RAINFOREST BIODIVERSITY

A SCIENCE 3D ADVENTURE

MIDDLE SCHOOL

By MIKE HEITHAUS Ph.D

symbio education™

KEY WORDS

ABIOTIC CONDITIONS

ARBOREAL

ATMOSPHERE

BIODIVERSITY

BIOSPHERE

BIOTIC CONDITIONS

CELLULAR RESPIRATION

CONSUMER

DECOMPOSER

ECOSYSTEM RESILIENCE

ELECTROMAGNETIC RADIATION

ENZYME

FOOD WEB

HYDROSPHERE

LITHOSPHERE

NATUAL RESOURCES

NICHE

PHOTOSYNTHESIS

PRODUCER

SYMBIOSIS

TERRESTRIAL

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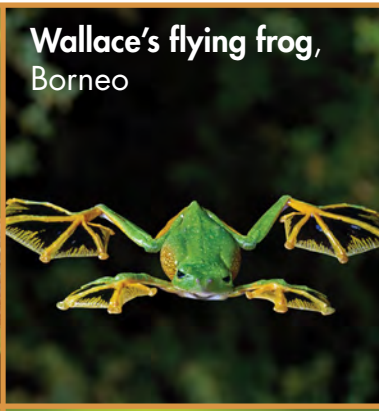
TEEMING WITH LIFE

Rainforests are home to millions of species. Think about this: one hectare (0.01 km^2) of rainforest can have more species of trees than are found in the almost 20 million km^2 of Canada and the continental United States combined! Scientists are still uncertain how many species of plants and animals live in the rainforest because new species are discovered and described by scientists all the time!


Honduran white bat, Honduras


Blue morpho butterfly, Costa Rica


Wallace's flying frog, Borneo


White-collared manakin, Costa Rica


Coatimundi, Costa Rica


Coral snake, Costa Rica


Tamandua, Costa Rica


Mushroom-tongued salamander, Belize


Cup fungus, Costa Rica

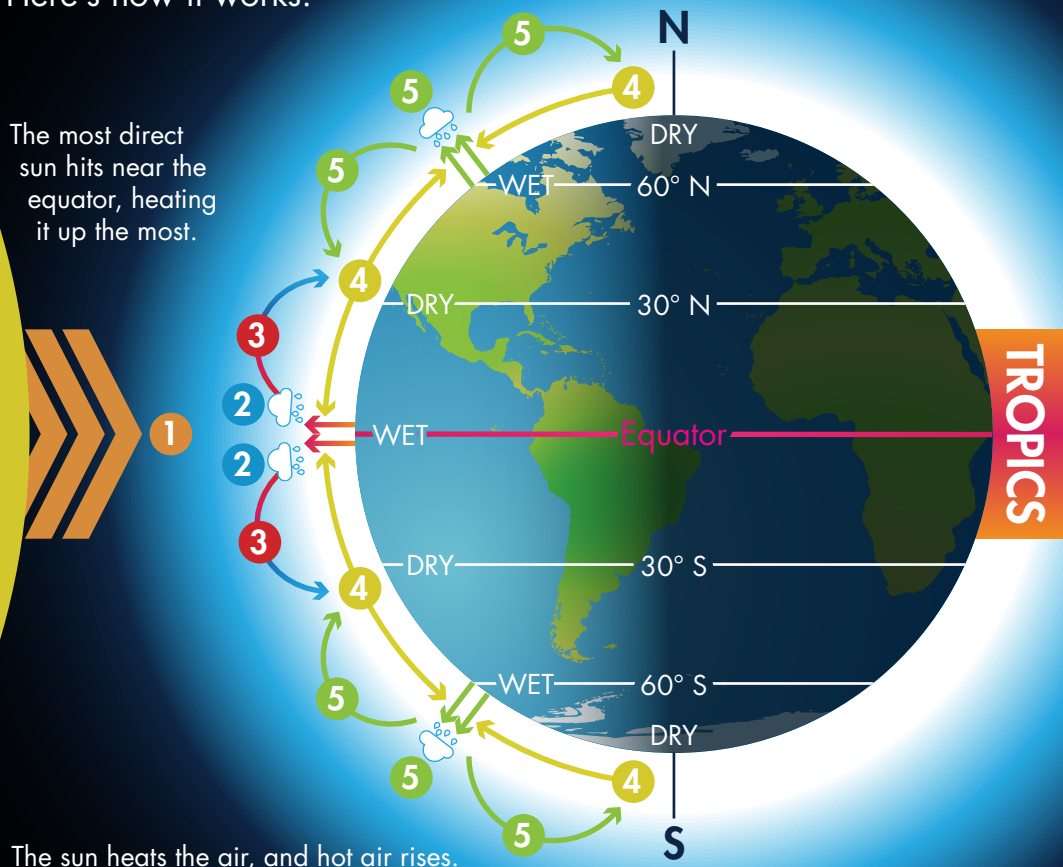
Biodiversity is a measure of the number of species in a particular area. There are many reasons biodiversity can differ across places. For example, in the tropics there are more available **niches**, or roles, for species. Also, some scientists think that enemies of plants in the tropics, like insects that feed on them, prevent any one species from dominating over others.

Biodiversity is important. High biodiversity allows ecosystems to bounce back from challenges. **Ecosystem resilience** is the ability for them to recover from disturbances. If biodiversity is lost, key species might disappear and ecosystems might lose some of their functions. Without important species or functions, ecosystems might never recover from certain disturbances! Think of an ecosystem as a tower of blocks. If you start pulling blocks out (or removing species and functions), eventually the whole tower (or ecosystem) will fall down and no longer exist. Because of its importance, biodiversity can be used to measure the health of an ecosystem.

Why does biodiversity matter? Imagine if the species that is needed to pollinate a flower disappeared. What would happen to the population of the plants that rely on the pollinator? If the pollinators rely on the plant for food, what would happen to their populations if the plant disappeared? Now think about what would happen to the animals that rely on the fruit from that plant for food.

WHERE IS THE RAIN?

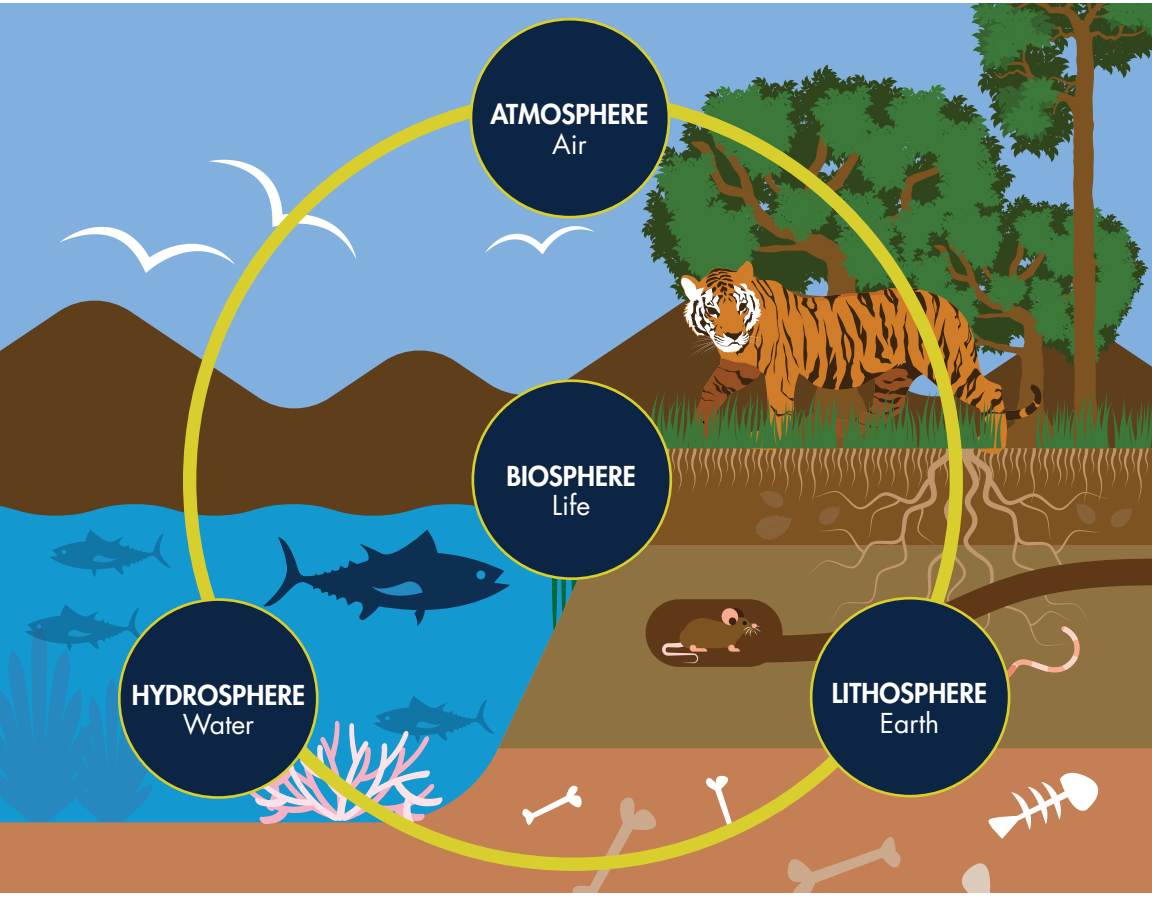
Tropical rainforests are found near the equator in Central America, South America, Africa, Asia, and Australia, where it is hot and there is plenty of rain. Rainforests cover about 8% of the Earth's land surface, but they are home to more than 50% of the **terrestrial** species! The abundance of plant life in the rainforest allows all of those species to thrive. The plant life needs a lot of rain. Why is there so much rain in the places where tropical rainforests are found? It's all about the sun… and physics. Here's how it works:



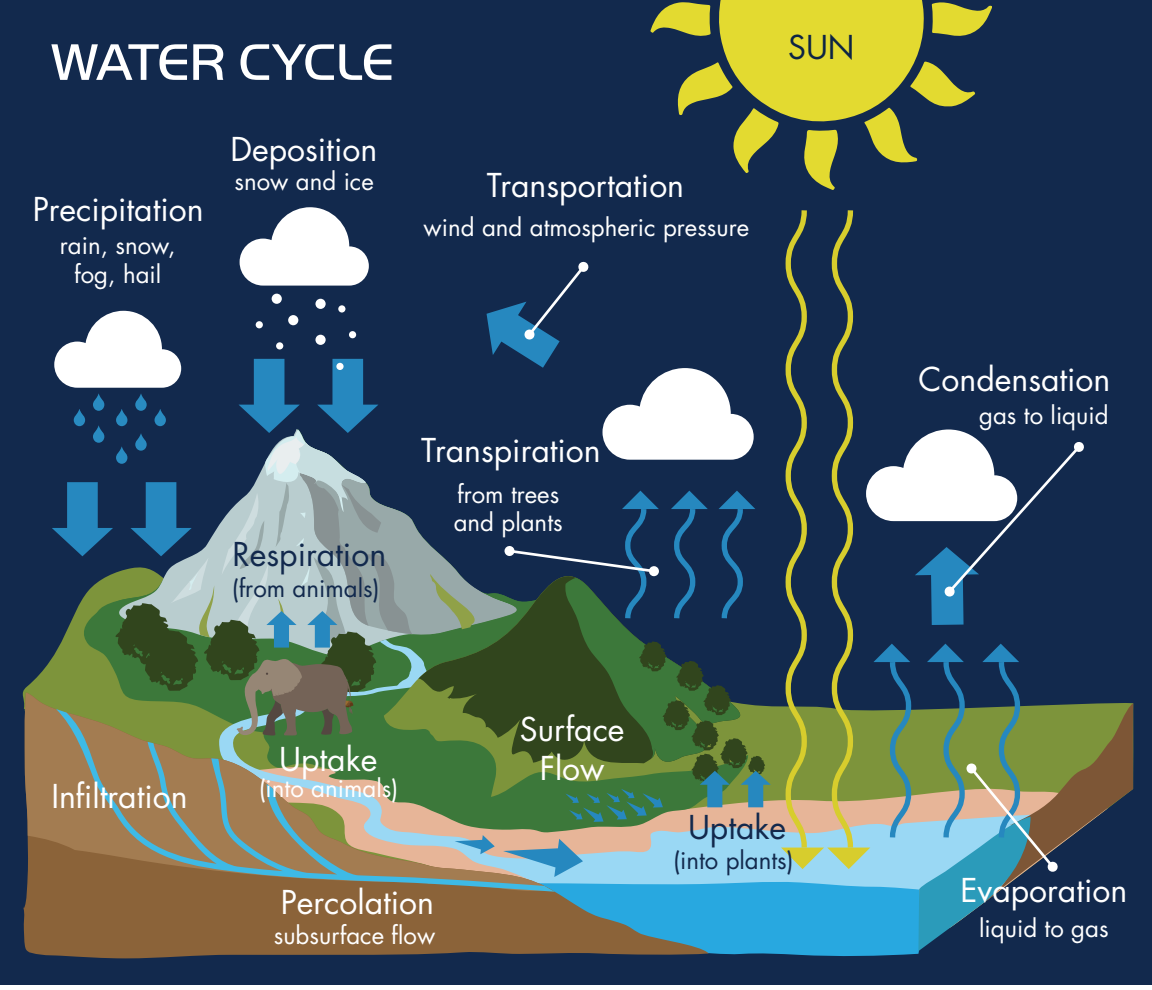
1. The sun heats the air, and hot air rises.
2. As the air rises, it cools and loses moisture as rain.
3. The cool, dry air moves north and south until it sinks back to Earth at 30° N and S.
4. Air moves across Earth to fill in places where air is rising.
5. At 60° N and S, wet air rises and drops its water as precipitation. By the time it reaches 30° N and S and the poles, the dry air sinks.

WATER, WATER EVERYWHERE

When you think about water, maybe you think about what comes out of your sink or shower. Maybe you picture rain or snow, or lakes, rivers, and oceans. You probably don't think about how water moves around the Earth. In fact, it moves among Earth's four "spheres."



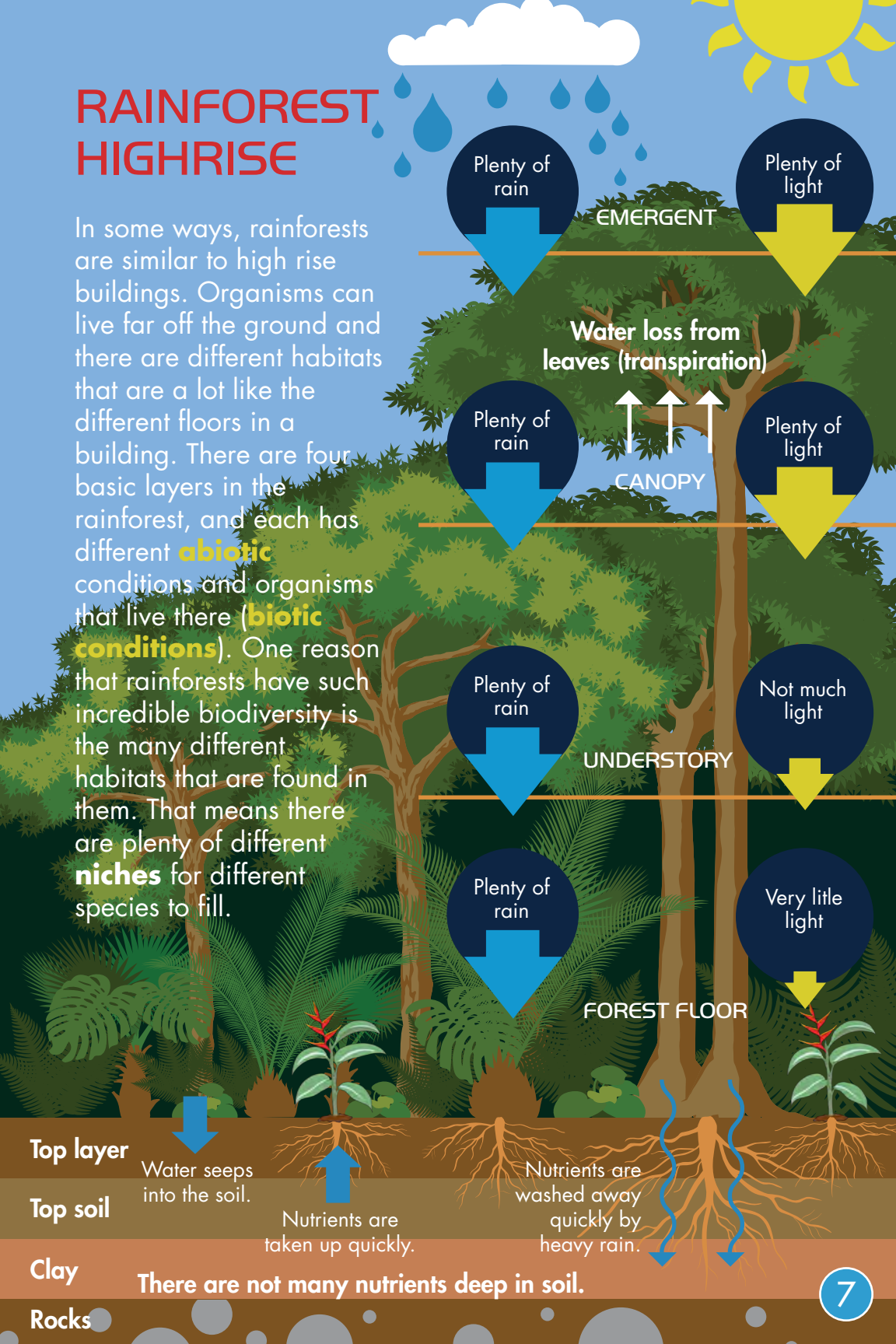
The **atmosphere** is the air that surrounds the Earth. It protects the planet from damaging radiation and traps heat. The **hydrosphere** consists of all the water on the planet, including on the surface, in the air as vapor, and running underground. The outermost layer of the Earth is the **lithosphere**. It includes the crust and upper mantle. All life on Earth is the **biosphere**.



The water on Earth has been cycling for billions of years. In fact, the water you drink today may have once been inside the body of a dinosaur! The water cycle describes how water moves through the atmosphere, lithosphere, and hydrosphere and into and out of the biosphere. Water enters the biosphere when animals drink or plants take water in through their roots. It can be lost as sweat, waste products, and water vapor exhaled during respiration. But most of the movement of water from the biosphere to the atmosphere takes place through a process called transpiration. Transpiration is when plants lose water from their leaves. In fact, they can lose 90% of their water this way! Want evidence? Seal a dry plastic bag around the leaves of a plant. The next day, open the bag. What is inside? Where did it come from?

RAINFOREST HIGHRISE

In some ways, rainforests are similar to high rise buildings. Organisms can live far off the ground and there are different habitats that are a lot like the different floors in a building. There are four basic layers in the rainforest, and each has different **abiotic** conditions and organisms that live there (**biotic conditions**). One reason that rainforests have such incredible biodiversity is the many different habitats that are found in them. That means there are plenty of different **niches** for different species to fill.



FOREST FLOOR

Height off ground: –4 m to 0 m

Light levels: none to very little

The ground is covered in leaf litter and decomposing matter. It is home to many plants and animals, including large mammals.

Soil is home to dead organisms, bacteria, fungi, plant roots and invertebrates. It may be meters deep. **Decomposers** return nutrients to the soil, but nutrients that plants need are in short supply; they are quickly used up by plants or washed away in rains.

RIVERS, LAKES, PONDS, AND PUDDLES

Height off ground: <0 m, but can flood up to 10 m above the forest floor

Light levels: a lot to very little

These bodies of water are home to many aquatic animals, fungi, plankton, and underwater plants. During the rainy season, rivers can flood into the forest, covering the trunks of trees.

UNDERSTORY

Height off ground: 0.1 m to 10 m

Light levels: low to moderate

The understory is home to many different kinds of animals and plants that don't grow tall. Most of the plants have big leaves to catch the limited sunlight that filters through the leaves of trees above them.

CANOPY

Height off ground: 20 m to 30 m

Light levels: high

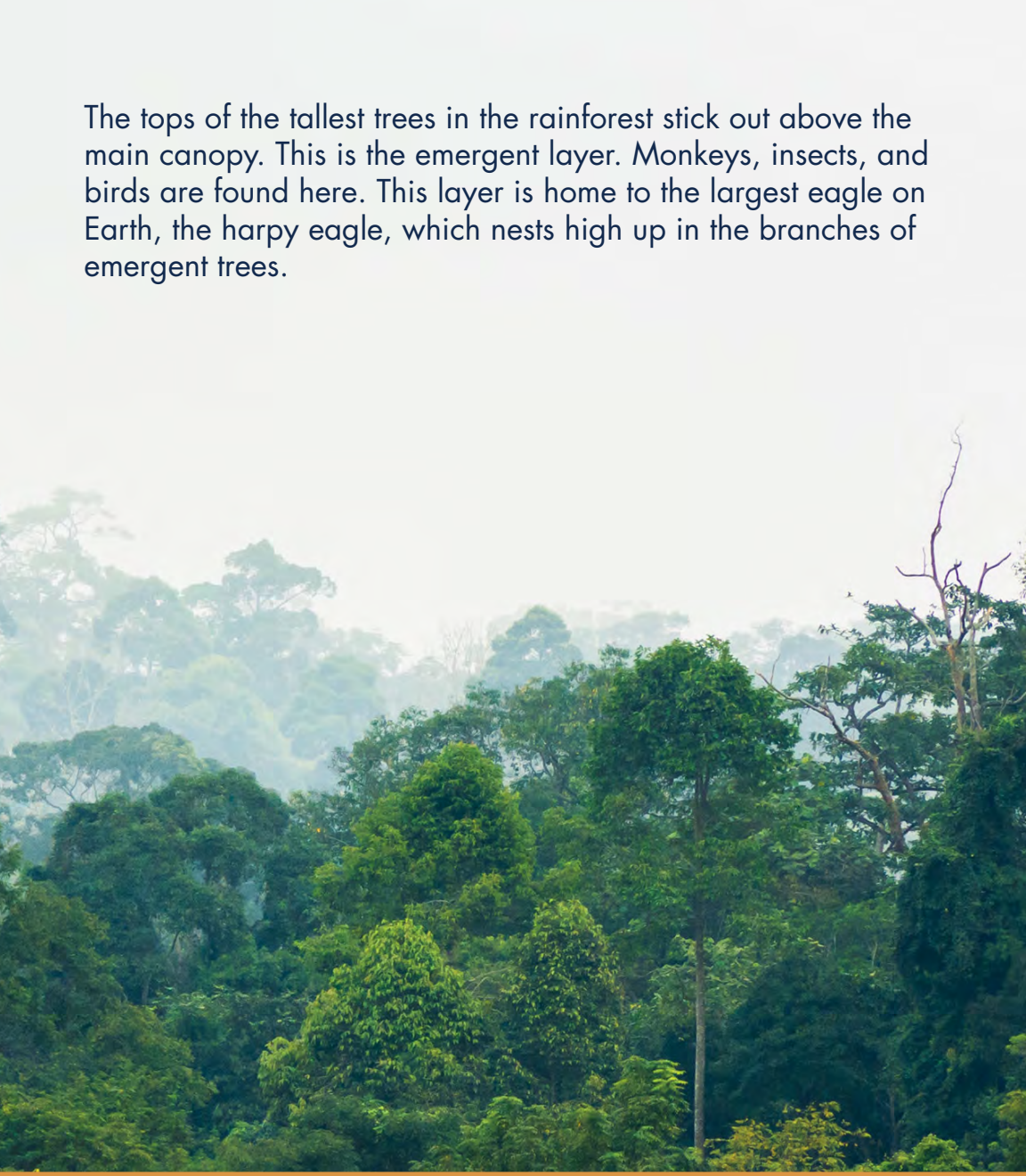
The tops of tall trees form the canopy. It is home to many flying animals, such as birds, bats and insects. Many **arboreal** mammals, including monkeys, kinkajous, and frogs live here too. There is a lot of light, so plants in the canopy only need small leaves. Small leaves help plants retain water in hot, direct sunlight. Fruits and flowers of trees are in the canopy, and the branches provide plenty of habitat for animals. Plants called epiphytes live on tree branches. Their roots never touch the ground! The canopy shades the forest floor and understory.

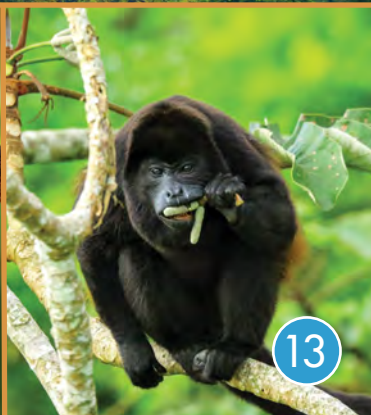
EMERGENT

Height off ground: 35 m to 45 m

Light levels: high

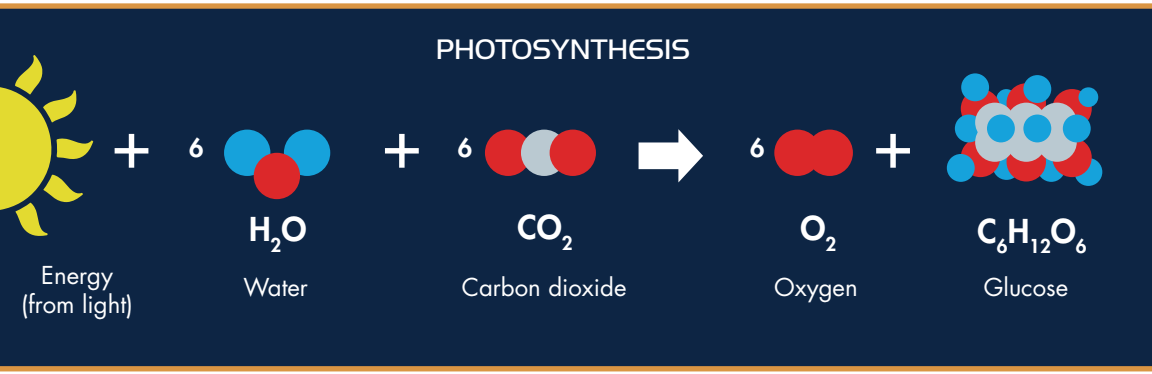
The tops of the tallest trees in the rainforest stick out above the main canopy. This is the emergent layer. Monkeys, insects, and birds are found here. This layer is home to the largest eagle on Earth, the harpy eagle, which nests high up in the branches of emergent trees.



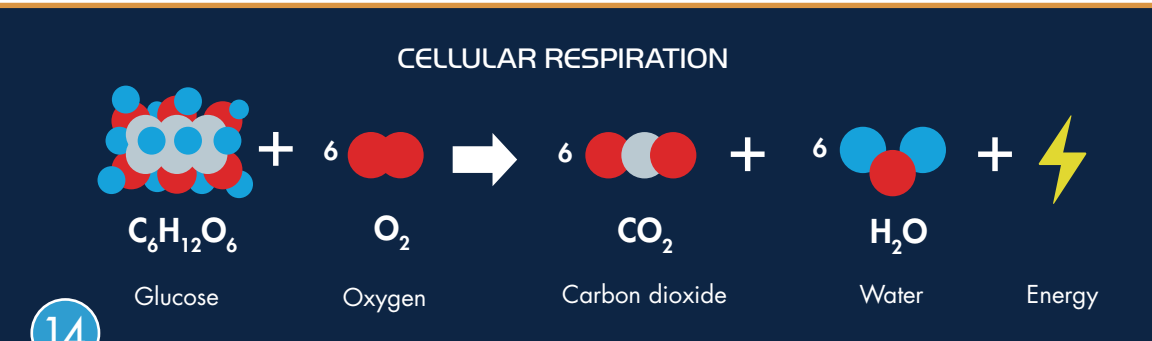


FUEL OF LIFE

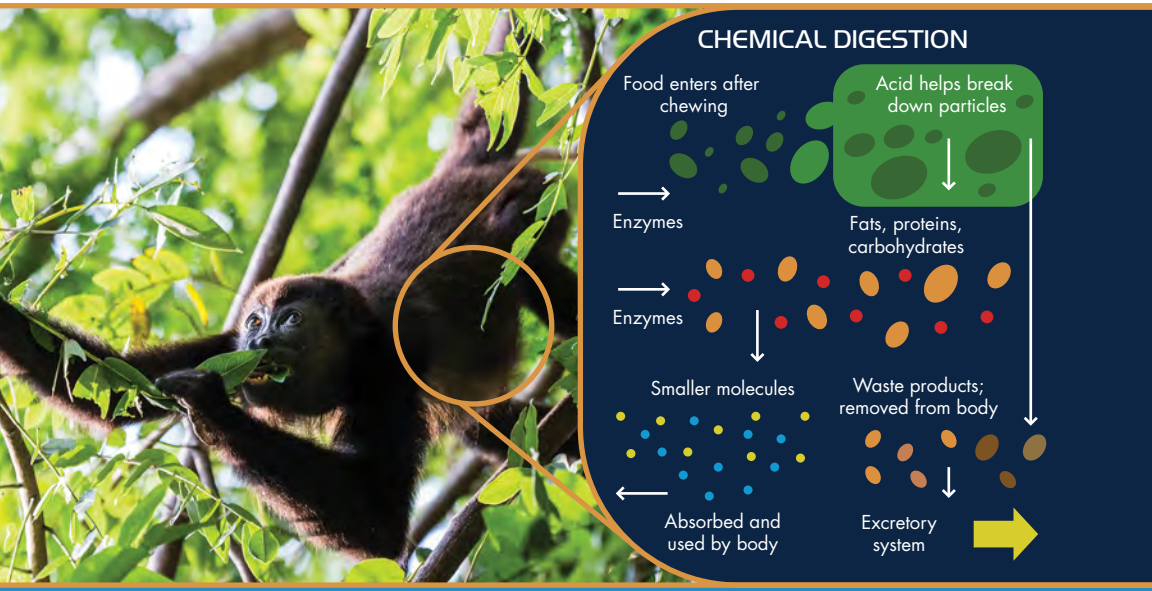
Energy in the rainforest comes from the sun. Matter comes from the air, water, and soil. Plants harness this energy and matter to create food and build their bodies through the process of photosynthesis. In **photosynthesis**, plants use energy from the sun to create a chemical reaction between water and carbon dioxide. The atoms of these compounds are rearranged to create sugars that store energy to be used later, and release oxygen as a waste product.



There are many types of chemical reactions that occur in the body as chemicals are broken apart or bonded together to be used by the body or removed. One of the most important chemical reactions is **cellular respiration**. In this chemical reaction (which occurs in plants, animals and other organisms) sugars are broken down to release energy. The energy is used to do work in the body, such as run the organ systems or move the organism around. Carbon dioxide and water are created as waste products when the sugar is broken down.



Chemical reactions are important in the breakdown of food into digestible molecules.



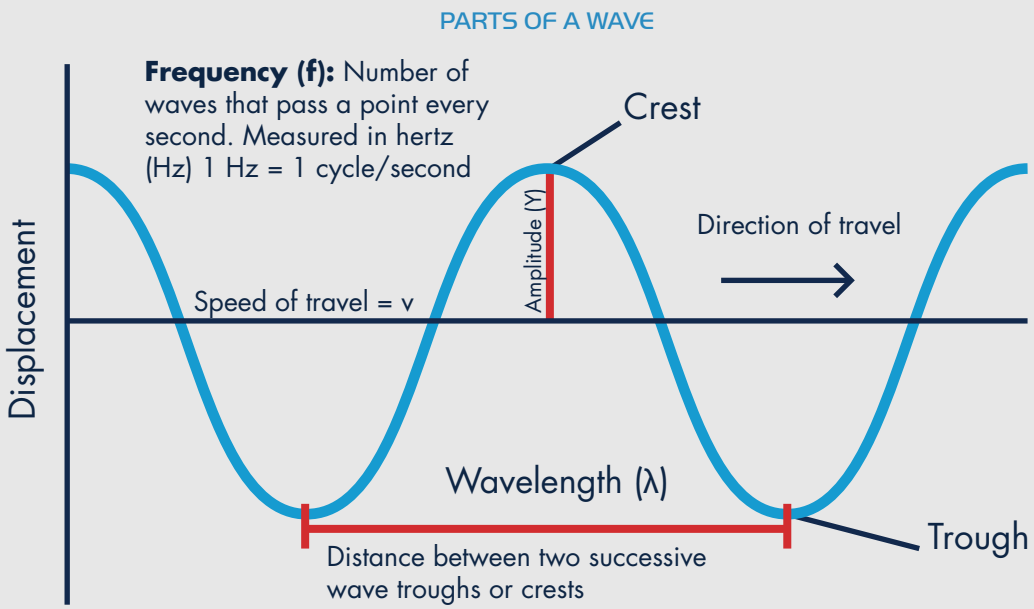
Useful molecules are absorbed and used by the body, while others are removed.

Not all food is easy to digest for animals. Predators usually have it fairly easy. Most fruits and animal matter, especially organs and muscle, break down easily. Herbivores that eat leaf matter have a more difficult time with digestion. Plant cells have compounds that are tough to break down. They also don't have as much energy as meat. Herbivores need to have special digestive systems and special **enzymes** to break down the plant material. Enzymes speed up chemical reactions that break molecules into smaller components.

ENERGY EVERYWHERE

Energy in the rainforest comes in many forms. There is the energy stored in chemical bonds in organisms. The energy in these bonds is released during cellular respiration and used to do work. Some is lost as heat. Energy in chemical bonds is transferred from one organism to another when a consumer eats its food.

Energy in the rainforest also comes from the sun that heats the land and waters. Energy from sunlight, which is a form of **electromagnetic radiation**, is used during photosynthesis. Electromagnetic radiation, like sunlight, travels in a wave that can move through a vacuum like space. How much energy the wave has depends on characteristics of the wave, including its wavelength and frequency. Wavelength and frequency are mathematically related. Waves with longer wavelengths have lower frequencies, and less energy. Here's how it works:

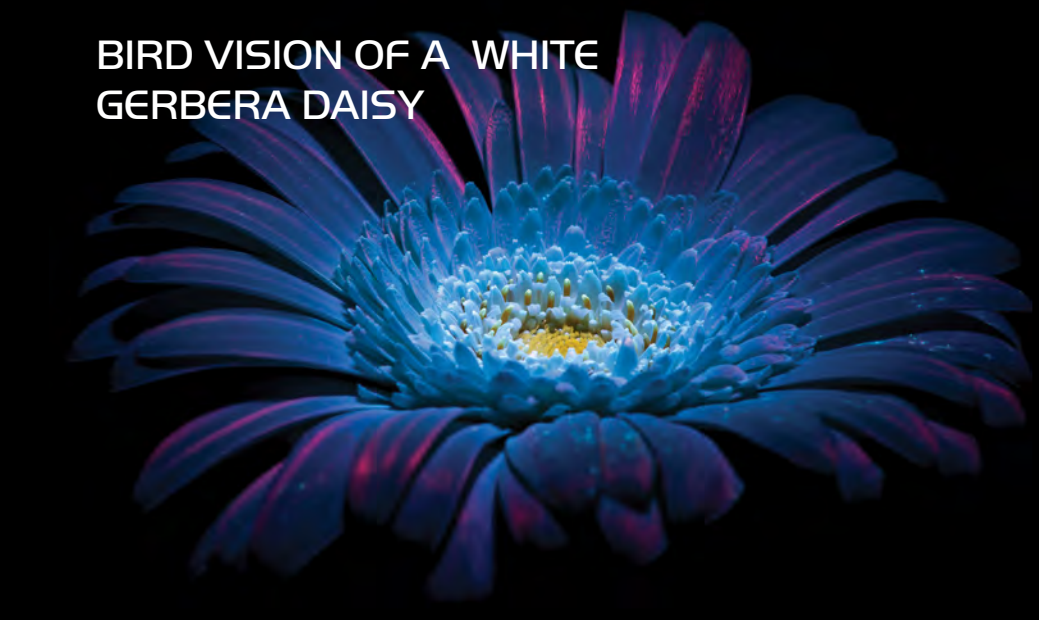


Light waves (electromagnetic radiation) travel at incredible rates. The average speed of light in a vacuum is about 3×10^8 m/s or 300,000,000 m/s. Sound waves travel 320 m/s in air, and 1,500 m/s in oceans!

Not all electromagnetic radiation from the sun is visible to humans. People can only detect certain wavelengths, called visible light. Infrared light has longer wavelengths and lower energy. Ultraviolet light has shorter wavelengths and more energy than visible light. Some insects and birds see ultraviolet light. The world looks very different to them! With bird vision, even some black objects burst with color!

HUMAN VISION OF A WHITE GERBERA DAISY

BIRD VISION OF A WHITE GERBERA DAISY



Not all waves in the rainforest are electromagnetic radiation. Sound waves transfer energy from one place to another. Like light waves, sound waves have wavelengths and frequency. Unlike electromagnetic radiation, sound waves have to travel through matter. Solids, liquids, and gasses can all transfer sound waves.

In the jungle, sound waves can be more helpful than light waves! Why? Sound waves can travel very long distances. Cicadas are one of the loudest animals in the rainforest, and howler monkeys can hear each other calling from kilometers away! Sound waves help them hear each other even if they are not within eyesight.

If you walk into a Central American rainforest, you are likely to hear both cicadas and howler monkeys before you see them. They use sound waves to communicate.

When it's difficult to see through the dense leaves in the rainforest, using sound waves to communicate and listen for danger is beneficial.

FOREST RHYTHM

The rainforest has rhythms. Chemical reactions that occur in plants can change from day to night. Flowers may open and close. There is also a rhythm to animal activity. As the day shift goes to sleep, the night shift wakes up to prowl the jungle.

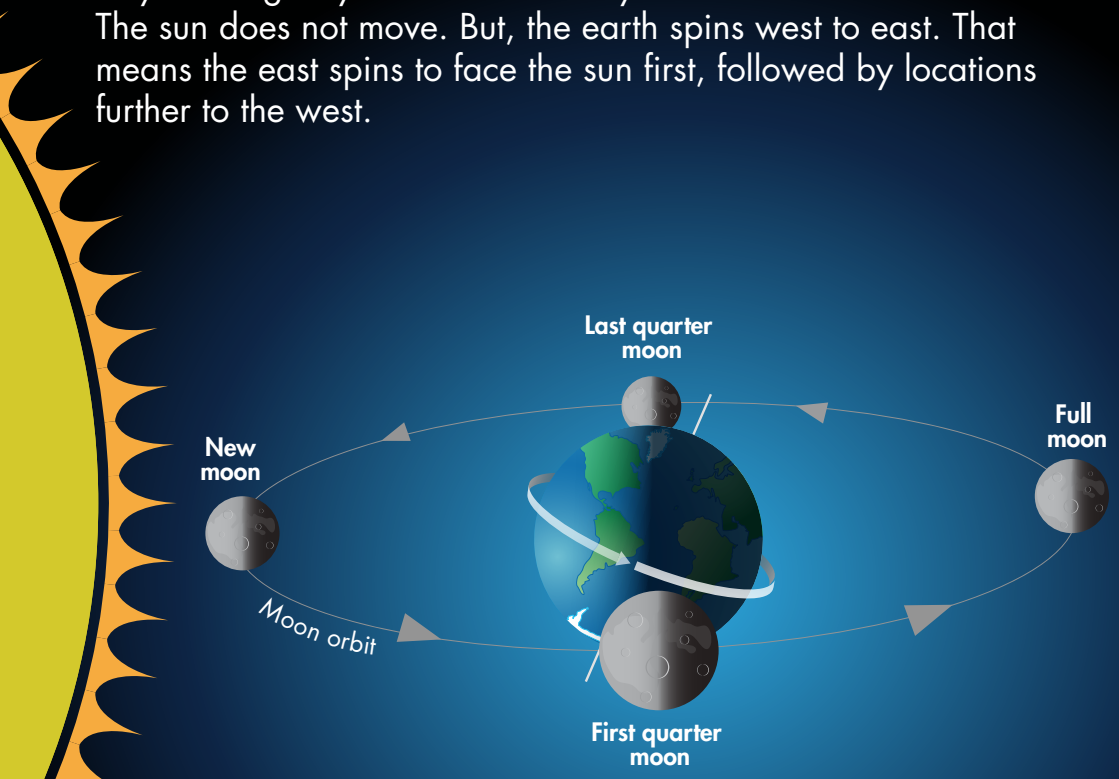
Strawberry poison dart frog

Tink frog

The rainforest is just as alive at night as it is during the day, but different organisms are active at different times.

There is also a cycle of the moon – from the new moon, when it provides no light, to the full moon when it is big and bright. The phases of the moon are caused by the orbit of the moon around the Earth. Animals may respond to these changes in light at night. For example, nocturnal animals may be less active when the moon is bright.

Day and night cycles are caused by the rotation of the Earth. The sun does not move. But, the earth spins west to east. That means the east spins to face the sun first, followed by locations further to the west.

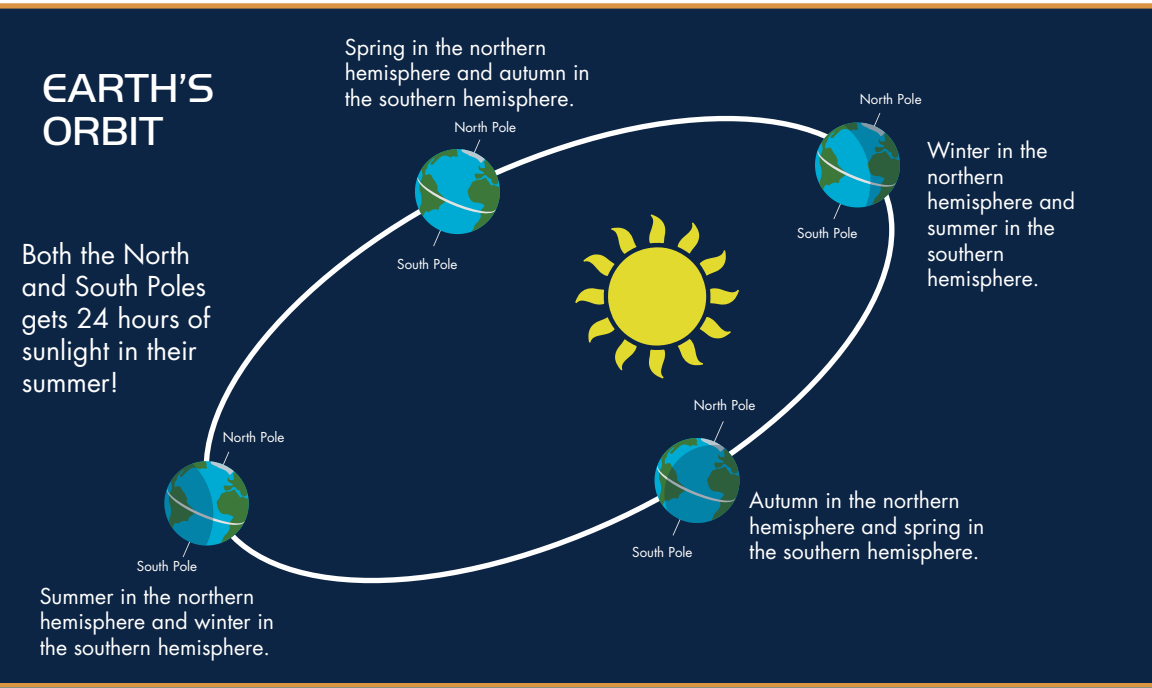


PHASES OF THE MOON

The orbit of the moon around the Earth and the positions of the sun, Earth, and moon determine the phases of the moon.

Seasons in the rainforest are not as obvious as seasons in places further from the equator. But, there are seasons. Even though it is warm and rains all year, it rains a lot more during the rainy season! During the dry season, rains can be few and far between.

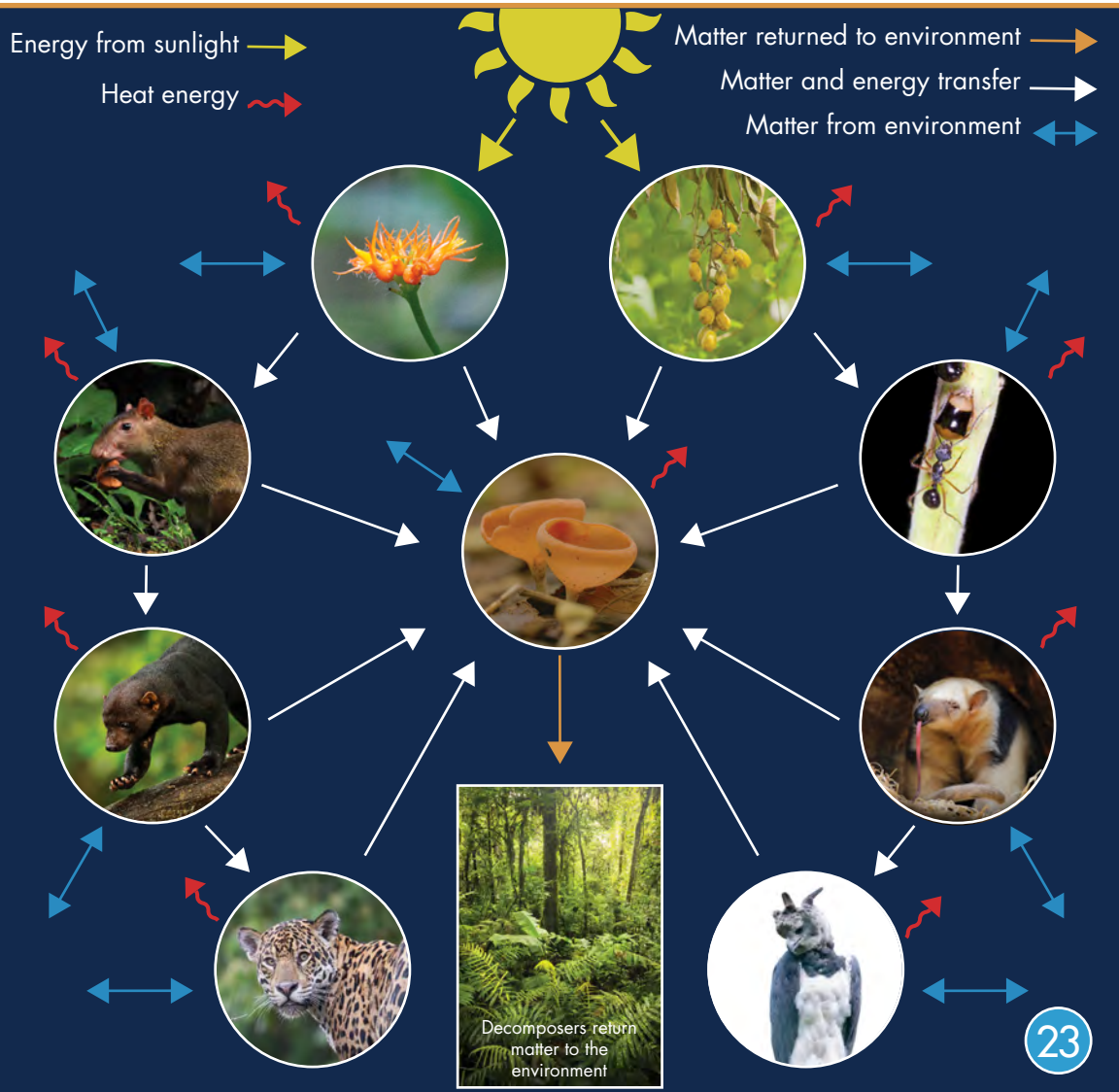
Seasons are caused by the Earth's orbit around the sun and the way the Earth is tilted. Here's how it works:



Look in the diagram to see that the sun hits Earth more directly near the equator. Near the poles there are greater differences in how direct the sunlight is between winter and summer.

CYCLE AND FLOW

Energy and matter flow or cycle within ecosystems. Energy is never destroyed. But, it is transformed or transferred. Energy in sunlight is transferred into chemical bonds of sugar during photosynthesis. It is released so the body can do work during cellular respiration. Energy doesn't cycle in the ecosystem. It flows from the sun, into the **food web**, and is eventually released back into the environment as heat. A food web is a model that shows how energy and matter move through an ecosystem.



Similar to energy, matter moves from the physical environment into **producers**, such as plants. Then it moves into **consumers** when they eat producers or other consumers. Matter is also not destroyed during these transitions or during chemical reactions. It just changes form. Much of the matter that enters food webs comes from the air! The carbon from carbon dioxide is used by producers to build sugars. Unlike energy, matter cycles in the environment. Some is released back to the environment from plants and animals. For example, carbon dioxide is released during cellular respiration and oxygen is released during photosynthesis. Other matter is returned to the abiotic environment when organisms die. Decomposers, like bacteria and fungi, break down matter and release it into the environment.

ALL TOGETHER NOW

Interactions will occur anytime species live together in one place. Many species depend on others for survival or reproduction. With so many species living together, interactions occur at a high rate in rainforests. But, they are found in all types of ecosystems.

PREDATION

In predation, predators catch and eat prey. Predators get energy from the meal and the prey dies.

COMPETITION

Everyone loses a little bit when competitors compete for resources. Populations can't grow as large if there aren't enough resources, and some animals or plants may not survive! Animals compete for food, safe shelters, territories, nesting areas, and mates. This competition occurs both within and between species.

In the rainforest, plants compete for space, light and nutrients. Soils don't have many nutrients in them because they are quickly taken up when they enter the soil. The growth of a plant depends on the local conditions, including the amount of light and nutrients it can get.

MUTUALISM

Win-win! Both species benefit.

Pollination: Pollinators get a meal. Plants get eggs fertilized.

Dispersal: Animals get a meal. The seeds of plants are moved away from their parent.

Farming: Leafcutter ants harvest vegetation to grow and feed fungus. The fungus provides food for young ants.

Parasitism: Strangler figs grow on other trees and sometimes kill them.

PARASITISM

The parasite gains and the host loses or even dies.

COMMENSALISM

Somebody wins and the other doesn't care.

Commensalism: The bird gets a free ride and a meal while the bear looks for insects. The bear isn't affected.

Commensalism: The epiphyte gets a place to live. It doesnt help or hurt the tree it lives on.

Parasitism: The cordyceps fungus reproduces and infects more ants. The ant dies.

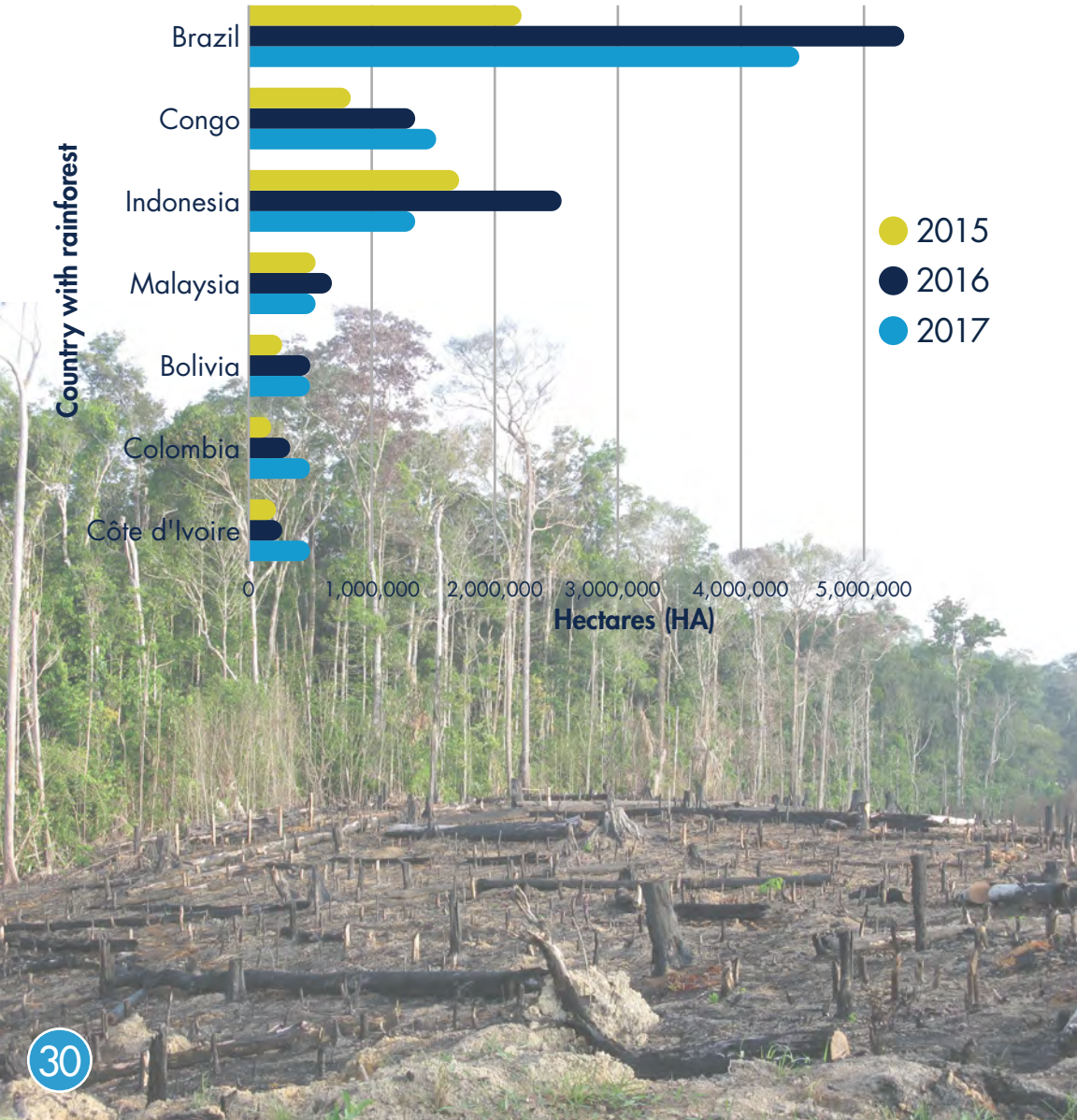
SYMBIOSIS

Two species live in close contact. A **symbiosis** can be a mutualism, commensalism, or a parasitic relationship.

RAINFORESTS IN PERIL

Rainforests seem to be so huge and wild that it can be difficult to imagine that they are in trouble. But in fact, they are at risk in most countries. Scientists estimate that over 80,000 km^2 (about the size of South Carolina) of rainforest are lost each year!

TROPICAL TREE COVER LOSS IN 2015, 2016, AND 2017 ACCORDING TO GLOBAL FOREST WATCH



There are many reasons that rainforests are being destroyed. In some places, they are cleared for agriculture. In others, trees are cut down to make room for cities and towns. Additionally, trees are cut down for their wood to build or to burn. There are other threats to rainforests and the species that live in them. A changing climate means that some species in some areas can't get enough water or are too hot. These species, if able, will be forced to move or be at risk of dying out. In other places, a lack of water and warm temperatures have led to huge wildfires that burn vast areas of forest. Excessive hunting is causing the disappearance of many animal populations. Some animals are hunted for food, while others are being captured to be used as pets. Many of these animals are sold illegally. Populations of beautiful parrots are threatened by poachers, who catch them and ship them overseas.

Finally, people mine **natural resources** in rainforests. If the mining is not done responsibly, toxic chemicals can flow into rivers and underground water. The water cycle can carry these pollutants long distances where they can harm or kill animals that live in the water, drink the water, or eat contaminated animals. Overall, biodiversity is declining in places where people are heavily using rainforests!

SAVING RAINFORESTS

Around the world, scientists and concerned citizens are trying to save rainforests. Farmers are finding ways to grow crops without clear-cutting the forests. By leaving some trees standing, farms and plantations provide habitat for animals. People are also finding ways to sustainably harvest forest resources. Governments are working to reduce or stop poaching for meat and the illegal pet trade. Border agents are getting better at finding and stopping illegal wildlife tracking. In some places, they are even turning the poachers into rangers and guides who take tourists into the forests to take pictures of wildlife!

People are also realizing that forests are most valuable when left intact. Life-saving drugs can be found in the chemicals of rainforest plants. A rainforest plant may become the next super food or provide chemicals needed for perfumes. If these species disappear before scientists can study them, their value will be lost forever. Rainforests are also valuable because they remove carbon dioxide from the atmosphere. Rainforest plants keep it in their bodies as they grow. Why is the removal of carbon dioxide important? Carbon dioxide in the atmosphere is the major cause of climate change. Every time rainforests are burned or cut down, more carbon dioxide is released, which worsens climate change.

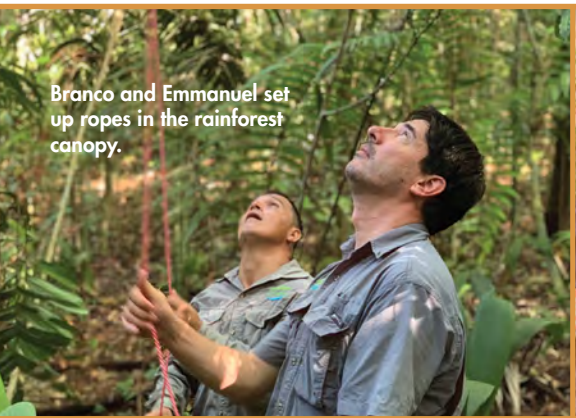
Rainforests have other benefits. The plants along rivers help minimize flooding, protecting people and farms. These plants can also help clean toxins from the water, safeguarding the water supply for people.

Progress has been made in saving rainforests, but there is a lot more work to do. For example, scientists still need to learn more about the species that live in them to fully protect them. Understanding more about rainforest biodiversity is key to saving them!

STUDYING BIODIVERSITY

Scientists study biodiversity for many reasons. Knowing the number and type of species, and what interactions occur gives them insight into an ecosystem's health. But, they need to understand even more. Scientists design studies to learn when certain species are around and what environmental conditions they need to survive and reproduce. Knowing what resources and conditions plants and animals need helps scientists make predictions about how they will respond to changes in the environment. What will happen if there is less rain or the rainy season comes at a different time? What will happen if instead of clear-cutting areas for agriculture, farmers kept some of the trees standing? What will happen if one or two species disappear? Will others that rely on them disappear too?

At the Tirimbina Biological Reserve in Costa Rica, scientists study rainforest biodiversity so they can protect the remaining rainforests and restore areas that have been damaged. They will need to use many techniques, including sound waves, to do their study. Now, its time to join the mission!



Branco and Emmanuel set up ropes in the rainforest canopy.

Carolina arms a camera trap to monitor biodiversity on the forest floor.

Bernal examines a bat as part of a research project.

GLOSSARY

ABIOTIC CONDITIONS
conditions related to non-living things

ARBOREAL
living in trees

ATMOSPHERE
the envelope of gasses surrounding Earth

BIODIVERSITY
the number of species in an area

BIOSPHERE
all the life on Earth

BIOTIC CONDITIONS
conditions related to living things

CELLULAR RESPIRATION
the process that organisms use to release energy stored in chemical bonds of sugars

CONSUMER
an organism that feeds on plants or animals for energy

DECOMPOSER
an organism that feeds on and breaks down organic material

ECOSYSTEM RESILIENCE
the capacity of an ecosystem to resist damage or recover from disturbance

ELECTROMAGNETIC RADIATION
waves that move through space and carry energy including light, radio waves, and x-rays

ENZYME
a chemical produced by organisms that speeds up biochemical reactions

FOOD WEB
a graphical representation of what-eats-what in an ecological community

HYDROSPHERE
all of the water on Earth, including on its surface, in the air, and underground

LITHOSPHERE
the rigid outer part of the Earth, consisting of the crust and upper mantle

NATUAL RESOURCES
materials or substances such as minerals, forests, water, and fertile land that occur in nature and can be used by people

NICHE
the role and environmental needs of species

PHOTOSYNTHESIS
the process that producers use to convert sunlight, water, and carbon dioxide into sugars and oxygen

PRODUCER
an organism (like a plant) that uses photosynthesis or another process to make its own food

SYMBIOSIS
an interaction between two organisms that live close together

TERRESTRIAL
of, on, or relating to the Earth

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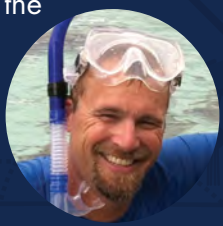
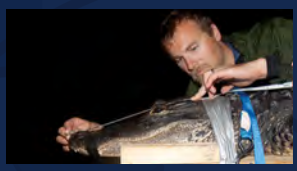
MIKE HEITHAUS PH.D.



Dr. Mike Heithaus is a scientist, explorer, author, educator, and television host. He is a professor of biology and Dean of the College of Arts, Sciences & Education at Florida International University. Mike and his students study sharks, whales, sea turtles, and other large marine animals around the world. They also work with people to help protect these species. Mike loves sharing his work with others. He has written text books and helped create programs for students in elementary, middle, and high school. He has been on television programs including on PBS, National Geographic, and Discovery Channel's Shark Week.

PATRICK GREENE

As a wildlife filmmaker, Patrick has always had a passion for animals. He started to draw pictures of sharks and whales when he was just five years old. Later, he went to college to become a marine biologist and learned a lot about science. Then he got a job in television and learned how to make videos, too. Since then, he's gone all over the world studying and filming wild animals. He's made shows for National Geographic, PBS and ABC, and even won an Emmy Award. He loves making videos to teach students about science and about the many creatures that share our world.



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