)
OSPREY
MOOSE
FLOODPLAIN
AQUATIC PLANTS
TRIBUTARY
RIVER CHANNEL
RIVER OTTER
PLANKTON AND ALGAE
RIVER BANK
FALLEN ACORNS AND LEAVES
WOOD DUCK
ARROWHEAD
BLUEGILL
ZOOPLANKTON
SMALL FISH
DRAGONFLY
CRAYFISH
MAY-FLIES
DELTA
OCEAN
FROG
SMALL FISH
RAINBOW TROUT
FLATHEAD CATFISH
DECOMPOSERS
GROUND WATER
ESTUARIES

# ECOSYSTEMS OF RIVERS

If the oceans are the heartbeat of our planet, then rivers are its veins and arteries. Fresh water is vital to most life on Earth, and massive networks of rivers and streams transport this important resource throughout the world. Rivers begin in various places where rainwater builds up, such as glaciers, snowy mountaintops, or ancient underground springs. Rivers can also start from easily accessible fresh water sources like lakes and wetlands, where water runoff builds up and comes together to become a moving river. Rivers intertwine and mingle with each other, creating tributaries.

Humans have depended on the natural resources provided by rivers and have transformed them to use their water and movement as a tool. We have built dams, canals, and irrigation systems for farming. Rivers have provided a means of transportation, trade, and exploration throughout human history. Almost all large cities are built near rivers. From the ancient Egyptian pharaohs building their civilization near the mighty Nile, to the Ming dynasty thriving in the delta of the Yangtze, to present-day London, which still depends on the Thames, rivers have allowed people to populate the world!

## BIGGEST BENEFITS

Rivers provide fresh water to entire ecosystems. People and animals all over the world depend on rivers for water and food. Throughout human history,

the fresh water of rivers has been used to **irrigate crops.** Rivers are also a source of energy, and the **kinetic energy** from the flowing current can be stored for later use. As rivers move through the land, they pick up **minerals** that eventually end up in the ocean, providing nutrients to those ecosystems as well.

Most of a river's current flows **beneath the surface** where it isn't visible and is sometimes much stronger and faster than it appears.

The **Mississippi River** is still a major shipping route for many American industries today.

The longest river in China, the **Yangtze,** supports the famous **giant panda** and the **Siberian crane.**

Most river animals live exclusively in **fresh water,** with the exception of a few special animals like **salmon,** which live as adults in the salty ocean and swim upstream to spawn in freshwater rivers.

## GREATEST THREAT

**Flooding** and **erosion** are a natural and healthy parts of a river's ecosystem. But when that natural flooding is disrupted by **poorly managed building,** floods can become catastrophic. **Pollution** and **overfishing** of rivers can also destroy river ecosystems and devastate nearby communities. Pollution in

**groundwater** makes its way to the ocean, polluting the "heart" of our planet. Only through proper management and a knowledge of ecology can we keep our rivers healthy and productive.


GREAT BLUE HERON
CANVASBACK DUCK
WATER LILIES
CATTAIL
PLANKTON AND ALGAE
ZOOPLANKTON
WATER FLEA
WILD CELERY
SNAPPING TURTLE
SMALLMOUTH BASS
LAKE TROUT
CHIRONOMID
OPOSSUM SHRIMP
YELLOW PERCH
CLAM
SNAIL
DEEPWATER SCULPIN
DECOMPOSERS
—SEDIMENT—

# ECOSYSTEMS OF LAKES

Water covers over half of our planet's surface, but most of that water is too salty to drink. Most of the fresh water is locked away in frozen glaciers or in the ground. Luckily, there are lakes! Lakes can be found on every continent and in many climates, from the coldest snowy mountaintops to barren-seeming deserts. Lakes can even be found at the brutally cold South Pole, like the frozen Lake Vostok. Lakes are created when fresh water fills up a basin on the earth's surface. Like the Great Lakes of North America, many lakes were formed 18,000 years ago during the end of the Ice Age, when large ice sheets and glaciers began to melt. With melting came movement, and these large sheets of ice slowly slid away from the Earth's polar regions, filling up basins and craters all over the world with melting water. Other lakes are formed by rainwater filling craters and bowl-shaped depressions that are often created by earthquakes.

Lakes are contained ecosystems and can be very different from one another. The main factors that determine the ecological makeup of a lake are its exposure to sunlight and wind, its temperature, and the chemical and pH balance of the water. The wildlife found in each individual lake has evolved to survive in the specific attributes of their home. For example, tilapia fish can live only in acidic waters. It is also important that all lakes have the correct balance of nitrogen and phosphorus to promote plant growth. Too little of these nutrients means no plants and no life. Too much phosphorus or nitrogen will cause algae to grow out of control. This pond scum (a type of algae) can take over a lake, making it impossible for other wildlife to survive. By understanding the balance and qualities of individual lakes, we can protect and preserve them.

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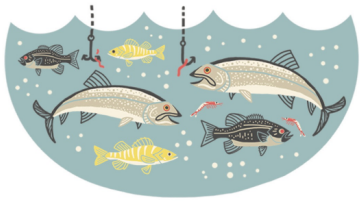
## BIGGEST BENEFITS

Like rivers, lakes also provide us with water for **drinking, farming,** and **transportation.** Like the ocean, they are a source of diverse marine life that

supports **commercial fishing.** Cooling winds that come off large lakes help to **regulate temperatures.** The fresh water and marine life in lakes support entire communities of people and animals; **millions of people** depend on lakes to live.



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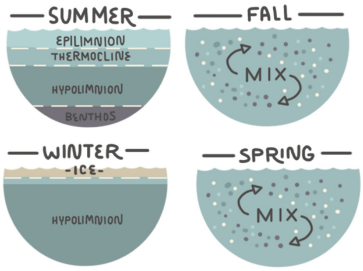
**Lake water** mixes when the seasons change. As the water cools, it sinks to the bottom and the dense lower layers rise to the top.

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Many lakes are formed in **inactive volcanoes** that fill up with rainwater.

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The difference between a **pond** and a **lake** is size; many classify small bodies of water as ponds when they have **rooted plants** growing in them.

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Lakes can be closed off or the source of a mighty river. Many closed-off lakes become **saltier than the ocean** through thousands of years of evaporation.

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Dry lakebeds are great for **fossil hunting.**

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## GREATEST THREAT

Lakes have natural life cycles. Over time, **dead animals and plants** decompose and sink to the bottom to form **sediment.** Eventually, this sediment can fill up a lake until it becomes a **marsh** or a **swamp.** Over thousands of years, lakes do naturally dry up, but **human activity** and **poorly planned construction** can speed up this process, causing lakes to dry up in a matter of decades, which is too fast for wildlife to adapt. Another threat is when **pollution** changes the chemical makeup of a lake, causing **pond scum** to grow. Too much pond scum can block the sunlight and use up all the oxygen in the water. This turns a lake into a **dead zone** where nothing can survive.


Every single thing in the universe is made up of matter. The atoms that make up matter can never be created or destroyed, just rearranged in different forms. That means that the atoms that were created during the Big Bang make up the tree in your backyard, your hand, the chair you're sitting in, and everything else! The important nutrients and molecules that we are made of all move through the food web (yum!). But the food web is just one part of our world's natural cycles. The carbon, nitrogen, phosphorus, and water cycles are some of the main ways that ecosystems recycle and transform matter. These cycles provide us with food, energy, and fresh water. They fertilize the soil and regulate our climate. Whether it is the rain from the sky, the carbon in our bones, or the dirt under our feet, we rely on the balance of these cycles that make life possible on Earth.

Nutrients and molecules like oxygen, carbon, and water can be stored in "reservoirs." Some reservoirs hold nutrients for a short period; others hold them for centuries. For example, a relatively short-term reservoir for water is a lake—water molecules ($H_20$) just need a hot day to cycle back up into the clouds via evaporation and later come back down as rain. Meanwhile, glaciers act as long-term reservoirs, storing water in its frozen form for centuries. Releasing too much of a locked-away resource too quickly can have negative effects on our global ecosystems. We need to understand these different reservoirs and responsibly preserve the delicate balance of these important cycles.


O
H
H
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N
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O

# THE CARBON CYCLE

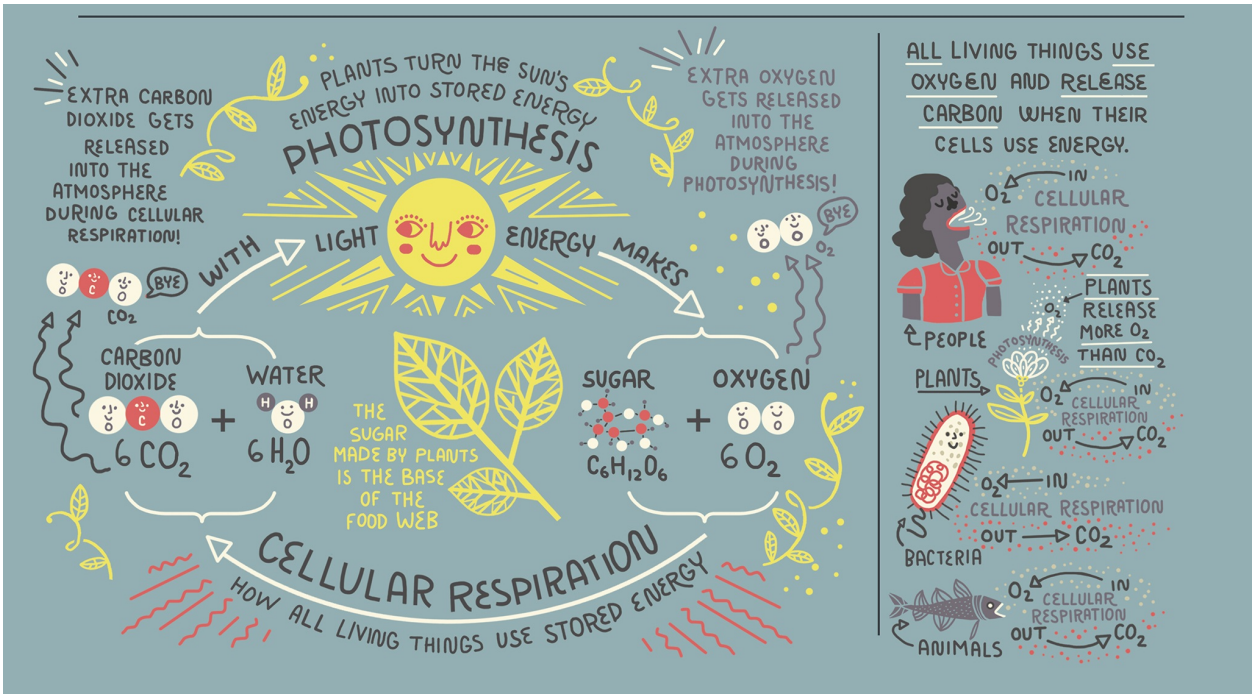
Every living thing you can think of is made of carbon. You, your dog, the grass on your lawn, and the worms in the ground are all carbon-based life forms. Not only is every living thing on Earth made of carbon, but we also depend on the carbon cycle for cellular respiration, breathable air, and climate regulation. The carbon cycle relies on algae and plants (aka producers), which absorb carbon dioxide ($CO_2$) from the atmosphere and use photosynthesis to turn it into sugars. During this process, carbon dioxide is absorbed and oxygen is released into the atmosphere. The sugars in plants are a form of stored energy. When plants are eaten, their stored energy and carbon compounds begin their journey through the food web.

Carbon is stored in the bodies of plants and animals for some time. Some of that carbon becomes poop or other waste. Eventually living things die and their carbon is broken down by decomposers. Both waste and dead matter are a part of the food web, and when broken down by bacteria and fungi, their carbon becomes part of the nutrient-rich soil that plants need. This is one reason that farmers use manure or compost to help crops grow.

Carbon is a vital part of sugar (glucose) molecules, which are a form of stored energy. Living things use this energy to do work in a complicated process called cellular respiration. During cellular respiration, carbon dioxide is released back into the atmosphere. Photosynthesis is the process that creates stored energy, and cellular respiration is the process of using that energy. Photosynthesis is only done by plants and other producers, and uses carbon dioxide, while releasing oxygen into the air as a byproduct. Meanwhile, cellular respiration is done by all living things and uses oxygen, while releasing carbon dioxide into the air as a byproduct.

The cycling of oxygen and carbon keeps our air breath-able, regulates global temperatures, balances the pH of the ocean, and helps to keep our soil fertile. Certain human activities are upsetting to the balance of the

carbon cycle. The rapid burning of fossil fuels is releasing more carbon dioxide into the atmosphere than ever before, causing global temperatures to rise and altering ecosystems worldwide (see this page). Understanding the balance of the carbon cycle is important to protecting our planet.




PHOTOSYNTHESIS
ATMOSPHERIC CARBON IN THE FORM OF $CO_2$
+
WATER AND LIGHT ENERGY
CARBON COMPOUNDS IN PLANTS (PRODUCERS)
CARBON STORED IN PLANTS GETS PASSED THROUGH THE FOOD WEB!
OXYGEN RELEASED BY PLANTS DURING PHOTOSYNTHESIS
$O_2$
ATMOSPHERIC CARBON AS $CO_2$
CELLULAR RESPIRATION
ATMOSPHERIC CARBON AS $CO_2$
CELLULAR RESPIRATION
ATMOSPHERIC CARBON
FUEL WE BURN RELEASES CARBON
CARBON COMPOUNDS IN PLANTS (PRODUCERS)
SECONDARY CONSUMER
CARBON
PRIMARY CONSUMER
CARBON
CARBON
PRODUCERS
POOP
YUM! MORE CARBON!
DECOMPOSERS
THE CARBON OF POOP AND DEAD THINGS ARE BROKEN DOWN BY BACTERIA
NUTRIENT-RICH SOIL
STORED FOSSIL FUELS

# THE NITROGEN CYCLE

Nitrogen makes up about 78 percent of our air and is an important building block for proteins and the nucleic acids that make up the DNA of living things. Although there is atmospheric nitrogen all around us, it is impossible for plants and animals to absorb it directly. Nitrogen is usually found as $N_2$, in which two nitrogen atoms are strongly bound together. Luckily, certain bacteria can "fix" this very strong molecule so that plants and animals can use it.

All living things rely on a process called "nitrogen fixation" that turns nitrogen gas ($N_2$) into compounds that plants can absorb. This transformation is done by certain types of microscopic bacteria that live in soil, certain types of blue-green algae found in water, and microbes that live on the root nodules of certain legume plants. Through several transformative processes, microbes turn nitrogen ($N_2$) into molecules that plants love, like nitrates ($NO_3$-). Certain plants, like rice, can also absorb nitrogen in the form of ammonium ($NH_4$+).

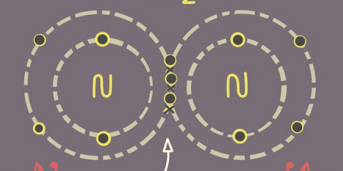
Once Nitrogen is absorbed by plants it becomes available to the rest of the food web. As consumers eat plants (and then are eaten by other animals), the nitrogen is also passed along and used. Nitrogen compounds return to the soil when bacteria decompose dead organic matter and waste. Plants absorb this recycled and decomposed nitrogen as well.

The nitrogen cycle is completed when different types of de-nitrifying bacteria turn nitrates back into pure atmospheric nitrogen ($N_2$). Those strong nitrogen molecules return to the atmosphere until the cycle starts all over again.

Nitrogen ($N_2$) bonds are so strong there is only one other way to break them apart: Lightning! The energy in a bolt of lightning can "fix" a small amount of atmospheric $N_2$ that plants can use. We also have learned how to artificially break apart $N_2$ to create fertilizer to help plants grow and create large farms to feed our growing population.

NITROGEN MAKES UP ABOUT 78% OF THE EARTH'S ATMOSPHERE.

$N_2$



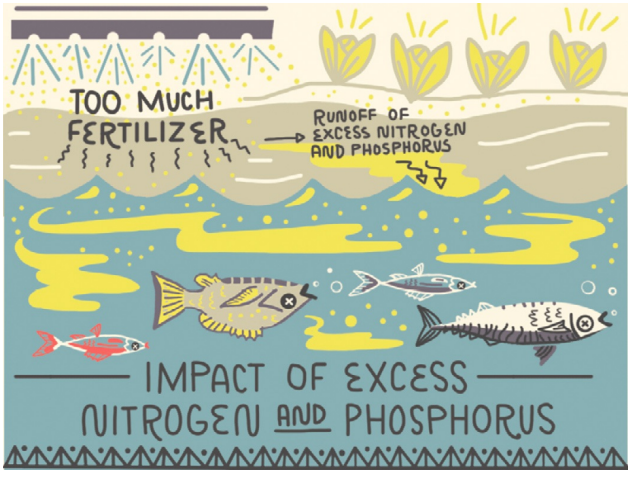

NITROGEN IS FOUND IN THE FORM OF AN $N_2$ TRIPLE BOND, WHICH MAKES IT HARD TO BREAK.

ERUPTIONS FROM VOLCANOES AND THE BURNING OF FOSSIL FUELS FROM FACTORIES AND CARS ADD NITROGEN TO THE ATMOSPHERE. EXCESS NITROGEN CAUSES SMOG AND ACID RAIN, WHICH CAUSES EROSION AND POLLUTES THE AIR.


$N_2$
WE'RE STUCK!
LIGHTNING IS STRONG ENOUGH TO BREAK A TRIPLE NITROGEN BOND.
NITROGEN JOINS WITH OXYGEN TO MAKE NITRATES AND DISSOLVES IN RAIN.
$N_2$ RETURNS TO THE ATMOSPHERE.
PRIMARY CONSUMER
REST OF FOOD WEB
POOP AND URINE
LEGUME PLANT
DECOMPOSERS
NITROGEN-FIXING BACTERIA IN SOIL
DENITRIFYING BACTERIA
PLANTS
DEAD THINGS
AMMONIFICATION
NITROGEN-FIXING BACTERIA FOUND ON ROOT NODULES
NITRATES $NO_3^-$
NITRIFYING BACTERIA
NITRIFYING BACTERIA
AMMONIUM ($NH_4^+$) AND AMMONIA ($NH_3$)
NITRITES $NO_2^-$

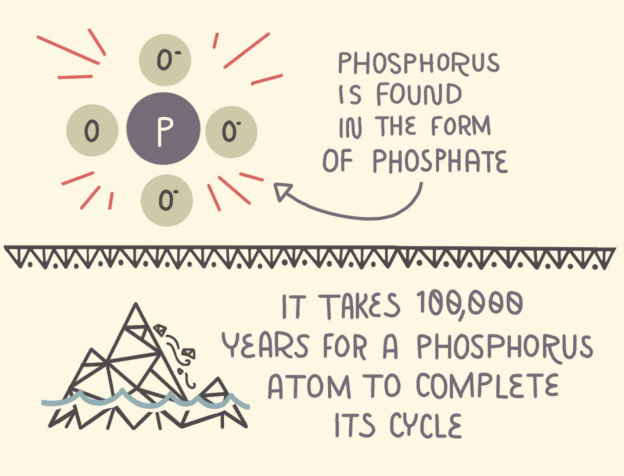
# THE PHOSPHORUS CYCLE

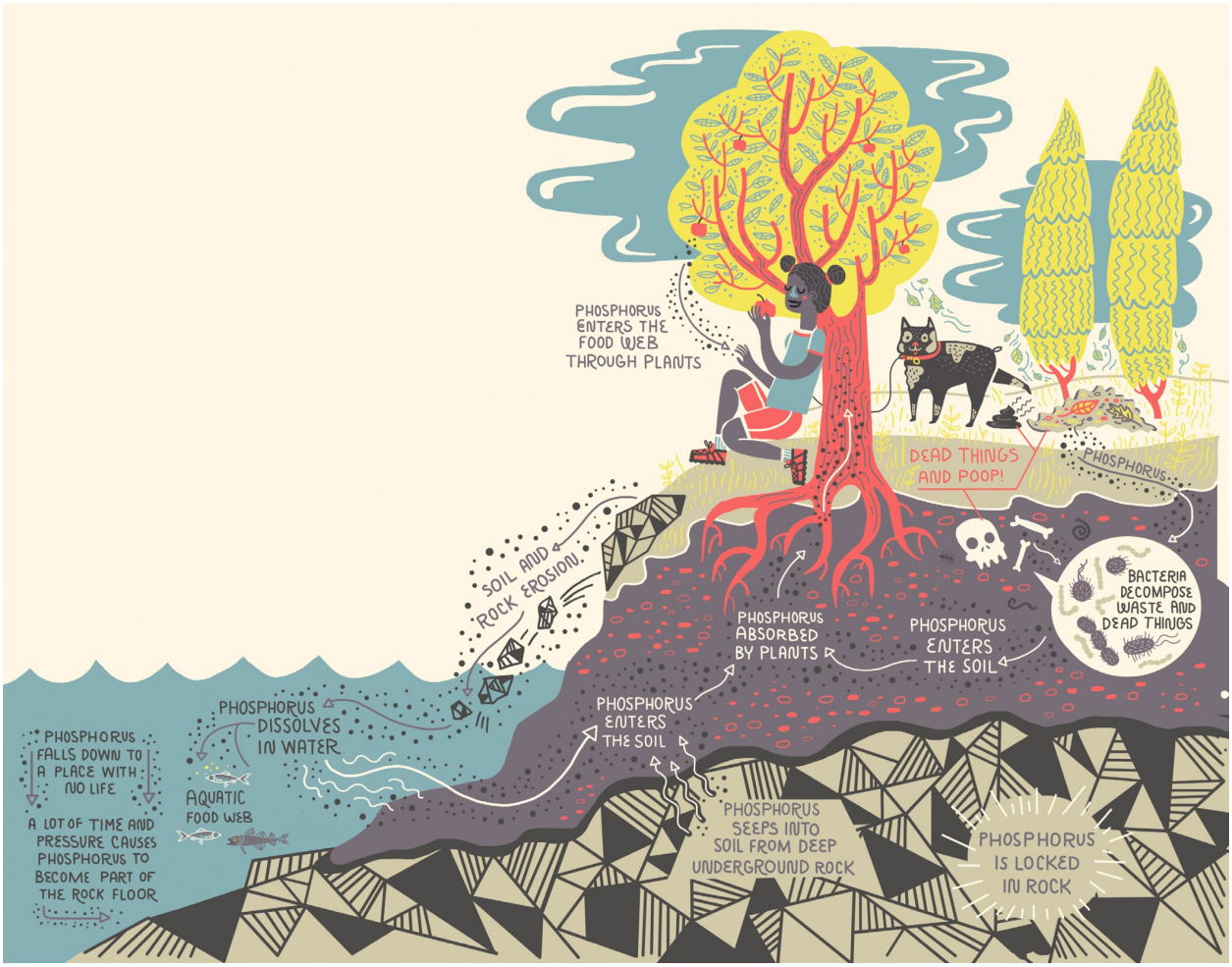
Like nitrogen, phosphorus is needed by all organisms to build DNA, the genetic code that tells our cells what to do. Phosphorus is locked underground in sedimentary rocks that formed from dead animals and plants over the course of millions of years. Eventually these rocks surface and are eroded by the weather or are eaten away by specialized bacteria called lithotrophs. The phosphorus then dissolves into water or seeps into the soil, where it can be absorbed by plants and become available to the rest of the food web. Animals and people eat food and the phosphorus becomes part of their DNA. Eventually plants and animals die and are decomposed by bacteria. Most of that phosphorus returns to the soil to be absorbed by plants again. A phosphorus atom can cycle through just the biological system of the food web and decomposition for over a hundred thousand years. Occasionally, dead animals or plants end up in deep holes in the ocean, where the environment is so extreme that there are no decomposers to break it down. Time and pressure turn dead organic matter into sedimentary rocks. Over millennia, rocks surface and erode, and the cycle begins again. As you can see, phosphorus rocks!




Phosphorus and nitrogen are vital to life on Earth but are hard for plants to

access. This is why people have created fertilizers to artificially reinvigorate the soil and ensure that plants will grow. Fertilizers have helped us feed our growing population, which is fantastic! But too much of a good thing can be dangerous. Fertilizer runoffs into waterways have thrown off the balance of ecosystems and have created dead zones in the oceans. We need to change how fertilizers are used by farms and prevent agricultural runoff so we can minimize this kind of pollution.




PHOSPHORUS ENTERS THE FOOD WEB THROUGH PLANTS
DEAD THINGS AND POOP!
PHOSPHORUS
BACTERIA DECOMPOSE WASTE AND DEAD THINGS
SOIL AND ROCK EROSION
PHOSPHORUS ABSORBED BY PLANTS
PHOSPHORUS ENTERS THE SOIL
PHOSPHORUS DISSOLVES IN WATER
PHOSPHORUS FALLS DOWN TO A PLACE WITH NO LIFE
AQUATIC FOOD WEB
A LOT OF TIME AND PRESSURE CAUSES PHOSPHORUS TO BECOME PART OF THE ROCK FLOOR
PHOSPHORUS ENTERS THE SOIL
PHOSPHORUS SEEPS INTO SOIL FROM DEEP UNDERGROUND ROCK
PHOSPHORUS IS LOCKED IN ROCK

# THE WATER CYCLE

Whether you're having a refreshing glass of water on a sunny day or you're stuck inside because of the rain, you're seeing the water cycle in action. Water ($H_20$) covers over 70 percent of the earth's surface and makes up about 60 percent of our bodies. Even though water is all around us, drinkable water is actually a scarce resource. We all depend on the water cycle to filter and distribute fresh water around the globe.

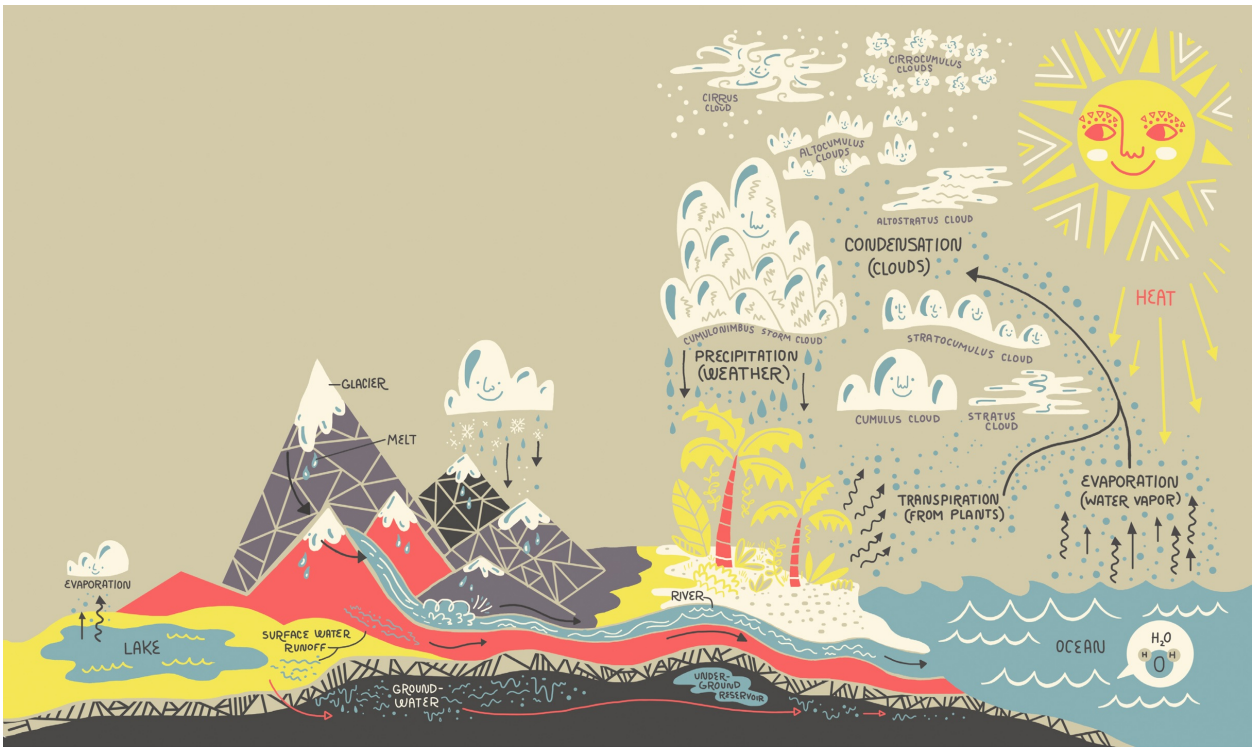
Eventually, all water molecules reach the ocean. As the sun heats the ocean's surface, water molecules evaporate into the air, leaving behind the salt or minerals that make it undrinkable. This fresh water condenses to form clouds. These fluffy reservoirs of fresh water float around the entire world. When the clouds get too heavy, gravity brings that fresh water back down to Earth in the form of rain, snow, or even hail, which distributes fresh water. Now plants, animals, and people have something to drink!

Some of that water evaporates right away because of the sun's heat. Some of it is frozen on the top of mountains as glaciers. Some is pulled down by gravity even farther, sinking into the ground. Over time, that soil moisture is used by plants or animals, or slowly moves underground and makes its way back to the ocean. The water in mountain snow slowly melts to feed streams and rivers that lead to the ocean. River and groundwater runoff draws salt and other minerals to the ocean. Mineral runoff, constant evaporation of fresh water, and erosion of rocks all contribute to making ocean water salty.

The water that is sucked up by plants and slurped up by animals and humans is also a part of the water cycle. What isn't released as urine will either evaporate from our bodies when we sweat or be released as water vapor on our breath. Water leaves plants in the form of gas in a process called "transpiration."

In certain parts of the world it can seem like drinkable water is everywhere; however, globally over two billion people do not have

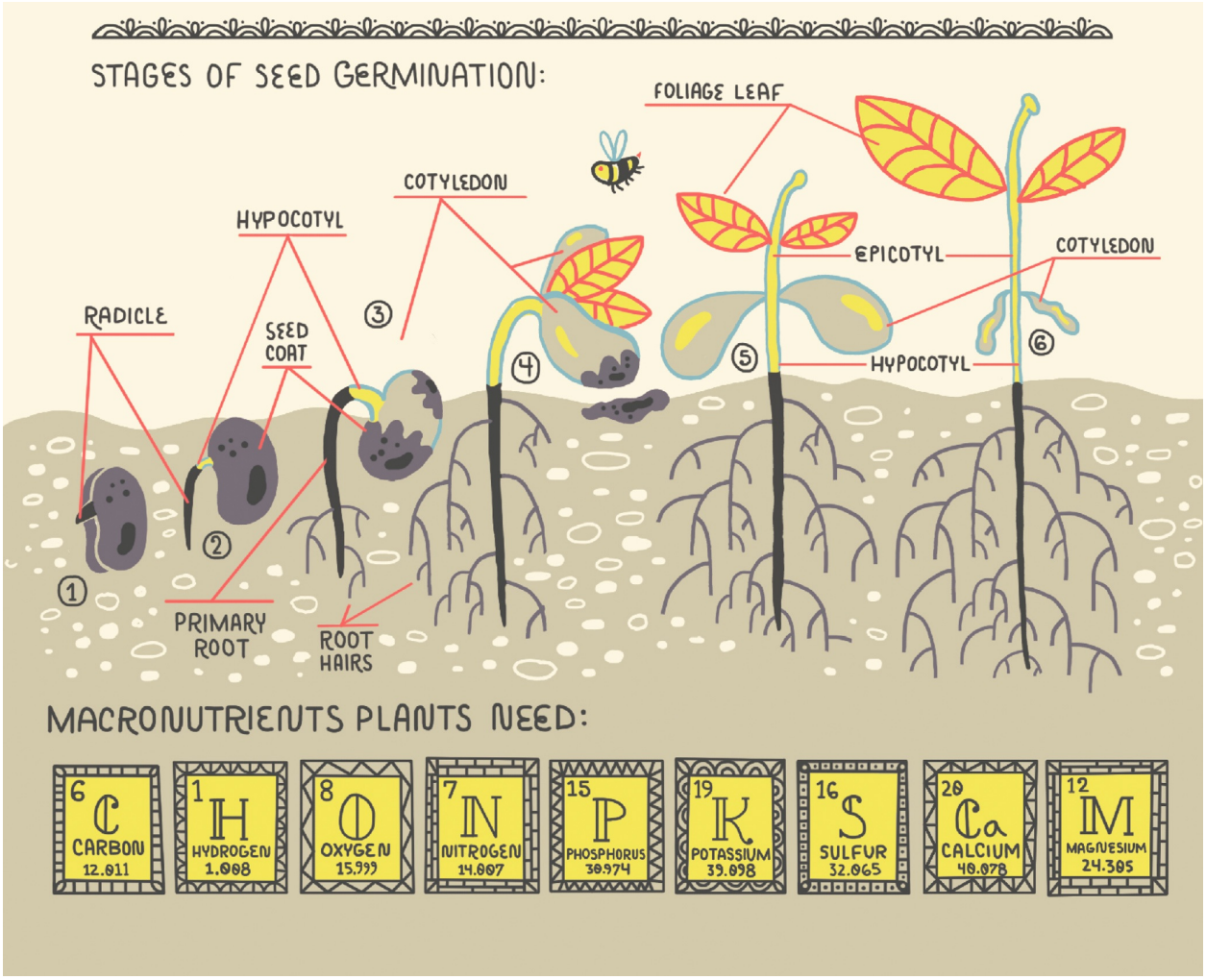
regular access to clean water. Water shortages are caused by scarcity in dry regions combined with the lack of funds to import water. Other water shortages are purely economic, when communities are surrounded by water but do not have the resources to dig wells or sanitize it. Together we need to think about how we are using water sustainably and how water can be equitably distributed.


CIRRUS CLOUD
CIRROCUMULUS CLOUDS
ALTOCUMULUS CLOUDS
ALTOSTRATUS CLOUD
CONDENSATION (CLOUDS)
HEAT
CUMULONIMBUS STORM CLOUD
PRECIPITATION (WEATHER)
STRATOCUMULUS CLOUD
CUMULUS CLOUD
STRATUS CLOUD
GLACIER
MELT
TRANSPIRATION (FROM PLANTS)
EVAPORATION (WATER VAPOR)
EVAPORATION
RIVER
LAKE
SURFACE WATER RUNOFF
OCEAN
$H_2O$
GROUND-WATER
UNDER-GROUND RESERVOIR

# PLANTS

We all depend on our leafy friends. Whether the mighty oak tree or a microscopic cell of algae, plants are the only living things that can get energy directly from the sun. Through photosynthesis, plants combine sunlight, carbon dioxide, and water to create glucose, a type of sugar. The plant uses this sugar for energy (food!) and helps to build its own structure. The waste that is released during photosynthesis is oxygen! Plants naturally create the oxygen-rich air that we must have to breathe.

Plants' ability to create their own food with sunlight makes them the start of almost every food web. They also cycle important nutrients into the food web by absorbing them from the soil. Energy and nutrients are passed along to us when we eat plants or animals that have eaten plants. Roots of plants also help stabilize the soil beneath our feet, prevent erosion, and protect coastlines from floods. The world we live in, the food we eat, and the air we breathe all exist thanks to plants!


STAGES OF SEED GERMINATION:
FOLIAGE LEAF
COTYLEDON
HYPOCOTYL
EPICOTYL
COTYLEDON
RADICLE
SEED COAT
HYPOCOTYL
PRIMARY ROOT
ROOT HAIRS
MACRONUTRIENTS PLANTS NEED:
6 C CARBON 12.011
1 H HYDROGEN 1.008
8 O OXYGEN 15.999
7 N NITROGEN 14.007
15 P PHOSPHORUS 30.974
19 K POTASSIUM 39.098
16 S SULFUR 32.065
20 Ca CALCIUM 40.078
12 M MAGNESIUM 24.305


FLOWERING PLANT
PETAL
STAMEN
CARPEL
STIGMA
STYLE
OVARY
OVULE
MID-RIB
VEIN
SEPAL
TERMINAL BUD
PETIOLE
RECEPTACLE
LEAF
WATER VAPOR ($H_2O$) LEAVES THROUGH TRANSPIRATION
POLLEN
$O_2$ GOES OUT
VASCULAR TISSUE
LIGHT ENERGY
AND $CO_2$
AND $H_2O$
MAKE STORED ENERGY (GLUCOSE)
VEGETATIVE SHOOT
LIGHT ENERGY
STOMATA
CHLOROPLAST
SHOOT SYSTEM
STEM
ROOT SYSTEM
PRIMARY ROOT
SOIL
LATERAL ROOTS
WATER ($H_2O$)
ROOT TIP
ROOT CAP


In many ways, human beings are the most remarkable animals on the planet. Humans have gone from living in caves and scavenging for food to being able to order a pizza and get it delivered without leaving the couch! Human beings have walked on the moon, broken the sound barrier, and created artificial intelligence to help us solve extremely complicated problems. We have developed technologies that allow us to travel all over the world relatively quickly, and communicate with anyone with just the click of a button. Together humankind has transformed Earth's landscape, striving to create shelter and provide food for our ever-growing population. Our caveman ancestors could never have dreamed of the safety, comforts, or technology that many people in the world have today!

But for all that we have built, there are still things that only nature can provide us. All around us, ecosystems create fuel in the form of wind, hydro, and solar energy. Thousands of years of decomposition have turned carbon into coal or fossil fuel that we can use to drive cars and heat homes. Ecosystems are the global cleanup crew, breaking down garbage and dead things into soil that can grow new plants and crops. Plants in certain ecosystems can prevent floods and coastal erosion. Intact, biodiverse ecosystems can even bounce back from natural disasters and "heal" themselves. Economists have valued the natural ecosystems of our world at over $142.7 trillion a year. But who could put a price on

breathable air, fresh water, nutrient-rich soil, and a livable home planet? As people continue to build wondrous cities and large farms, we also need to preserve the natural world, so it can continue to work hard for us.


ORCHARD
APPLE
BARN
SILO
TOMATO
BACTERIA BREAKS DOWN WASTE
COMPOST FERTILIZER
GRAIN BIN
WINDMILL
GREEN HOUSE
PIG
SHEEP
STABLE
HORSE
HOG HOUSE
CHICKEN
TRACTOR
COW
CHICKEN COOP
TURNIPS
BARLEY
CLOVER
WHEAT
MANURE
YEARLY CROP ROTATION
ROTATING CROPS NATURALLY RETURNS NUTRIENTS TO THE SOIL

# THE FARM

Human civilization all comes down to food. Long ago, before recorded history, the only way to eat was to find the food yourself. Our ancestors were nomadic, constantly on the move seeking new plants and animals to eat. But sometime after the Ice Age, nomadic tribes across the world started to plant seeds and cultivate crops. Farming created a surplus of food, and more food meant people could spend more time doing other kinds of work. People began to settle in fixed places around these new farms, and also took on new jobs, like inventing and building new tools. This created a boom in technology. New methods of farming were developed to yield even more crops. People began to transform the land around them, tilling the soil, irrigating to bring water to the crops, and selectively breeding the plants and animals that were most beneficial to their community. Large-scale civilizations and cities began to emerge.

Now, with new technology, we can feed humanity's fast-growing population. Machines dig the soil, plant, and harvest; crops can be genetically selected to withstand drought or keep pests away; and chemical fertilizers boost soil productivity. Our food is grown all over the globe and transported worldwide. We can eat a slice of pizza that is made with tomatoes from Italy, wheat from Europe, and cheese from America. But with all of our progress, it is critical to remember that it is our limited natural resources that make farming possible at all.

Farming sustainably means feeding our growing population while keeping the environment healthy for the future. The main challenges to overcome when feeding a large population are depleting the soil of nutrients, overusing water, and using fossil fuels both to fertilize and to run farming machinery.

Biodiversity is as important on a farm as it is in the wild. Although planting a large field of one type of plant has its benefits and is easier to manage for a farmer, it also depletes the soil and forces farms to rely heavily on chemical fertilizers. An overuse of fertilizers can pollute the

groundwater, which in turn pollutes our oceans. When farms grow only one type of plant, the entire crop becomes more prone to disease and pests, requires more pesticides, and is less able to withstand changes in the weather.

When there is a diversity of plants and animals on a farm, the natural benefits of an intact ecosystem abound. Different plants take different compounds from the soil and put back different nutrients. By rotating crops, farmers can naturally enrich the soil instead of overtaxing it to produce a single crop. Planting cover crops and using compost and animal manure can also lessen the need for chemical fertilizers. Certain plants can even repel insect pests. Biodiversity can also help us conserve water: by planting drought-resistant plants and using methods to reduce water volume irrigation, we can make water reserves go farther and last longer during dry seasons. Every place is different, and plants native to an area often have unique properties that can help keep the soil rich and moist! Introducing native grasses and trees often helps make farms more sustainable.

We use fossil fuels to run the machines that help to grow our food and ship it all over the world, so even a single carrot grown commercially has a carbon footprint. Eventually our oil reserves will run out, but our need for food will not. More and more people live in cities, and getting food to where people can eat it is just as important as growing the food in the first place. The high price of oil leads to a higher price for fresh, healthy food, creating "food deserts" in poorer parts of cities that often lack large grocery stores. Food deserts can be found in the United States and all over the world, wherever people do not have access to fresh fruits or vegetables. Advancements in technology, like electric-run engines, and alternative energy sources are necessary to feed the world.

When new technology and our knowledge of ecology come together, we can feed our growing populations while preserving our planet for the future.


FALCON
ROOF-TOP GARDEN
SOLAR PANELS
PIGEON
POWER LINES
CABLES
RACCOON
GROCERY
FRESH FOOD
STRAY CAT
///CITY BUS///
FOOD DELIVERY
SQUIRREL
SEWER GRATE
DOGWOOD TREE
SEWER SYSTEM
PIPES
CABLES
UTILITY TUNNEL
SUBWAY
COCKROACH
RAT

# THE CITY

Every living thing on Earth has its habitat and its home, and that includes us humans. Our ancient ancestors lived in caves, for protection from predators and harsh weather. As humans have evolved and progressed, so have our homes. Whether they be tents, huts, houses, or skyscrapers, human-built structures protect us from the elements and provide functions we've come to rely on. Now humanity has transformed large parts of our earth to create a habitat designed specifically for human comfort.

Cities come in many shapes and sizes and are defined by the people living there. Some look more like a village than a concrete jungle. Right now, over half of the human population lives in cities. To support all of these people, cities need complex infrastructures: lines to deliver power and communication, plumbing and waste systems. Networks of wires and cables are laid underground, in the sky, and under the sea for places to have electric energy and internet capability. In most major cities, roads have been paved and subways have been dug so people can travel and transport food easily. There are also cities in undeveloped areas where not everyone has access to clean water, plumbing,and electricity.

The way cities are built now allows few animals to coexist with people. Biodiversity may be low, but there is still wildlife among us. In some cities, it's not uncommon to see a pigeon, rat, or raccoon enjoy a snack out of a garbage can. There are also unexpected animals in cities who take advantages of these unusual ecosystems in new ways. Peregrine falcons, who have evolved to nest on tall cliffs, can now be found perched and nesting on skyscrapers. The rhesus macaque monkey scavenges in the markets of Indian cities. And in Albi, France, catfish, which usually stay at the bottom of a pond, actually jump out of the water to eat nearby unsuspecting pigeons.

As our population grows, so do our cities. Streets, fences, and walls cut off natural animal movement and light pollution disrupts the natural habits of nocturnal animals. The more concrete we lay down to build, the more

wildlife habitat we destroy. Each decade, an area of wilderness the size of Great Britain is destroyed for city expansion worldwide.

Yet there are ways to build our cities without having to completely sacrifice our natural ecosystems. Some cities are starting to integrate plants into their urban planning. In 2015, giant vertical hanging gardens were built in Singapore. These 164-foot-tall steel structures are called "super trees," and although they are not actual trees, there are so many plants growing on their sides that they naturally cool the area. In parts of Africa, North America, and Europe, passageways for animal migration are being built underneath highways so wildlife can pass through uninterrupted by roads.

Cities are the world leaders in finding ways to use renewable energy. In 2013, Malmö, Sweden, became Europe's first "carbon neutral neighborhood." It was powered entirely by renewable energy, including wind and solar power and the burning of compost. Their cars and buses were run on electricity and biofuel made out of food waste instead of gasoline. In 2015, Burlington, Vermont, became the first U.S. city to use renewable energy for 100 percent of its electricity. Since then, over 40 cities (and the number keeps growing!) in America have also pledged to be powered by 100-percent clean renewable energy before the year 2050.

People are responsible for building our cities, and we choose how they impact nature. With proper planning, we can preserve or even create wildlife habitats and lessen harmful impacts on nature.

# HUMAN IMPACTS ON NATURE

Development and progress are good things! But as we continue to grow and work to provide for all humankind, we also need to be mindful of the ways we affect the natural world. By understanding the main ways we impact the environment, we can build and farm more sustainably.

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## DEFORESTATION

Forests around the world have been clear-cut for timber logging and to make space for farms, ranches, buildings, and other development. This creates many problems, such as stormwater runoff and loss of habitat for animals. We also depend on large forests to absorb carbon from the air and to create oxygen; scientists estimate that 15 percent of unwanted greenhouse gases in the atmosphere come from rapid deforestation and a lack of trees to filter the air. When a large forest is cleared, it alters the area's rain and weather patterns. Water that once was absorbed by the trees and plants flows freely into and over the ground, causing erosion and the pollution of nearby rivers.

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## INVASIVE SPECIES


Many of the crops and domesticated animals we rely on are from different parts of the world. However, the introduction of invasive species in the wild can harm an ecosystem.

Sometimes invasive species are brought to a new region on purpose with unintended impacts. For example, your

neighbor might love his pet python, but if it escapes, it can wreak havoc on nearby animals. The kudzu plant was brought to the United States as a garden novelty. Now kudzu is a rampant weed in the Southern United States that smothers other plant life and sometimes entire vehicles and buildings! Sometimes invasive species are introduced by accident, like the Mediterranean fruit fly, which infests fruit with its larvae. When produce is transported all over the world, so is this pesky fly, which now threatens crops globally.

The animals and plants in a local ecosystem have evolved to compete only with each other, and when a new species is introduced, it can become invasive, dominating the landscape and out-competing the local species for resources, which can destroy the ecosystem. Right now, we can see this happening in the American Great Lakes, where invasive species like zebra mussels threaten entire ecosystems.

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## OVERHARVESTING

Overfishing, overhunting and overgrazing are major strains on our ecosystems. Overharvesting occurs when we use our natural resources at a faster rate than they can be replenished. Some animals, like the passenger pigeon, have been overhunted to extinction. We are depleting the ocean of marine life by indiscriminately fishing in massive amounts, killing off marine species before they have had a chance to breed. Often, large-scale industrial fishing nets catch and kill animals people don't even eat, which is called bycatch. We are overusing the land for livestock, and overgrazing grasslands. Without enough grass roots to stabilize it, the soil erodes quickly. Large monocrop farms tax the soil and deplete it of nutrients. All of this makes plants harder to grow, and can even lead to soil death. Farming, fishing, and herding on a large scale are necessary to support our population. But we need to use our resources in sustainable ways so that they do not become depleted.

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## DESERTIFICATION

A drought or rise in temperature—combined with human activity like deforestation, overgrazing, or the overexploitation of soil—can lead to desertification. Dust storms become frequent, and nothing can grow in the dry, nutrient-depleted land. Even the most fertile land can be turned into a desert. The United States experienced its own desertification problems when the Dust Bowl of the 1930s was created by bad farming practices and overgrazing. Land can bounce back with the correct intervention, like growing and rotating an appropriate succession of crops or, with luck, by a rainy season. But desert can also spread. For example, the Gobi Desert in China is getting larger every year by 1,300 square miles because of overgrazing and deforestation in the surrounding areas. Global warming continues to speed the process of desertification worldwide.

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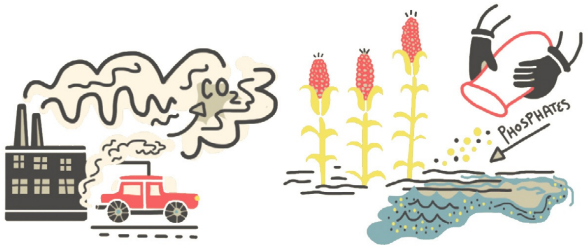
## POLLUTION




We have all seen someone throw trash out of their car window or drop litter on the sidewalk. Although this is annoying, the most harmful type of pollution comes from chemicals that are overabundant or in the wrong place. When chemical compounds, both naturally occurring and synthetic, are overused or disposed of in the wrong way, they can wreak havoc on our ecosystems.

There can be too much of a good thing. For example, phosphorus and nitrogen are necessary for plants to grow, and we depend on chemical fertilizers that include these nutrients for large-scale farming. But our overuse of these fertilizers has caused agricultural runoff, which has polluted the groundwater in the Mississippi basin. All of that water flows into the Gulf of Mexico, where the excess chemicals cause an extreme algae bloom, which uses up most of the oxygen in the water. Low-oxygen water can't support life, and every year, this pollution creates a "dead zone" the size of New Jersey where no marine life can survive.


It's also harmful when toxic chemicals enter the ecosystem. For example, mining operations and the burning of coal release tons of mercury into the atmosphere every year. Too much mercury can cause nerve and kidney damage in humans. And certain chemicals in plastics and medications act as endocrine blockers (affecting hormones); when they are thrown away or flushed down the toilet, their harmful chemicals contaminate our water and harm fish and other water creatures.

Light and sound pollution also have a negative effect on wildlife. To see how this works, we can look at a new problem for baby sea turtles. For thousands of years, baby sea turtles have hatched on beaches at night and relied on moonlight to guide them toward the ocean. But bright lights from beachfront towns confuse many turtle hatchlings, making them follow electric lights away from the ocean. Many towns turn off their lights during turtle hatching seasons, but in the places that don't, entire generations of turtles have been lost. Sound pollution also confuses animals and cuts off their communication with each other during important mating seasons. There have even been extreme cases of submarine sonar causing hearing loss in whales, destroying their ability to navigate the ocean.

# CLIMATE CHANGE

The earth's climate has changed a lot over 4.5 billion years. Before human beings even existed, the earth experienced at least five Ice Ages and warmings due to small changes in its orbit. Since the last Ice Age, Earth has had a climate ideal for supporting human life. But now, a new type of climate change threatens our existence, and it's not due to the shifting of Earth's position in relation to the sun—it is because of humanity's own actions. The excessive burning of fossil fuels is causing the climate to warm, and the effects will devastate the planet we call home.

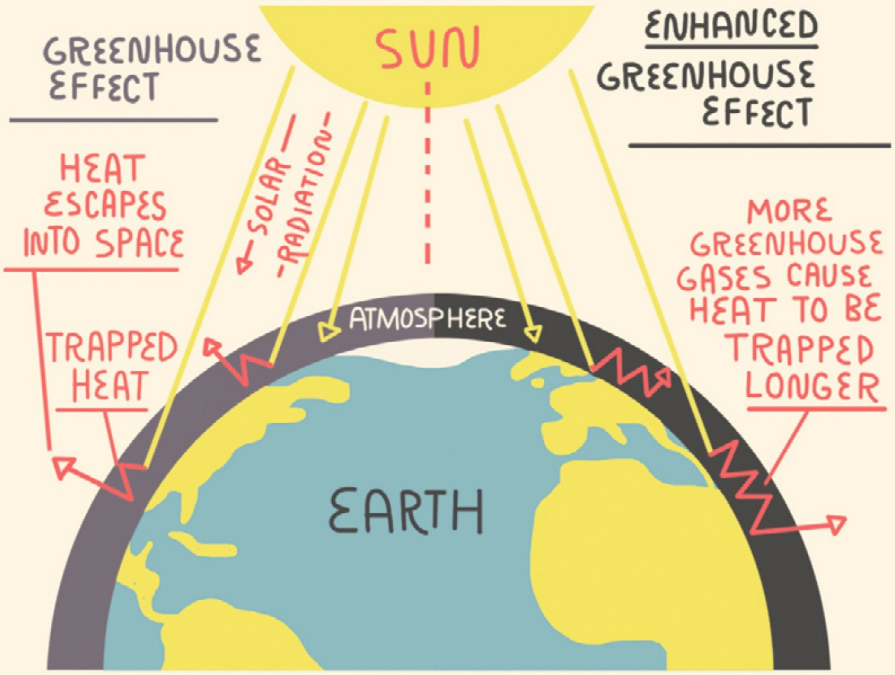
Since the Industrial Revolution, humans have made wonderful advances in technology, but we have also increased our use of energy. Right now, humanity's main sources of fuel are coal, gas and other fossil fuels that are burned to release energy. When they are burned, they rapidly release carbon dioxide and other greenhouse gases that pollute the atmosphere. The cycling of carbon is a natural process in our ecosystems, and carbon has many natural reservoirs, like forests and underground rocks. But we are releasing too much carbon at a faster rate than our carbon reservoirs can absorb. That means that these greenhouse gases linger and build up in our atmosphere and oceans. These greenhouse gases over-insulate our planet, trapping the sun's heat much longer than is normal before it escapes back into space. This trapped heat raises global temperatures.

Scientists measure global climate of the past by looking at ice cores, fossils, sedimentary rocks, and tree core samples. Satellites orbiting the planet and a network of sophisticated scientific instruments on earth are used to measure recent climate change. Our planet's temperature has raised approximately two degrees Fahrenheit over the past 100 years, and most of that change has happened in the past few decades. Two degrees may seem small, but measuring climate over a long period of time is different than measuring the daily temperature. The difference between the climate of the last Ice Age—when the United States was covered in 3,000 feet of ice—and today is less than nine degrees Fahrenheit in total. By measuring the climate in recent years, scientists have seen a pattern of

longer and hotter summers. Extremely cold winter days are less frequent and the number of extremely hot days per year is increasing. For the past decade, we have had some of the hottest years for the global temperature in human history.

The overwhelming majority of scientists agree that global warming is caused by human activity and the burning of fossil fuels. As the global climate continues to rise at this rapid rate, scientists predict that in the next century there will be more frequent natural disasters and many inhabited parts of the earth may become too extreme for human life. But there is hope! If humanity works together to reduce the amount of greenhouse gases in the atmosphere, we can slow down and maybe even stop the negative effects of global warming. By changing how we use our resources, we can give people and the planet more time to adapt to our changing climate.

# THE GREENHOUSE EFFECT AND GLOBAL WARMING




ATMOSPHERIC GREENHOUSE GASES TRAP THE SUN'S HEAT, WARMING THE EARTH. EXCESS GREENHOUSE GASES RAISE GLOBAL TEMPERATURE DRAMATICALLY.

GREENHOUSE GASES INCLUDE CARBON DIOXIDE ($CO_2$) METHANE ($CH_4$), NITROUS OXIDE ($N_2O$), HALOCARBONS, OZONE, AND WATER VAPOR.

## A RISE IN SEA LEVELS

As glaciers and sea ice melt, more water is released into the ocean. For the past twenty years, sea levels have been rising at a rate of about three millimeters per year. That may seem small, but the ocean is enormous, so it takes a *lot* of water to make the *entire* ocean rise three millimeters! The rise in sea levels has already caused erosion, storm surges, and flooding in coastal cities. If this continues, it could lead to even larger problems, and possibly the total flooding of low-lying coastal cities.

## THE ACIDIFICATION OF THE OCEAN

Excess carbon dioxide has nowhere to go but the surface of the ocean and into the air, causing the ocean's acidity to increase. In the past 200 years, the ocean's acidity level has risen by 30 percent, the fastest rate seen in the past 50 million years. Many marine animals, including coral reefs, cannot survive this change.

## EXTREME WEATHER

A warmer climate means that more water evaporates from the ocean, creating more intense rainstorms. Warmer oceans also mean that hurricanes can grow much larger and travel much farther than they previously could. Meanwhile, the warmer climates cause dry parts of the

world to become drier, which means more frequent and extreme droughts and larger forest fires.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## MELTING OF THE POLAR ICE CAPS

One of the clearest indicators of global warming is the melting of the polar ice caps and surrounding permafrost. We depend on those ice caps to reflect the sun's heat back into space and ultimately cool the entire planet. Melting sea ice is the largest contributor to higher sea levels.

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## THE EXTINCTION OF CERTAIN SPECIES


As extreme changes in the environment continue, not all plant and animal species will be able to adapt quickly enough to survive. Right now, cold weather animals continue to migrate in search of their shrinking natural habitats. Some animals, like polar bears, who live on sea ice, may eventually lose their habitat completely. Deserts are getting hotter and harsher, and with an increase in dust storms and evaporation, animals are being pushed farther to *the* deserts' edges. All over the world, animals are migrating to escape the effects of global warming.

# PROTECTING OUR PLANET

Truly seeing and understanding our world is the first step to protecting it. In this book, you have learned about ecosystems all over the world, why they are important, and how they are at risk of being destroyed. You have seen how mountains are connected to rivers and oceans, why forests are important to the atmosphere, and how the faraway ice caps keep our whole planet cool. The natural world and its wildlife provide us with irreplaceable benefits. With a new understanding of our earth, we can begin to protect it. As the great conservationist Jane Goodall said, "Only if we understand, will we care. Only if we care, will we help. Only if we help shall all be saved." There are many things we can do to preserve the natural world. Never forget that you have the power to protect our planet!

## EDUCATE

We need to understand how our ecosystems work in order to protect them. Share what you have learned!

## REDUCE YOUR CARBON FOOTPRINT

Use less fossil fuel and coal energy in daily life. Use less electricity! Drive your car less! Use less plastic!

## VOLUNTEER!

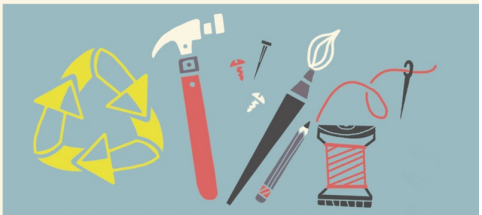
Conservation groups need your help.


## ALTERNATIVE ENERGY

To reduce greenhouse gas emissions, we need to change and diversify the types of energy we use.

## PLANT TREES

Our trees and forests filter greenhouse gases and create oxygen.



## RECYCLE AND REUSE

Don't just throw away broken things. Repair them or turn them into something new!


## ZERO LANDFILL WASTE

Recycling in your home is great, but to have a larger impact it needs to happen on a bigger scale. Help create systems for everyone to compost and recycle where you work or go to school.

## SUSTAINABLE FARMING

The huge and growing human population will always need large-scale farming, but with a knowledge of ecology, biology, and economics, we can invest in making large-scale agriculture profitable and healthy for the whole world!


## PROTECT WILDLIFE

To preserve important ecosystems, we need protected areas of natural wildlife.

## HOW WE DO BUSINESS

Often, clothes, electronics, and other products are created to be thrown away and replaced. This is a waste of valuable resources. Instead, demand and buy products that are created to last a long time and can be repaired!


## FIGHT POVERTY

When people in poverty have few options, they can turn to illegal poaching, lumber exploitation, unsustainable farming and herding, and dangerous mining. We cannot expect poor people to shoulder the responsibility of saving the planet when their communities are worried about providing for themselves. By addressing the underlying problems of poverty, we can all find a way to live, survive, and thrive without harming our planet.

## EAT LESS MEAT

It takes more energy and resources to raise livestock than to grow crops. Reducing your meat and fish consumption helps the whole world.

## SUSTAINABLE FISHING

Our entire world depends on our marine ecosystems. We need to end overfishing and only fish responsibly.


Fresh water is a limited resource, and it's scarce in many parts of the world. Using less water also leads to less runoff and waste water dumped into the ocean.

## REGULATIONS

We need to create and enforce regulations that prevent farms and factories from polluting our streams, oceans, and air.


Get out there and demand the change you want to see in the world.

# GLOSSARY

## ABIOTIC

Parts of an ecosystem that are not made up of biological organisms. Air, soil, rocks, weather, water, nutrients, and molecules are all considered abiotic. They are not, and have never been, alive.

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## ALGAE

A type of plant that does not flower and has no real roots, stems, or leaves. Often refers to microscopic, single-celled marine plants, but also includes certain types of seaweed like giant kelp that can grow to lengths of 50 meters.

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## APEX PREDATOR

An animal on the very top of the food web, which has no predators. Many think that human beings are the top apex predator of the world.

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## ARCHAEA

A single-celled organisms with no cell nucleolus and a slightly different structure than bacteria. Can be found in human intestines and marshes but also in extreme conditions like super-acidic water and hot underground vents.

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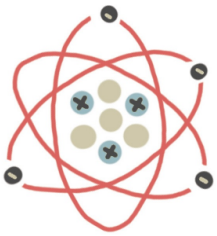
## ATOM

The smallest unit of matter. Different types of atoms come together to make molecules. Atoms of the same kind come together to create elements. Everything in the known universe is made up of atoms.



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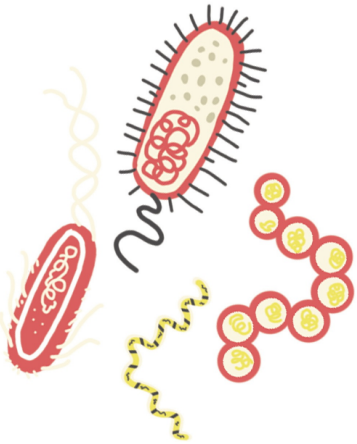
## BACTERIA

A type of single-celled microscopic organism found everywhere. They are instrumental in the breakdown of decomposing organisms and the cycling of nutrients through our ecosystem, and we depend on them to live. They can be harmful, causing disease, but also useful, in making cheeses, wine, and medicine!



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## BIG BANG

A theory of how the universe began. Many scientists theorize that billions of years ago there was nothing but an infinitely small and dense point called a singularity. This exploded, creating all of the atoms and matter in the universe.

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## BIODIVERSITY

When many different types of animal and plant species live in a particular ecosystem or habitat. Biodiversity is essential to the overall health and resilience of an ecosystem. Only through biodiversity can ecosystems adapt to change.

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## BIODIVERSITY HOTSPOT


An ecosystem or region with a significantly high amount of biodiversity that is also currently under threat of being destroyed. By identifying these regions, ecologists hope to intervene to protect them before it is too late.

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## BIOME

Areas on Earth that have similar climates, plants, and animals. Biomes are defined by their average precipitation rates and temperature. For example, very cold, dry areas are considered tundras, while very hot, wet places are considered tropical rainforests.

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## BIOTIC

The parts of an ecosystem that are made from living or formerly living organisms. Plants, animals, and bacteria—alive or dead—are all biotic. For example, a rotting log is considered biotic, and so is a chair made from dead wood.

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## CARBON FOOTPRINT

The amount of carbon dioxide and other fossil fuels created by the actions of a particular person or group of people. You can calculate your own carbon footprint by adding up the total amount of fuel used to heat your home, produce the food you eat, drive, fly, and so on.

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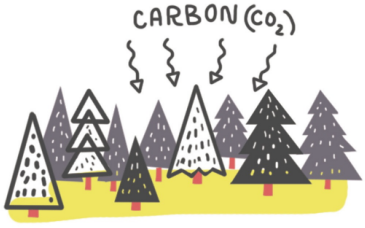
## CARBON SINK

A natural part of our environment that absorbs and stores massive amounts of carbon from the atmosphere. Large forests and parts of the ocean are considered carbon sinks.

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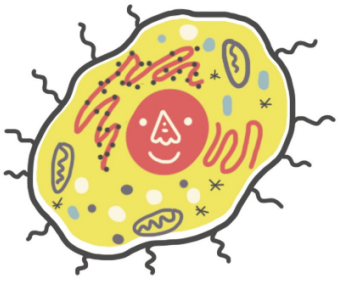
## CELL

Cells are the smallest unit of living organisms. They can form an entire single-celled organism or can be components of the tissue that makes up plants and animals.



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## CLIMATE

The regular, prevailing weather and temperature conditions of an area over a long period of time. Climate is not the same as weather. Weather refers to what happens at a specific time, or from one day to the next, while climate refers to the average temperature and weather conditions through the seasons.

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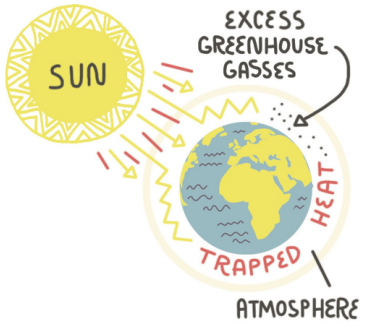
## CLIMATE CHANGE

Specifically refers to the rapid increase in global temperatures the earth has been experiencing, starting in the nineteenth century to now. It is the result of an increase of carbon dioxide and other greenhouse gases in the atmosphere from the burning of fossil fuels.

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## COMMUNITY

All of the living or biotic parts of an ecosystem and how those animals, plants, fungi, and bacteria interact with each other.

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## DEFORESTATION

The removal of a large number of trees or even entire forests in order to use the land for other purposes. Often forests are cleared for farmland or urban development.

---

## DESERTIFICATION

The process wherein previously fertile land becomes a desert, a biome with little to no precipitation and not many plants. Forests and grasslands can turn into deserts through a combination of drought, unsustainable farming, and deforestation. Usually results in "soil death."

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## DEVELOPMENT

The process of people building up areas like cities, towns, or agricultural centers and the infrastructure that supports them, like roads, dams, plumbing, and electrical transmission lines.

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## ECOTONE

The space between major ecosystems where they blend together; for example, the area where the edge of a forest meets a grassland. Ecotones have

their own characteristics and are important for specific animal activity and protecting core ecosystems.

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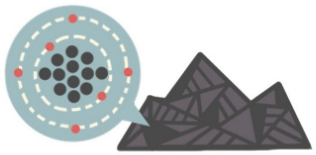
## ELEMENT

A substance made up of only one type of atom.



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## ENDANGERED SPECIES

A species of animal or plant that is in danger of going extinct.


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## EROSION

The process of wind, water, or other natural forces breaking down something over a period of time. For example, the ocean waves hitting the shore can erode the coastal rock over time.

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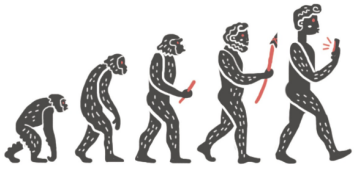
## EVOLUTION



The process by which new species are created through mutations in their genes at birth. Mutations can be beneficial, neutral, or negative, but they must be passed down to the next generation to create a change in the species. Over a long period of time these mutations can add up—for example, enabling humans to walk upright. This explains why we are so different from our ancient ancestors.

---

## EXTINCTION

Event when an entire species dies out and no longer exists. The dodo bird was hunted to extinction in 1662; more recently, the West African black rhinoceros was declared extinct in 2011. Today, many animals are

endangered—at risk of extinction—due to climate change, illegal hunting, and habitat loss.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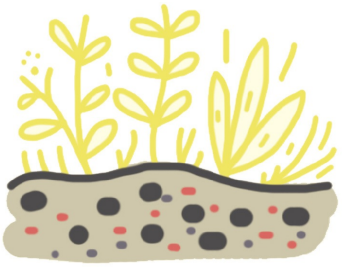
## FERTILE

A quality of soil that is capable of producing vegetation. It is rich in the nutrients plants need and has no toxic substances that prevent plants from growing.



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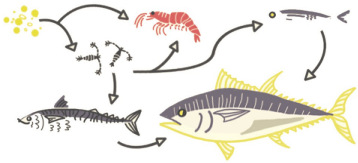
## FOOD WEB

The mapping of the flow of energy through an ecosystem: who eats what, and who gets energy from whom.



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## GREENHOUSE GASES

Gases like carbon dioxide, water vapor methane, ozone, and fluorocarbons, which absorb heat and solar radiation. Greenhouse gases occur naturally and are also a byproduct of burning fossil fuels like coal and petroleum. The rapid release of these greenhouse gases caused by human activity has accelerated global warming resulting in climate change.


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## HABITAT

The natural home of a living organism.

---

## INVASIVE SPECIES

A nonnative plant, animal, bacteria, or fungus that is introduced into a new ecosystem, often to the ecosystem's detriment. Invasive species usually harm an ecosystem by outcompeting other species for resources like food, sunlight, and space.


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## KEYSTONE SPECIES

A plant, animal, bacteria, or fungus that an entire ecosystem depends on. If a keystone species is removed from an ecosystem, the whole community could collapse.


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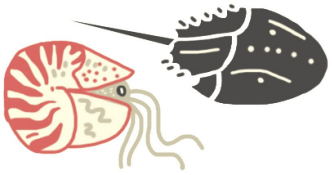
## LIVING FOSSIL

An animal or plant species that has been around for a very, very long time. Close relatives of the species are usually all extinct.



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## MATTER

Matter is made up of atoms and molecules and comprises everything around us. Matter cannot be created or destroyed, only rearranged. Matter cycles through ecosystems through many processes like eating and decomposing.



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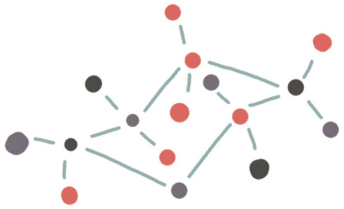
## MOLECULE

Atoms come together to form molecules. For example, carbon and oxygen are both atoms. One carbon and two oxygen molecules come together to create carbon dioxide ($CO_2$).



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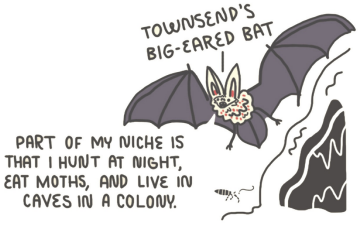
## NICHE

How a certain plant, animal, or other living thing fits into its ecosystem. What is the organism's behavior? What job does it do? What resources does it need for survival? These special roles define its niche.

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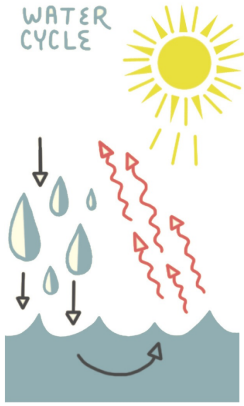
## NUTRIENTS

Vitamins, minerals, and other substances necessary to support life. Carbohydrates, fats, proteins, carbon, and water are just some of the many nutrients humans need to survive.


---

## NUTRIENT CYCLE

The movement of organic and inorganic matter through an ecosystem to be used by living things. Nutrients are necessary for living things to grow and repair their bodies. These nutrients return to the soil and air through life processes like breathing, pooping, and eventual decomposition after death. The carbon cycle and the phosphorus cycle are two examples of nutrient cycles.

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## ORGANISM

An individual living thing. A plant, animal, single-celled life form, even you

—all are organisms.

## PHOTOSYNTHESIS

The process whereby plants turn sunlight into food. Sunlight energy combines with carbon dioxide and water to form a sugar called glucose (food!). The excess "waste" from this process is oxygen, which plants release into the atmosphere.



## PHYTOPLANKTON

Microscopic plants found in water; the basis of almost all marine ecosystems.

## POLLUTION

When a harmful substance is put in the wrong place and/or in the wrong quantity and has a harmful effect on the environment.

## POPULATION

A group of a certain species that live in the same place. People count the population to know how many animals, plants, or people occupy an area. For example, there is a population of about 54,453 people living in Timbuktu, Mali.

## PRECIPITATION

Water vapor that has condensed to fall to earth as rain or snow. When talking about whether a region is wet or dry, we are describing how much precipitation, or rainfall, the place gets.

---

## PRIMARY CONSUMERS

Animals that get their energy directly from feeding on plants. They are usually the second trophic level in a food web.


---

## PRODUCERS

Plants that get their energy (and "food") directly from the sun. They are the first trophic level in a food web.

---

## RESERVOIR

A deposit of stored resources. A frozen glacier or lake is a reservoir for water. Underground rock sediment is a reservoir for phosphorus. The atmosphere is a reservoir for oxygen.


---

## SOIL DEATH

Soil that has been depleted of nutrients. This happens when land is overused and nutrients are removed from the soil faster than nature can replenish them. It is usually

associated with overgrazing or depleting the soil with one kind of crop.

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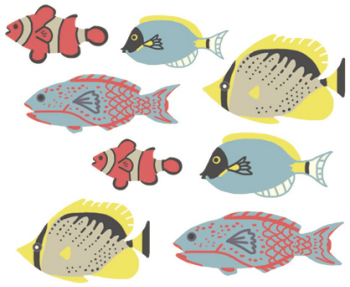
## SPECIES EVENNESS

A measure of how biodiverse and how equal in population species are at each trophic level. It is key to understanding the health of an ecosystem, the ratio between living things competing for the same resources, and the ratio between predator and prey.



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## SUCCESSION

The process of change that happens in an ecosystem over time. Biodiverse ecosystems can adapt to changes that happen to the land.

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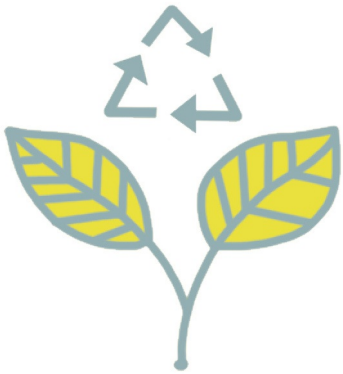
## SUSTAINABLE

Term for use of the earth's resources without destroying or depleting them. Sustainable use allows our natural resources to replenish themselves for the next generation.



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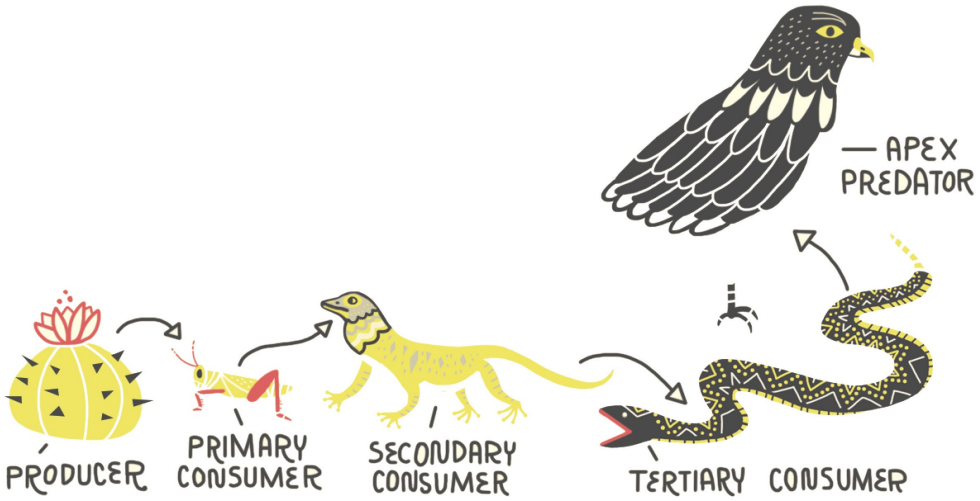
## TROPHIC LEVELS

The hierarchy of how energy flows through an ecosystem, starting with plants (producers) and ending with the apex predator. Shows who eats whom and who is eaten by whom. The number of levels can change depending on the ecosystem.

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## WEATHER

The state of the atmosphere at a specific time. It could be sunny, cloudy, rainy, dry, or other states. Weather is informed by the climate. While climate refers to averages over long periods of time, weather can change from day to day, hour to hour, or even minute to minute in some places!

---

## ZOOPLANKTON

Tiny microscopic animals found in water. Usually they are the secondary consumers in a marine food chain and eat phytoplankton.

# SOURCES

Throughout the writing of this book, I read books and scientific articles and watched documentaries and videos. I visited national parks and even traveled to the UN to talk to program consultants for the Equator Initiative. The following are a few of the sources I used. I hope you take the time to read, watch, and learn some more about our wonderful world!

For a complete bibliography, please visit my website at rachelignotofskydesign.com/the-wondrous-workings-of-planet-earth.

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Equator Initiative: www.equatorinitiative.org

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# ACKNOWLEDGMENTS

I want to give a huge thank-you to everyone who helped me with the research, writing, and creation of this book. Your support means the world to me!

First, I want to thank my extraordinary editor empress, Kaitlin Ketchum! Her belief in this project and her passion for publishing educational books makes my work possible. Thank you so much for all of your insight, support, and amazing edits!

A huge shout-out to the rest of my Ten Speed team and their incredible skills. A big thank-you to my always posh and on point publicity and marketing team—Daniel Wikey and Erin Welke—for getting these books out there! Thank you to Kristi Hein for copyediting and spell checking! My books look as good as they do thanks to the production wizardry of Jane Chinn and talented typesetting stylings of my designer, Lizzie Allen.

Thank you to my agent, Monica Odom, for always having my back and being the all-time lady boss, helping me make all my book fantasies become reality.

A special thank-you to Eva Gurria, Martin Sommerschuh, and Natabara Rollosson for meeting with me at the United Nations and sharing their work and stories from the Equator Initiative with me.

Thank you to my dear friend, Aditya Voleti, for help fact checking and midnight walk-and-talks. A huge I love you to my husband, Thomas Mason IV. His help with fact checking, feeding me, and being my ultimate cheerleader has helped to make this book and my life wonderful. And one last huge thank-you to my family for all their Ignotofsky love and encouragement.

# ABOUT THE AUTHOR

Rachel Ignotofsky is a *New York Times*–bestselling author and illustrator. She is the author of *Women in Science: 50 Fearless Pioneers Who Changed the World* and *Women in Sports: 50 Fearless Athletes Who Played to Win*. With this book, she wants to introduce readers to the exciting world of nature, ecology, and conservation!

Her work is inspired by history and science. She believes that illustration is a powerful tool that can make learning exciting. Rachel hopes to use her work to spread her message about scientific literacy and feminism.

You can find her on Instagram @rachelignotofsky an online at rachelignotofskydesign.com.

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