

THE ADVENTURE OF ECHO THE BAT



Written and Illustrated
by Ginger Butcher

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Dedication

In memory of my father Dr. James E. Kupperian, Jr. who conceived and planned the observatory series of spacecraft, including the Orbiting Astronomical Observatory (OAO) and was chief of the astrophysics branch at Goddard Space Flight Center from 1959 to 1970.

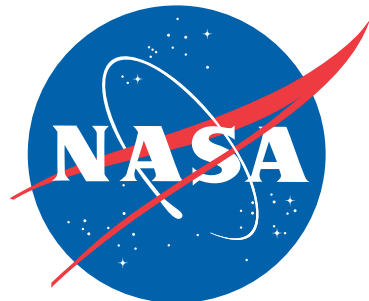
Acknowledgements

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High in the mountains of Arizona, there is a forest of tall Ponderosa pine trees. Under the loose bark of one of these pine trees, there lives a colony of Big Brown mother bats.

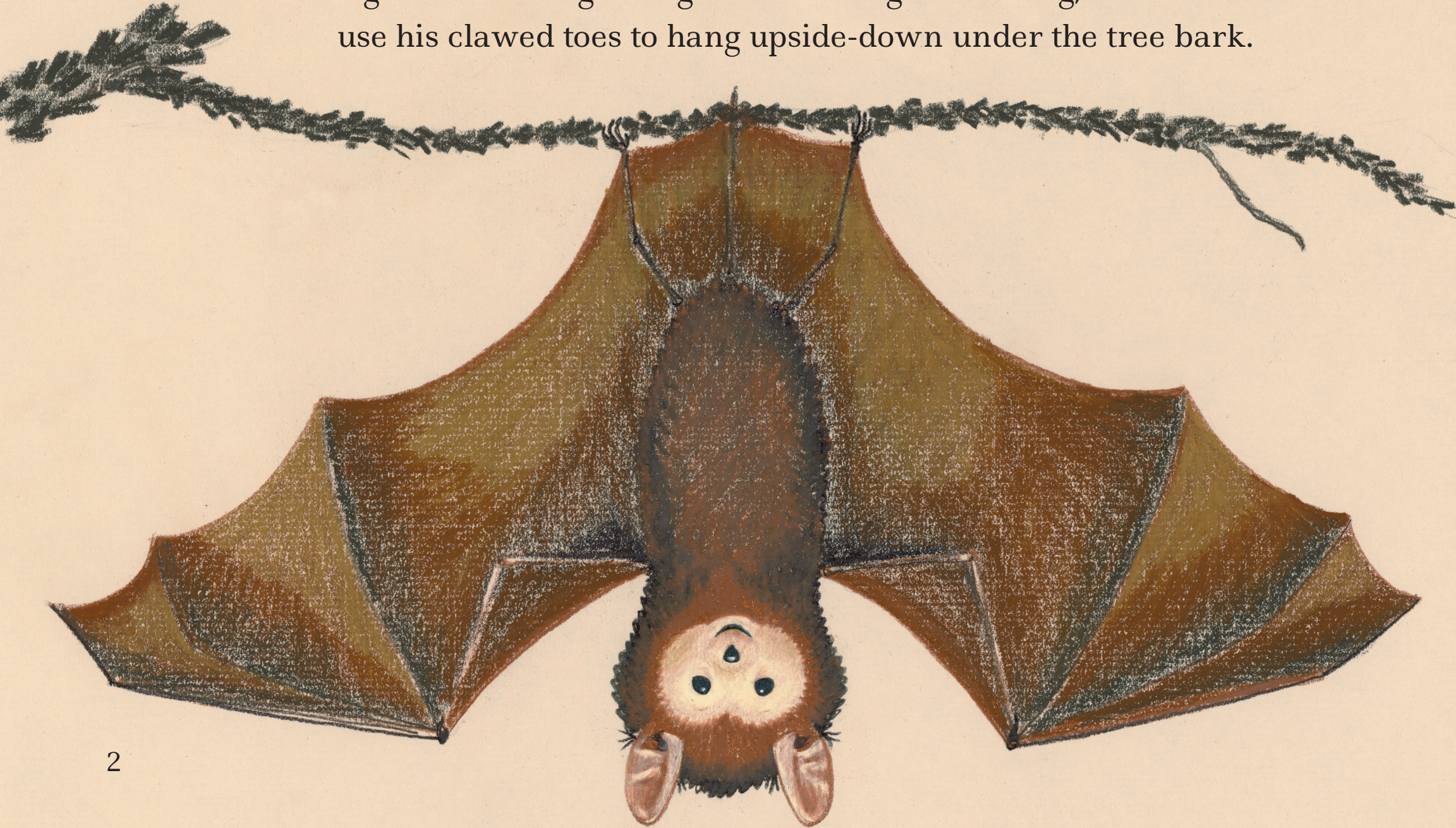
When the warm days of spring lead to summer, a baby bat is born. Mother Bat calls to her baby and her baby calls back, like echoes in a canyon. She names her baby Echo.



Echo's tiny, fuzzy body is covered with brown fur and he has very big ears.

His wings are made of long finger-like bones covered with stretchy skin.

His legs aren't strong enough for standing or walking, but he can use his clawed toes to hang upside-down under the tree bark.



One night, Echo looks down and sees something moving. It's coiling around a branch and slithering up toward their roost. Mother Bat whispers, "Shhh, that is a snake. Be very quiet and maybe he won't find us."

Echo tries hard not to be scared. He hears the wind howling. It is getting louder and louder. Just then, a gust of wind snaps the branch and the snake falls out of sight into the dark forest.

"Hold on tight," Echo's mother tells him. "We need to leave quickly before the snake comes back and tries to eat us for dinner!"

"Where are we going?" Echo asks as he clings to his mother.

"To find a new roost safe from snakes and other dangers," she replies.

"There are many more lessons for you to learn."



One evening, Echo wakes up in his new roost and sees his mother about to fly from the tree. "Where are you going?" Echo asks.

"I am going to find bugs to eat, but I will be back," replies Mother Bat.

"But I want to learn to fly. When can I learn?" pleads Echo.

"You will be ready soon. But now you must wait here and be careful not to fall," she explains. "Snakes aren't the only animals to worry about. Owls and hawks also like to eat bats."

With that warning,
Mother Bat flies
from the tree to
hunt for bugs.



An illustration of five baby bats with brown fur and large, dark eyes, huddled together in a hollowed-out section of a tree trunk. The tree bark is dark brown and textured. Above the bats, a bright blue crescent moon is visible against a dark, starry night sky. The overall mood is quiet and contemplative.

Echo watches his mother fly
toward the setting sun. He
remembers the feeling
of holding onto her
and flying through
the air. "I can't
wait until I am
old enough to fly
on my own," he
thinks to himself.

Echo and the
other baby bats are
frightened by the
thoughts of snakes, owls,
and hawks. They hold
tightly to their roost
inside of the tree bark
and begin calling for their mothers.

Mother Bat hears Echo calling to her and flies back to the roost. "There she is!" cries Echo, as he sees his mother returning in the moonlight. She knows Echo's call well and can find him even if there are hundreds of baby bats in the nursery colony.

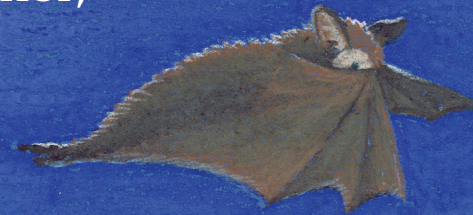
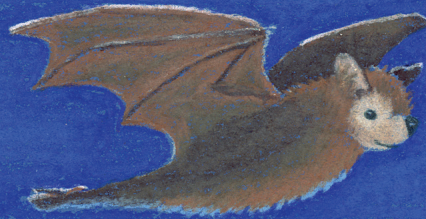
Echo is glad his mother is home, but still wishes he could fly.



Soon Echo is a month old and has grown almost as big as his mother. The time has come for him to learn how to fly. He is very excited.

Echo lets go of the tree and begins to flap his wings. He starts to fall toward the ground so he flaps his wings faster and faster until he starts to fly.

"Look at me!" Echo shouts. "Look at me, Mother, I'm flying!"



Echo and his mother fly around the pine trees. It takes a lot of energy for bats to fly because they have to flap their wings the whole time. They don't have feathers and cannot glide like birds. Echo soon becomes tired and hungry. "Follow me!" Mother Bat calls. "We will find some bugs to eat."

Echo, like all bats, can see well. But he uses another sense to help him catch bugs. Echo calls out with an ultrasonic sound, a sound too high for people to hear. Using his big ears, he listens for the sound to bounce off a bug, and return to him. Echo learns the bug's location by sensing the direction from which the sound returns. This is called *echolocation*. If the sound takes a long time to return, Echo knows the bug is far away. If the sound returns quickly, the bug is close.

When Echo finds a bug, he flies closer and catches the bug. He uses his tail to push the bug into his mouth and almost does a backflip.

"Wow!" Echo cheers, "This is so much fun."

Mother Bat tells Echo about all the best places to find bugs like around lakes, near farms, and even close to streetlights in a city.



Back at their roost in the pine tree, Mother Bat tells Echo a story.

“Soon the weather will get colder and there will not be enough bugs for us to eat. We will take a long trip and fly to a new home for the winter. This is what it means to migrate,” she explains. “As we fly, we will see shapes on the land made by rivers, lakes, and mountains. The patterns these shapes make will help guide us to our new home, a cave. We will meet other bats and sleep in this cave all winter, hibernating until spring.”

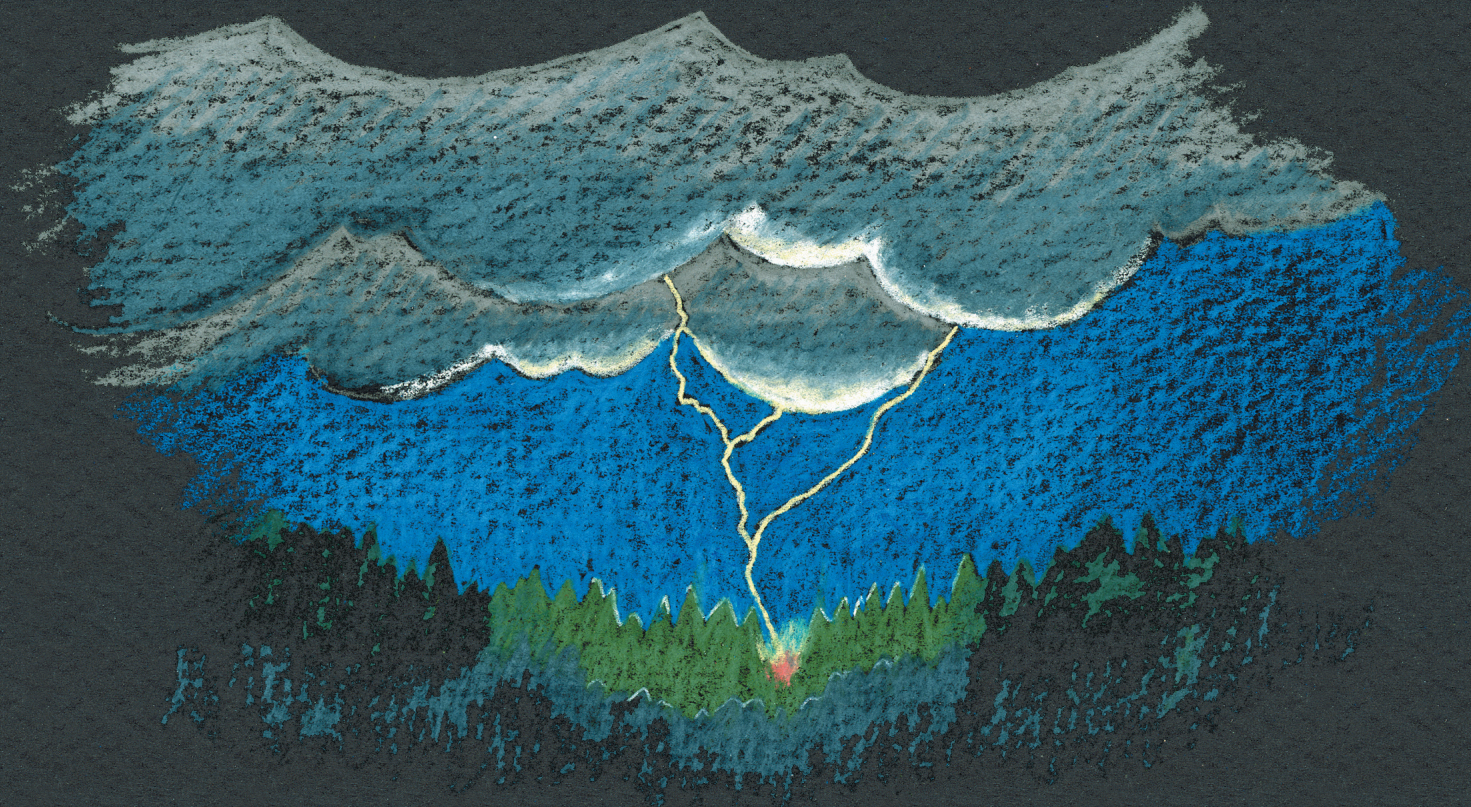
Echo snuggles close to his mother and falls asleep dreaming of the bat cave.



The next night, Echo and his mother leave their roost to hunt for bugs. Just then, dark clouds fill the sky. Lightning flashes and frightens Echo. Then soon after, the sound of thunder hurts his ears.

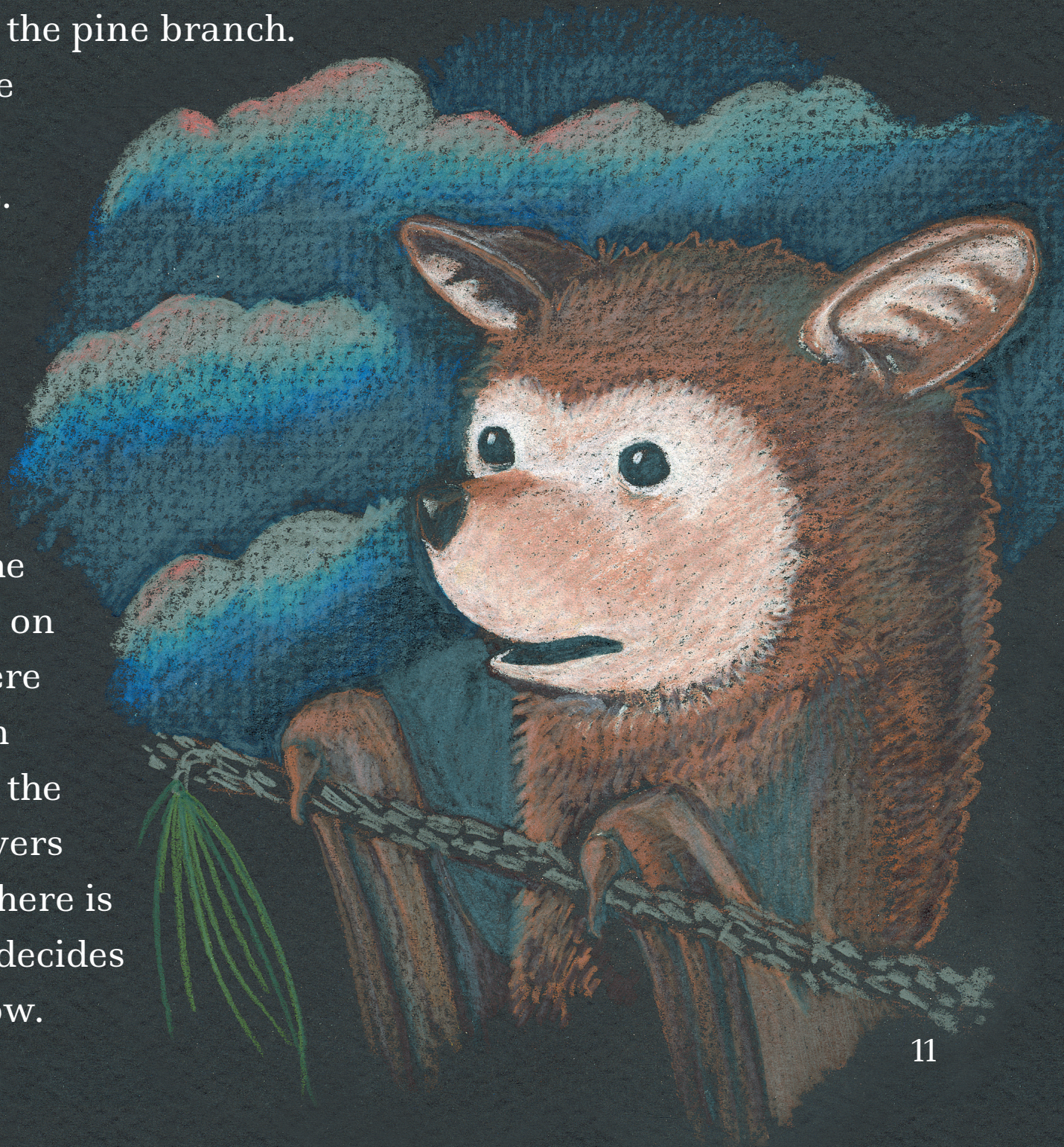
CRASH! A lightning bolt strikes a nearby tree and starts a fire. Echo grasps a tree branch with his clawed thumbs and watches the flames.

"Mother!" Echo cries. "Where are you?" But there was no answer. He cannot see or hear his mother anywhere.



Lost and alone, Echo clings to the pine branch.
He wonders if he will ever see
his mother again. Echo thinks
of the long journey to the cave.
He is scared to go alone but
remembers the lessons his
mother taught him about
following the shapes and
patterns to find the cave.

Mother Bat told Echo about the
different habitats he will pass on
their way to the cave and where
to find food. In the city, he can
find bugs near streetlights. In the
mountains, bugs live along rivers
and lakes. Just past a desert, there is
a farm with more bugs. Echo decides
to set out for the cave tomorrow.



The next night, Echo begins his journey to find the cave. He flies higher and higher. Looking down, he sees many shapes on the ground. He sees green and brown rectangles next to a dark line. Echo swoops down and discovers the rectangles are fields and the line is a road. He wonders if the road will lead him to a city.

"Where there is a city, there are streets and streetlights," Echo thinks as his tummy rumbles, "and where there are streetlights, there are bugs!"

As Echo flies closer, he sees square shapes of buildings and more lines. These streets cross each other forming a grid pattern of streetlights as far as he can see. He uses echolocation to catch bugs around the lights. Soon, Echo has a full belly and is very tired. In a neighborhood just outside the city, he finds a small box on the side of a house. The box is open at the bottom just like his home beneath the tree bark. "It was nice of someone to build this little box," he thinks to himself as he yawns and falls asleep.



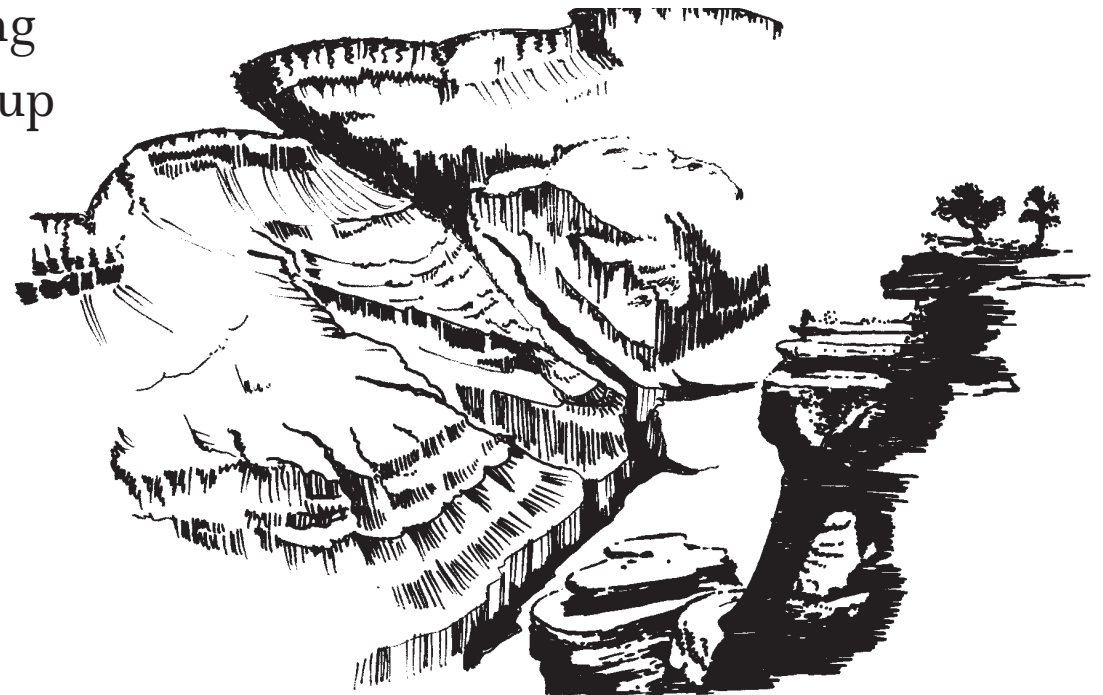


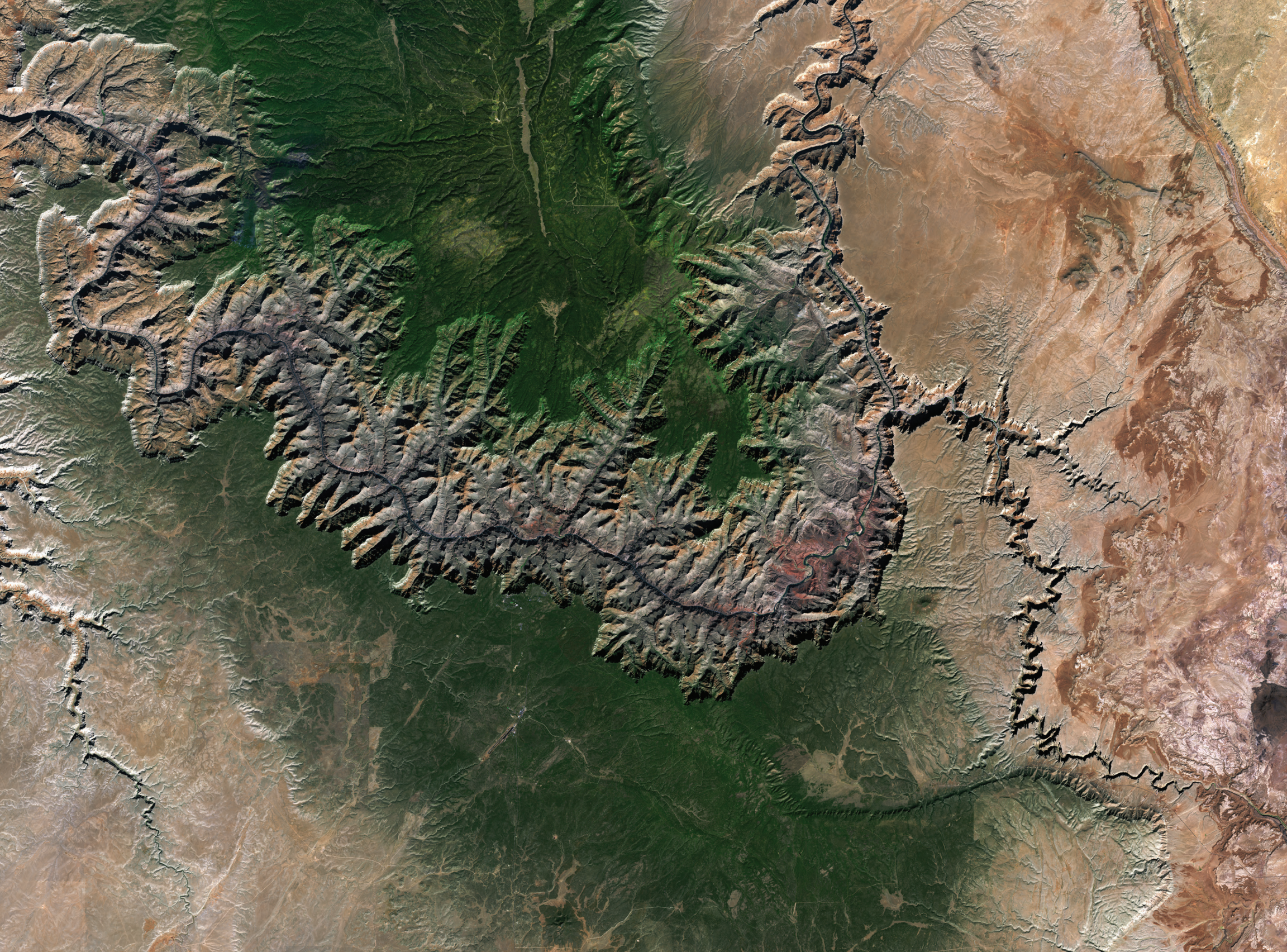
The next night, Echo sets out again to find the cave. Looking down, Echo sees a squiggly line.

"The straight lines in the city were streets. I wonder what a squiggly line is." Echo ponders. As he gets closer and closer, the squiggly line appears larger and larger. "It's a river!" Echo says. "Maybe this river will lead me to the cave."

Echo remembers what his mother taught him about finding bugs near water and his tummy starts to growl. He flies through a grand canyon, flutters across the river, and finds a small pond where he feasts on all types of bugs.

"My tummy feels so full and I am getting tired." Echo thinks to himself. He looks up and sees rocks on the top of the cliffs. Under the ledge of a large rock, Echo finds a perfect space to rest. As Echo slowly drifts off to sleep, he hopes that no snakes will find him there.



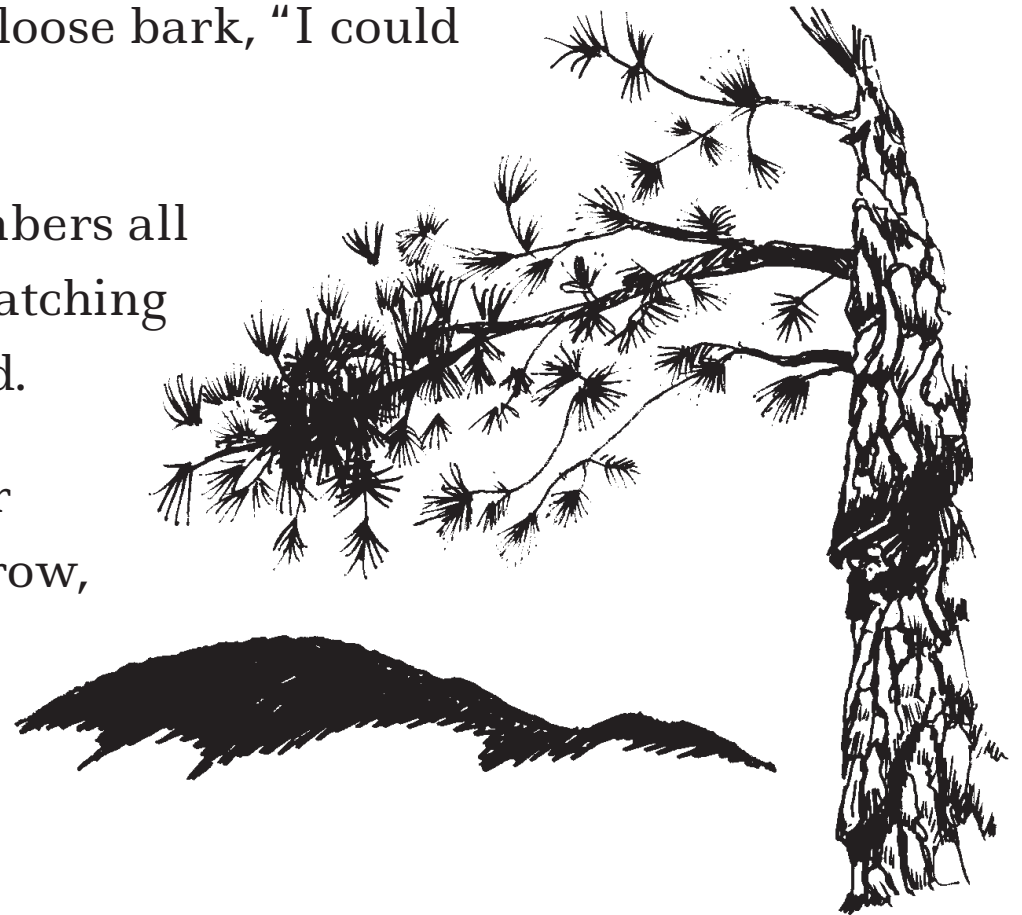


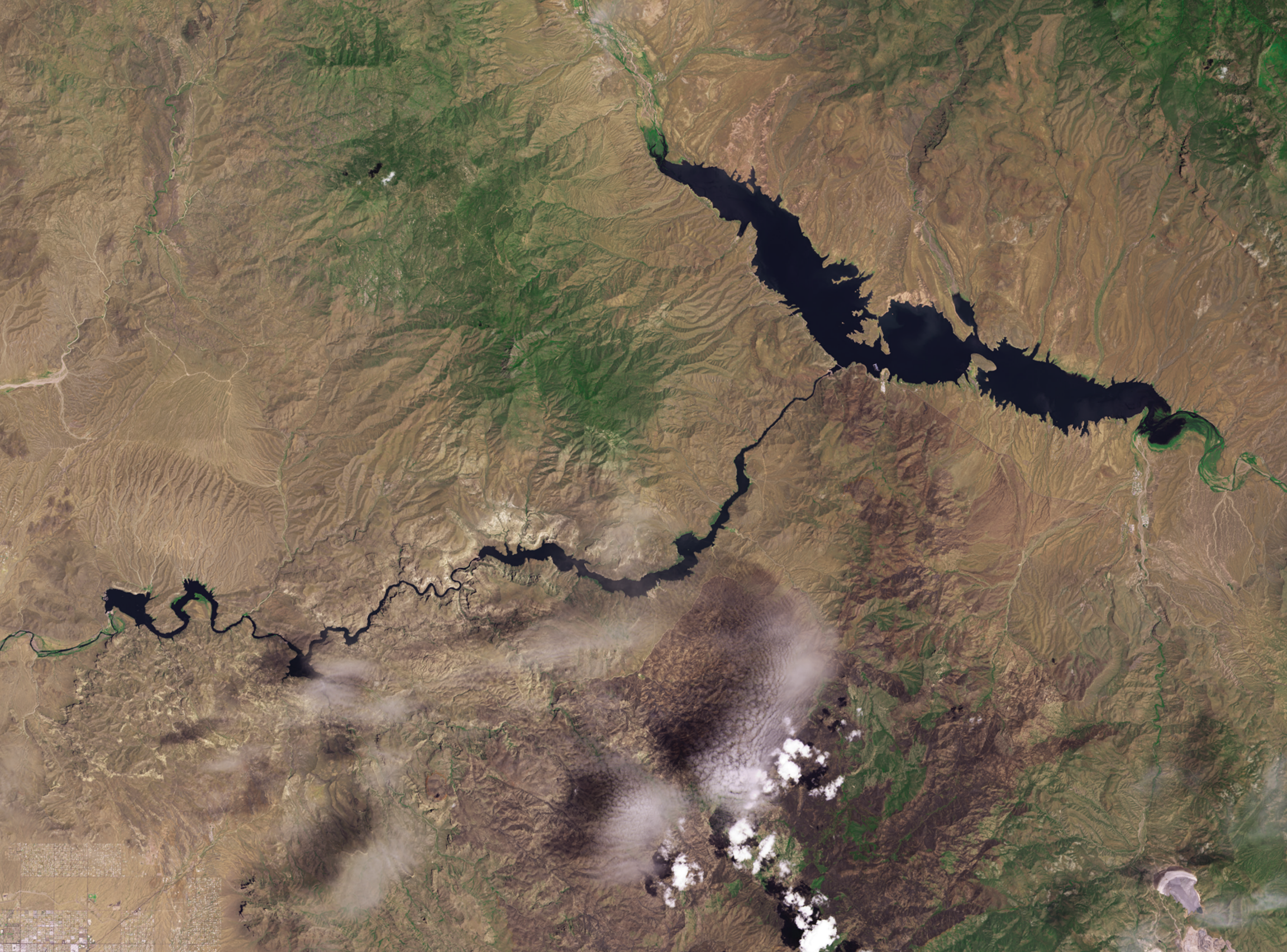
The next night, Echo sets out again to find the cave. He flies higher and higher following another squiggly line. "Will this river lead me to the cave?" Echo wonders. He swoops down and finds that the river opens to a lake. He remembers that there are many bugs around lakes.

After dinner, Echo flies toward a wrinkly mountain covered with trees. He finds the perfect roost in a Ponderosa pine tree. "This place is just like home." Echo thinks as he nestles under a piece of loose bark, "I could stay here forever."

Echo dreams about his mother and remembers all the fun they had flying around the forest catching bugs. He misses his mother and is very sad.

"I must find the cave," Echo cries. "Mother said we had to travel past a desert. Tomorrow, I will continue my journey and look for that desert."



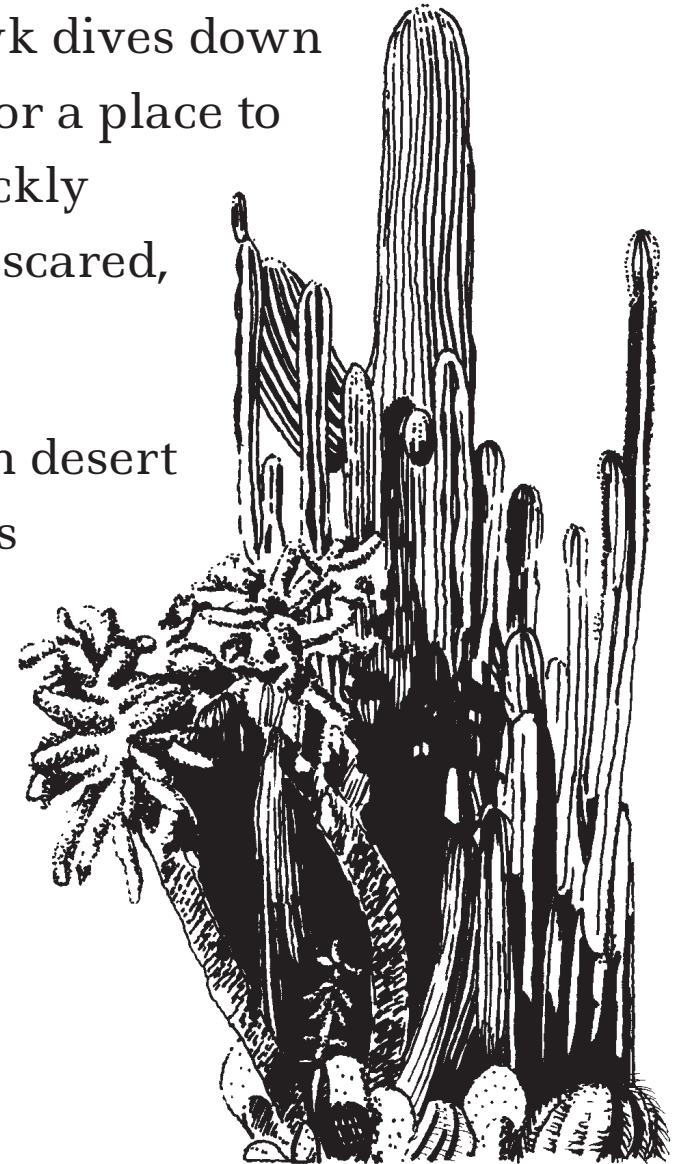


The next night, Echo sets out again to find the cave. Flying higher and higher, he starts to notice the textures of the ground. Mother Bat said that the desert has smooth sand and bumpy rocks. Echo wonders if the cave is beyond this desert.

Suddenly, Echo hears a loud screech and a Red-tailed hawk dives down from a nearby cliff. Echo is frightened and quickly looks for a place to hide. He finds an empty woodpecker nest inside a tall prickly tree, called a saguaro (SAH-WA-ROW) cactus. Tired and scared, Echo decides to hide there.

The next night, Echo flies as fast as he can over the smooth desert sand and past the bumpy rocks until he sees green squares next to a river. Echo flies closer and finds that the squares are farms.

"Where there are farms, there are bugs!" exclaims Echo. "I can help the farmers by eating lots of beetles."



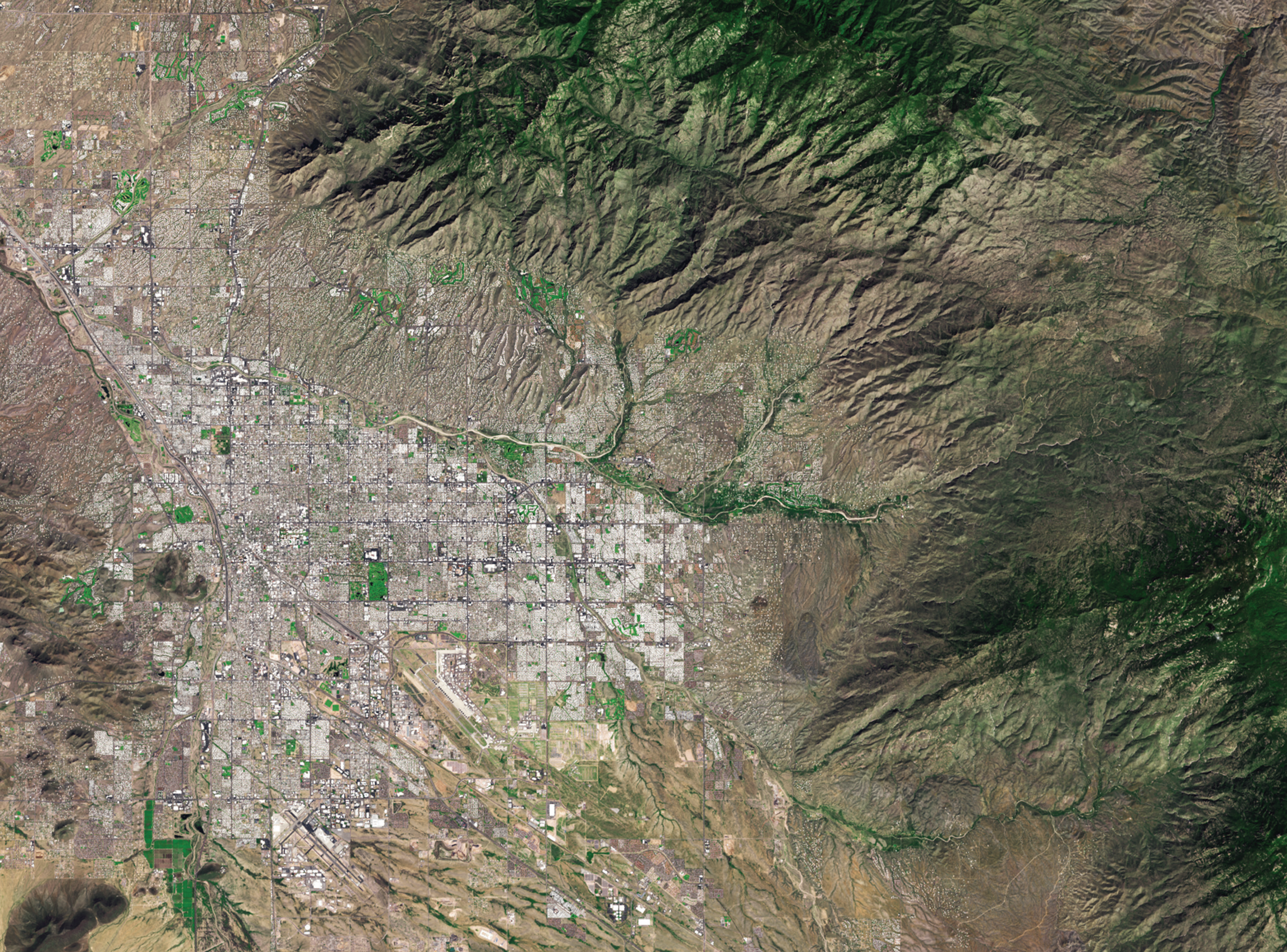


With his tummy full of beetles, Echo sets out again to find the cave. He flies higher and higher and soon he sees lines of streets and squares of city blocks. Just beyond the city, Echo sees the wrinkly texture of a mountain. "Mountains are good places to find caves," Echo thinks. "Maybe I'll find the cave there."

Echo flies closer to the wrinkled land and finds a mountain with lots of trees but no cave. He flies toward another wrinkly-looking mountain and sees that this one is covered with stacks of rocks. To his surprise, he sees a bat! He looks again, but the bat is gone.

"Where did he go?" Echo wonders. "Could I have found the cave?"





When Echo reaches the rocks, he flies through a small opening and finds a big cave filled with bats. "How will I ever find my mom?" Echo wonders. He begins calling for her as he flies deeper into the cave. Finally, Echo hears his mother answer. He is so excited he flies into her wings for a big hug.

He tells her all about his adventure following the shapes on the land. He followed lines and square shapes to the city where he ate bugs by the streetlights. The squiggly line of a river led him through a grand canyon and another squiggly line led him to a lake. He explains how he escaped from a scary hawk who lives atop the bumpy rocks next to the smooth, sandy desert. He tells her about all the places he found bugs and how he helped farmers by eating beetles around their fields.



"Sounds like you had quite the adventure, Echo." Mother Bat says, "You must be very tired and ready for our long winter's nap."

"I am," Echo whispers. "Goodnight Mother."

"Goodnight Echo," Mother Bat whispers.

About Big Brown Bats

Big brown bats live almost everywhere in America, even in mountains and deserts. In summer, many rear their young in the walls and attics of buildings, so people often see them flying through yards or around streetlights in the evening. During winter, many travel to the nearest cave or mine to hibernate until spring, like Echo and his mother did in this story. Others hibernate in buildings or deep rock crevices. Amazingly, during hibernation, they can allow their body temperatures to fall below freezing and still survive.

Like many other kinds of bats, big brown bats are special friends of farmers. Even a small colony can eat many hundreds of thousands of insect pests each summer. In Texas, the colony of Mexican free-tailed bats living in Bracken Cave eat billions of pests nightly, and in tropical areas, bats that pollinate flowers and carry seeds to new locations are equally as important. Without these bats, we might not have many important foods, such as bananas, peaches, dates, figs, and cashew nuts.

Big brown bats are just one of 45 species of bats in the United States. These species include brilliantly colored red bats, silver haired bats, and even spotted bats that are black and white with huge pink ears and pink wings. There are nearly 1,000 species in other parts of the world. In Indonesia, there are giant bats with six foot wingspans, while Thailand's tiny bumblebee bats weigh less than a penny. In South America, fishing bats use huge feet to catch fish, and in Mexico many bats use very long noses to sip nectar from flowers. To learn more about bats, check out Bat Conservation International at www.batcon.org.

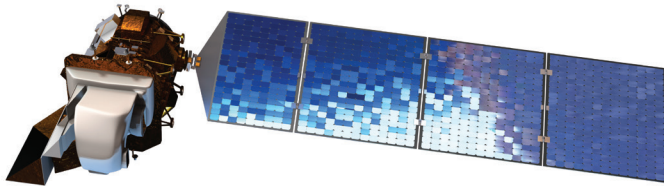


Seeing and Sensing from Space

Echo the bat followed the shapes and patterns he could see on the ground. When he learned that rivers looked like squiggly lines from above, Echo was using remote sensing. To learn about an object without physically touching, smelling, or tasting that object is called **remote sensing**. Remote sensing is an important tool to help us study the world around us.

Sensors on planes and satellites can remotely collect data about our planet allowing scientists to study large areas like the Amazon rain forest or harsh environments like Antarctica. Remote sensing is used for studying geography, observing and predicting weather, monitoring Earth processes like ice melting, forest fires, ocean levels, and more.

The images of Arizona in this story use Landsat 8 satellite data from the U.S. Geological Survey. Landsat instruments are like our eyes, they can see the reflected sunlight (energy). The Landsat satellites have been collecting information about our planet since 1972 and have helped to improve our understanding of Earth.



Both our eyes and our ears allow us to sense the world around us remotely. When you look at a tree, you can tell it is a tree without having to walk up to it and touch it. When you hear a bird chirping outside, you know there is a bird around somewhere even though you cannot see it. Seeing a tree or hearing a bird are examples of **passive remote sensing**. Passive means that you do not have to actively do anything but open your eyes and ears to sense the world around you.

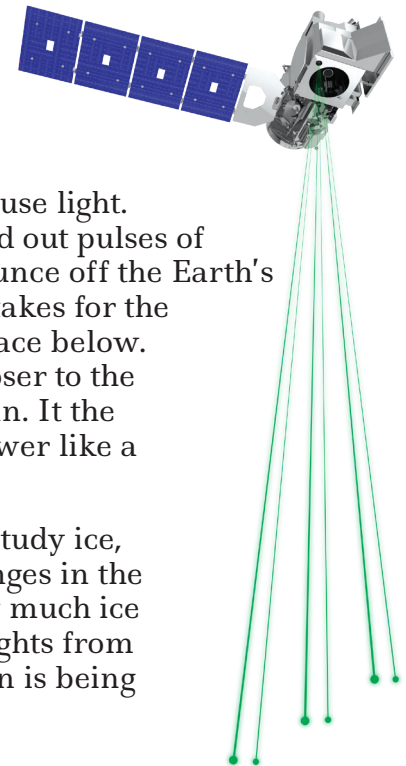
You can also actively sense the world around you. Have you ever played Marco Polo? When you actively call out “Marco,” your friends answer back “Polo” and you can tell roughly where your friends are from the direction you hear their voice. Echo can also locate bugs, similar to the game Marco Polo, by using echolocation.

Echo called out an ultrasonic sound and listened for that sound to bounce back. Echolocation can also tell how far away the bug is by the amount of time it takes for the sound to return. The longer the sound takes to return, the further away the bug is. Echo is using **active remote sensing** to figure out the location and distance to the bug.

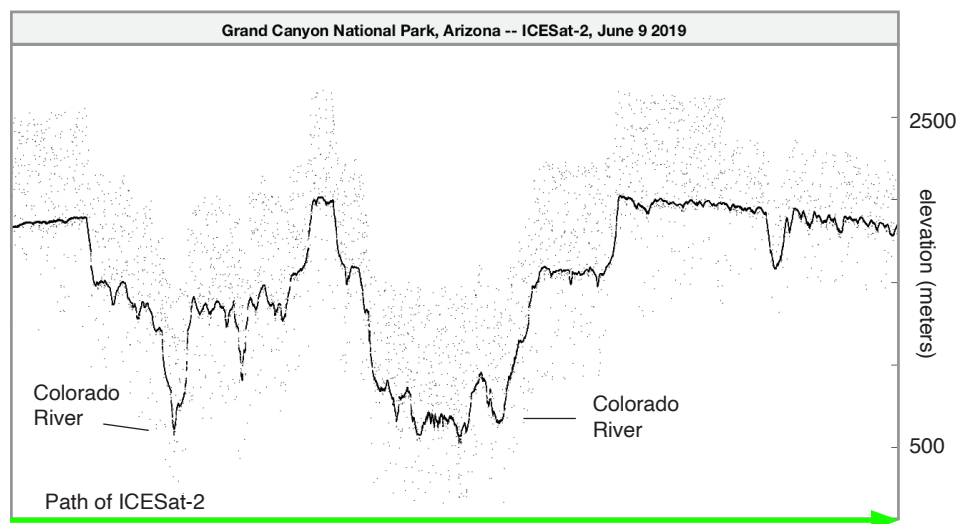
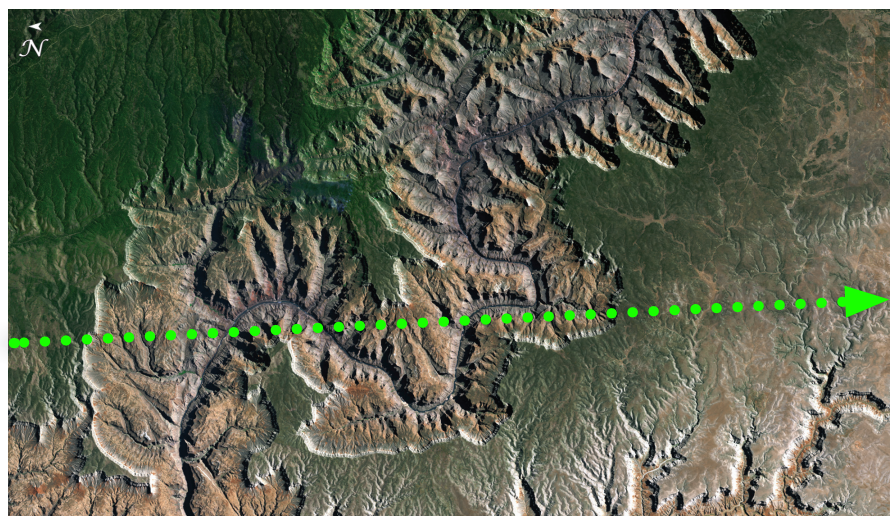
Instruments onboard ships and submarines also use sound for active remote sensing. This is called sonar. Sound travels through the water and bounces off objects like other ships or underwater landforms. But using sound for remote sensing does not work on satellites orbiting our planet because sound requires something to travel through like water or air molecules.

Active remote sensing from satellites in space use light. Lasers onboard NASA's ICESat-2 satellite send out pulses of light (photons) down to Earth. The photons bounce off the Earth's surface and return to the satellite. The time it takes for the photons to return tells us the height of the surface below. If the photon returns quickly, the surface is closer to the satellite or at a higher elevation like a mountain. If the photon takes longer to return, the surface is lower like a basin or crater.

Measurements from ICESat-2 help scientists study ice, forests, water, and land. By looking at the changes in the height of ice sheets, scientists can calculate how much ice is melting into the oceans. Monitoring tree heights from space help scientists calculate how much carbon is being stored in the forests.



ICESat-2 Flies Over the Grand Canyon



Measurements from ICESat-2 can help map topography – the peaks, valleys, and other forms and features of land surfaces. On June 9, 2019, ICESat-2 flew over the Grand Canyon, passing from south to north over a bend (green line), recording a detailed topography or height profile of the deep canyon and its tributaries. The Landsat image on the top shows the path of ICESat-2 across the canyon.

Try This!

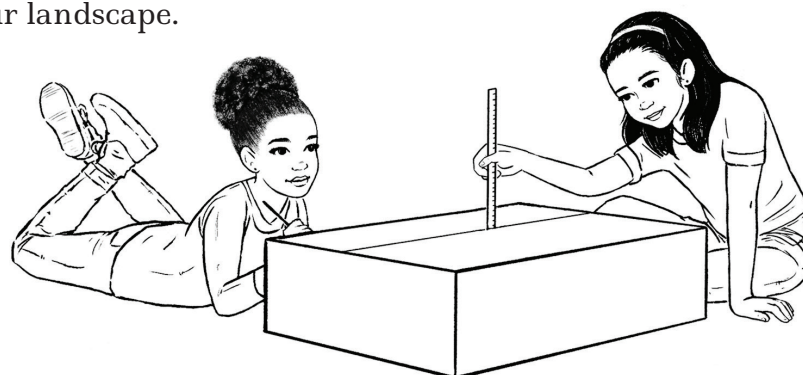
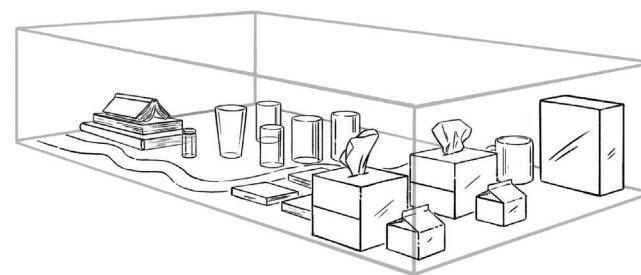
Visit the Echo the Bat website (<https://go.usa.gov/xsBFX>) for videos and activities about Landsat and ICESat-2. Hands-on experiences have been created for several age levels that you can do at home to explore the differences between active and passive remote sensing.

Bumpy, Wrinkled, Smooth! (ages 5-8)

Echo made his journey across Arizona following patterns on the land. He looked down at green circles, brown rectangles, grid patterns, and wrinkly textures. As he flew higher and higher, the mountains look wrinkly and city blocks look like patterns of squares. Try this activity to learn more about how scientists use color, shape, patterns, and textures to identify features in Landsat satellite images.

Lasers, Light, and the Earth's Surface (ages 8-12)

Make your own landscape in a box and see what you can discover through active and passive sensing. You and your partner can act like the satellite and use your different senses to discover your landscape.



Note to Teachers and Parents

The following sets of prompts are provided to introduce and engage children to interpreting features in satellite images.

Introduction

As Echo begins his journey in search of the Bat Cave, he doesn't know that there is a satellite flying high in the sky above him. The big pictures in the second half of the story show you what the satellite sees. Lift the pop-up pictures to see what Echo is seeing as he is flying. As you read the story, ask the child what shapes they see. Can they recognize a pattern? Can they describe a color or a texture? After reading the story, go back through the pages with the satellite images and ask some of these questions.

Perspective

Do you think that the satellite and Echo are looking at the same city, river, mountain, collection of fields, and desert? They are. Are you surprised?

What does the city look like from the satellite's view? What does it look like to Echo as he flies over the streets, yards, and buildings? Can you tell if objects are tall or short? What do you see when you ride or walk through a city? How can the same buildings, streets, and yards look so differently when seen by a satellite, by Echo, and by you?

Shape/Pattern/Color

Close the pop-up pictures so that you can see only what the satellite is seeing. Pretend that you are riding on the satellite and looking down. From your perch high in the sky, what colors do you see? What shapes and patterns do you see? What kinds of shapes and patterns have the same colors?

Pretend that your friend is flying beside Echo and can talk to you through a special telephone. What colors, shapes, and patterns do you see from your satellite view? Can you guess what your friend is seeing as he/she is flying with Echo? Lift the flaps in the satellite images one at a time to test your guess. How many did you get right?

Texture

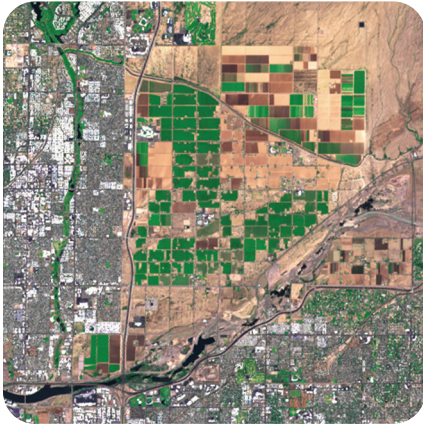
Look at each one of the satellite images with pop-up pictures hidden. Do any parts of the satellite images look like they could feel rough, smooth, bumpy, hard, spongy, feathery, soft, sticky, sharp etc. Choose a pop-up picture section and try to describe the texture (what it would feel like if you could touch them). Guess what you will see when you lift the pop-up. Were you right? What kinds of textures do mountains, rivers, fields, cities, canyons have? Can the texture in a satellite image help you identify a feature on the ground?

What to Expect?

At the end of this book, children ages 5-6 should be able to distinguish between what a satellite sees and what Echo sees. Older children ages 7-9 should begin to describe what the satellite is seeing by just looking at the satellite view. Younger children should be able to identify patterns and color in the satellite image and compare these to what Echo sees. Older children should be able to describe the location of these patterns and colors such as the square pattern of irrigated crops near the river and green forests on the tops of mountains. Texture is another important tool scientists use to interpret satellite imagery. Younger children should begin to extend the concept that texture is not only the way something feels, but is also the way something looks. Older children should be able to make more elaborate observations about texture in the satellite images.

Shapes, Patterns, & Textures of Arizona

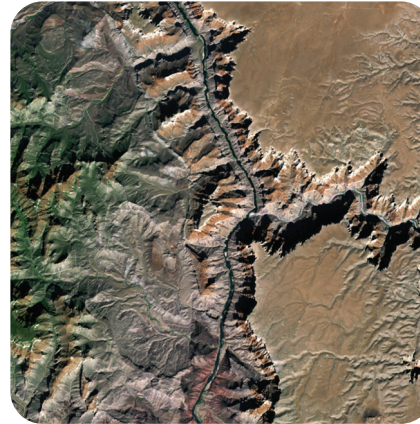
The farms near Phoenix look like **green** and **brown rectangles**.



The Colorado River looks like a **squiggly line** in the Grand Canyon.



The steep cliffs of the Grand Canyon appear **jagged**.



The Salt River looks like a **dark squiggly line** through the bumpy landscape.



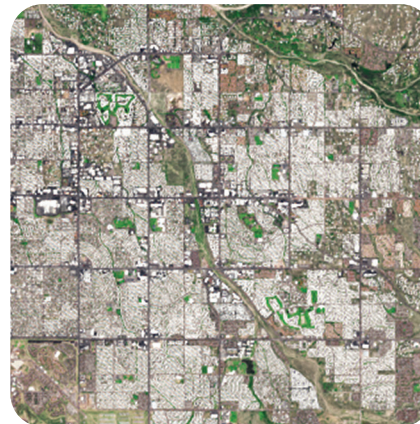
The Sonoran Desert has **bumpy** mountains and **smooth** desert sand.



The Gila River flows through the desert and farm fields nearby form **green squares**.



The **lines** created by Tucson's city streets form a **grid pattern**.



Mount Lemmon appears **wrinkly** and is covered with a **green** forest.



The joint NASA/USGS Landsat program provides the longest continuous space-based record of Earth's land in existence. For nearly half a century, the Landsat mission has shaped our understanding of Earth. Since the launch of the first Landsat satellite in 1972, the mission has gathered and archived millions of images of our home planet's terrain, including farm fields and sprawling cities, forests and shrinking glaciers. Every day, Landsat satellites provide essential information to help land managers and policy makers make wise decisions about our resources and our environment.

Landsat 9 will collect the highest quality data ever recorded by a Landsat satellite, while still ensuring that these new measurements can be compared to those taken by previous generations of the Earth-observing satellite.

