LESSON 1

WHAT IS ZOOLOGY?

flying higher

As we study the flying creatures in this book, you may find yourself astonished at some of the things you learn this year. When you do, remember that God created these awe-inspiring creatures and their features.

Then God said, "Let the water swarm with living creatures, and let birds fly above the earth across the expanse of the sky." So God created the large sea-creatures and every living creature that moves and swarms in the water, according to their kinds. He also created every winged creature according to its kind. And God saw that it was good. God blessed them: "Be fruitful, multiply, and fill the waters of the seas, and let the birds multiply on the earth." Evening came and then morning: the fifth day.
Genesis 1:20–23

WELCOME

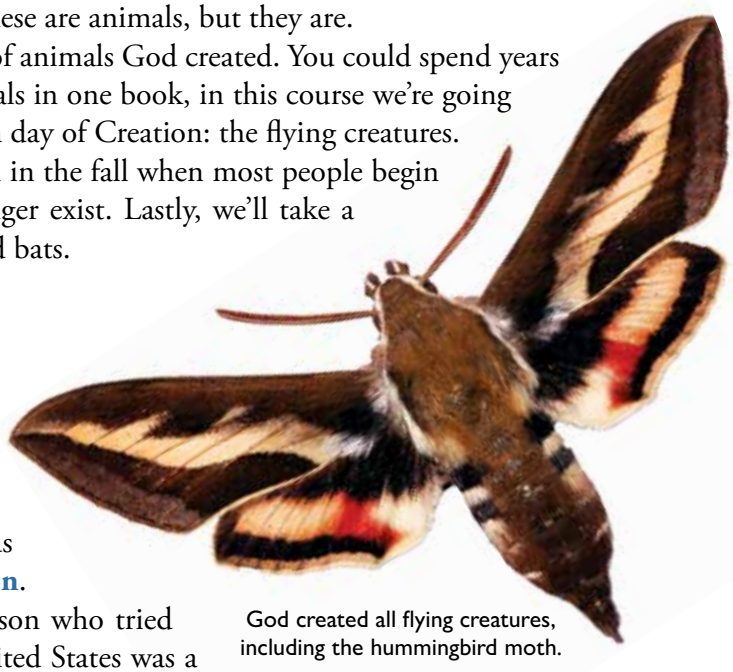
Welcome to the study of zoology! Did you know that you've actually studied zoology before? Every time you examined an insect or watched a squirrel in your backyard, you were doing zoology, because **zoology** is the study of the animals God made. All animals are included in zoology, even fleas, ants, and spiders. Some people don't realize that critters like these are animals, but they are.

Try to picture in your mind all the different kinds of animals God created. You could spend years learning them all! Instead of trying to study all the animals in one book, in this course we're going to focus on a special group fashioned by God on the fifth day of Creation: the flying creatures.

We will start with insects because they are plentiful in the fall when most people begin this book. Then we'll discover pterosaurs, which no longer exist. Lastly, we'll take a closer look at beautiful soaring creatures we call birds and bats.

OBSERVING NATURE

As you study flying creatures this year, you will learn to think like a scientist, see like a scientist, and record what you observe the way scientists do. Many scientists keep a nature journal in which they write about and draw what they see in nature. One of the most famous people to do this was a man named **John James Audubon**.



God created all flying creatures, including the hummingbird moth.

Audubon lived in the 1800s and was the first person who tried to write about and draw every bird in America. The United States was a young country then, and Audubon was one of the first to draw and paint America's wildlife. Even today, people still refer to and enjoy his drawings of America's birds. Later, a group called the Audubon Society was formed to study birds, and it's still in existence today.

Let's look at a few of Audubon's paintings. Notice his incredible attention to detail.

Audubon was very observant, wasn't he? You'll learn to be observant, too, as you study zoology this year. Before long, you'll be seeing the world just like Audubon. Let's start now training your eyes to see, your ears to hear, and your mind to think like a scientist.

Activity 1.1
NATURE JOURNALING

From now on, you'll be keeping your very own nature journal. Your nature journal will be a record of all the interesting things you observe in nature. You will write about these things, draw them to the best of your ability, and even collect items that can lay flat and be taped onto the pages of your journal. You can create one, or you can use the specially designed nature journal pages in the back of your Zoology 1 Notebooking Journal. Throughout the course, you will be encouraged to go outdoors and record what you see. When in nature, look carefully around. What do you do see? What do you hear? What do you smell? What is new and different? What is the same from season to season? Record your most interesting observations in your journal with words and pictures. Be sure to include somewhere on the page the date, the time, and the weather.

Take your nature journal outside now with some colored pencils and something to write with. Look around you. What kinds of things do you see? Maybe you notice the color of the leaves, moss growing on a tree, or the number of sticks lying on the ground. Perhaps you see an acorn, an ant, a caterpillar, or a bird. What flying creatures are in the area? Begin recording what you see by writing down or drawing pictures of the interesting things around you.

Activity 1.2
GO ON A NATURE SCAVENGER HUNT

Now that you have spent some time observing the world for yourself, it's time to begin your Nature Scavenger Hunt. Here is a list of items to find on your scavenger hunt. You might find some today, but you will discover many of these items throughout the year. If you have a Zoology 1 Notebooking Journal, you will find this list with boxes to check off as you discover each item on the list. Every time you find an item, make a check mark by it.

SCAVENGER HUNT LIST

- ❒ A hole in a tree high above the ground

- ❒ A leaf with eggs laid on the underside
- ❒ A leaf with eggs laid on the upper side
- ❒ A gall (an unusual growth) on a leaf or a plant (oak leaves and branches commonly have them)

- ❒ A beetle
- ❒ An anthill
- ❒ A bumblebee

- ❒ A grasshopper that has wings and can fly (best found in late summer)
- ❒ A praying mantis or one of its egg cases
- ❒ A dragonfly

- ❒ A butterfly with yellow colors
- ❒ A butterfly with brown colors
- ❒ A butterfly with orange colors
- ❒ A butterfly that is mostly white

- ❒ The cocoon of a moth or the chrysalis of a butterfly
- ❒ A caterpillar (the young version of a moth or butterfly)

- ❒ Three feathers found on the ground (NOTE: If you wish to collect them, the feathers must come from a game bird like a duck, goose, pheasant, chicken, dove, etc. Many other birds are protected as endangered species, and it is illegal to keep their feathers.)
- ❒ A bird with red coloring on it
- ❒ A bird with blue coloring on it
- ❒ A bird's nest (Do not take it home!)
- ❒ A bird soaring through the air
- ❒ A flock of birds

- ❒ A bird's eggshell on the ground (best found in spring or early summer)
- ❒ A type of bird (other than a duck or goose) that is using water in some way
- ❒ The sound of a bird singing (See if you can find it by following its sound.)
- ❒ The sound of a woodpecker drumming
- ❒ A bird carrying food or nesting material

- ❒ A bat flying through the sky (Look for bats in the evening around dusk.)

Before you learn about specific types of flying animals, let's spend a few moments to talk about how scientists put animals in groups. Then we'll discover how God designed the wings that help some creatures fly.

ANIMAL CLASSIFICATION

Scientists who study animals are called **zoologists**. They have a tough job because there are a *great many* animals in creation. In order to organize and study all these animals, scientists place them into groups based on how similar some animals are to one another. Then they name each animal based in part on the group it belongs to.

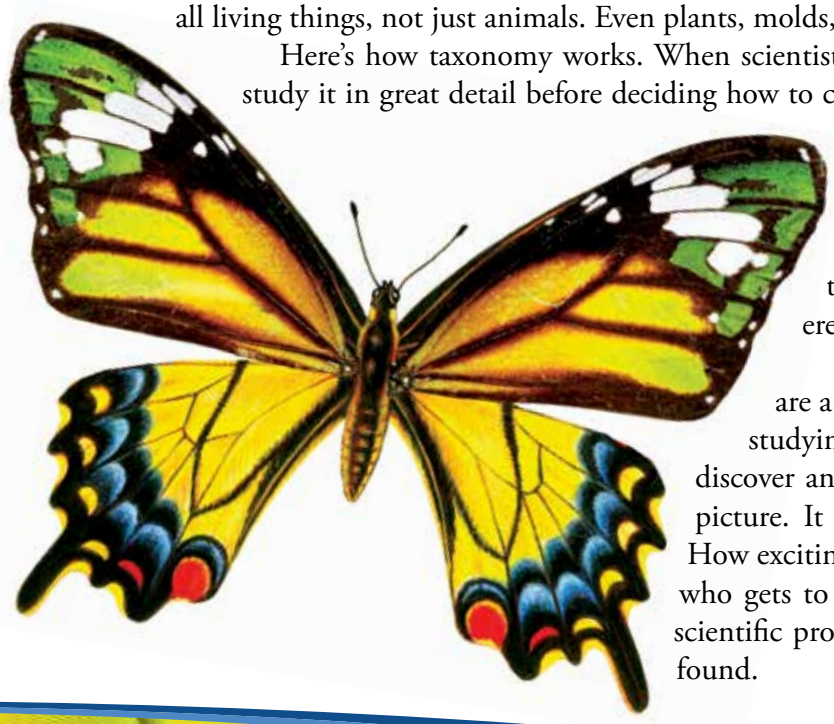
Did you know that God gave Adam work to do in the Garden of Eden? One of his jobs was to name the animals. All of them!

> ***The LORD God formed out of the ground every wild animal and every bird of the sky, and brought each to the man to see what he would call it. And whatever the man called a living creature, that was its name.***
> **(Genesis 2:19)**

God brought each animal to Adam to see what he would name it.

Taxonomy

So you see, Adam had the honor of naming all the animals in the Garden. Today, people are still doing what Adam did. Whenever an animal is newly discovered, it's placed into a group and then named. This process is called **taxonomy**. The word comes from a pair of Greek roots meaning "arrangement method." Taxonomy is used to group and name all living things, not just animals. Even plants, molds, and bacteria are grouped and named.



Here's how taxonomy works. When scientists learn of a newly discovered animal, they study it in great detail before deciding how to classify it, or group it. Wouldn't it be fun to discover an unknown animal? Believe me, there are animals discovered every single year, often deep in the jungle or deep, deep in the ocean. In fact, in 2018, more than 200 living things were newly discovered—and lots of them were flying creatures!

For this section of the book, pretend you are a zoologist hiking through the rainforest and studying the animals you find there. Suddenly, you discover an animal that looks like the creature in this picture. It has never been scientifically documented. How exciting! Because you discovered it, you're the one who gets to classify and name the creature. Here's the scientific process you will follow to classify what you've found.

Kingdom

First, scientists determine which kingdom group applies to a living thing they have discovered. Since your creature would be considered an animal, you will place it into a very big group called the **animal kingdom**, or ***Kingdom Animalia*** in Latin. (I'll explain later why scientists use Latin.) There are other kingdoms used to group plants, non-animal organisms, and microscopic living things such as bacteria. But since this book is focused on Kingdom Animalia and you know your winged creature is an animal, you have got our animal grouped in the right place for now. But we need to go further. Why? Because scientists organize animals together into smaller groups that share similar features in order to better study them.

Your backbone, or spine, protects your spinal cord.

Phylum

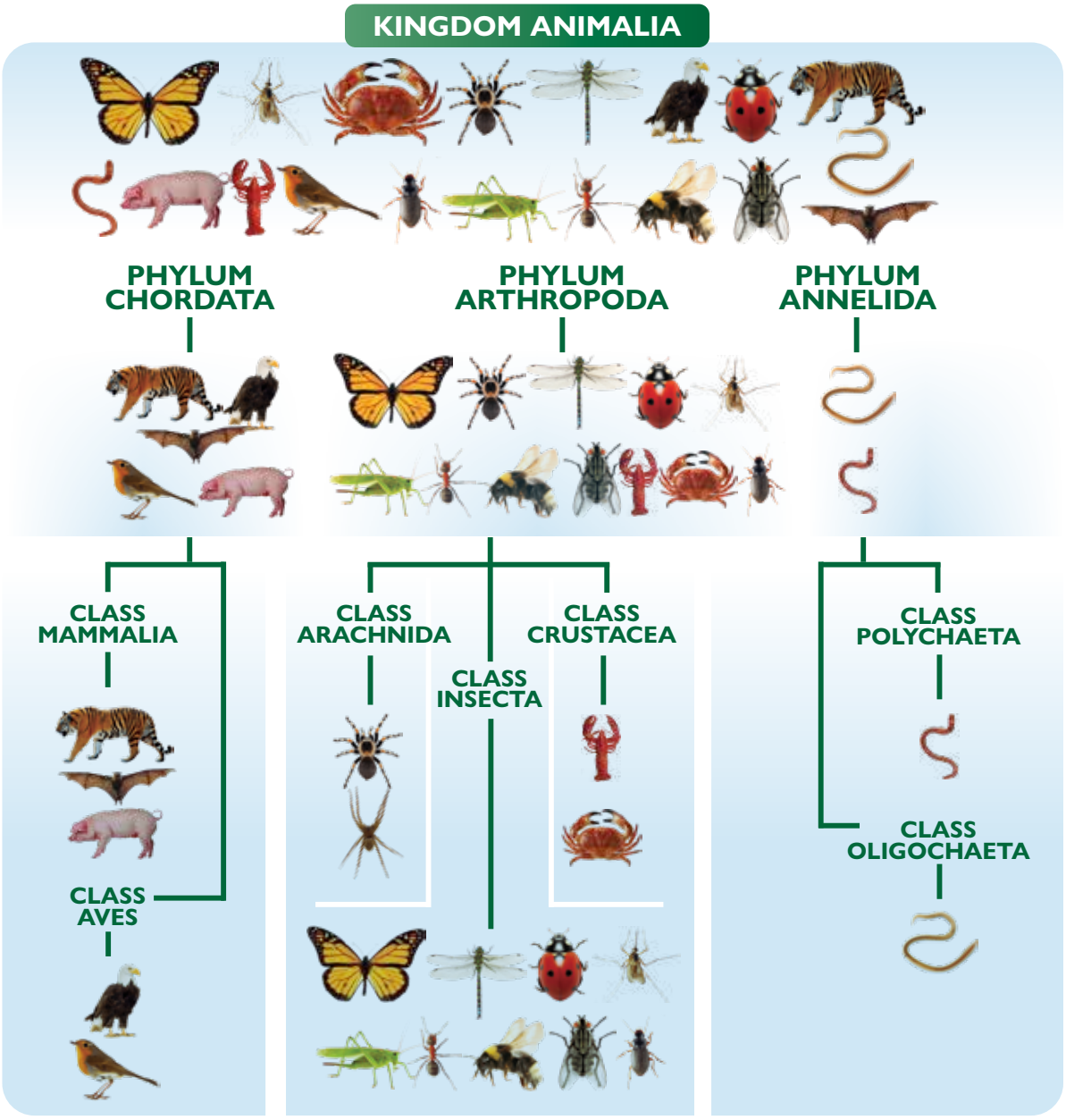
Now that we have classified your creature in the huge group called Kingdom Animalia, it's time to place it in a smaller group, called a **phylum**, with other similar animals. Each phylum group has its own scientific name. For example, all animals in the animal kingdom that have a backbone, or spine, are separated and placed into phylum **Chordata**. Do you have a spine? Yes, you do. You can feel it if you run your fingers down the middle of your back. This means you are in phylum Chordata along with all creatures that have a spine. The easy way to remember the name Chordata is to remember that inside the spine is a special cord of nerves. That nerve cord is so important that if you were to injure it badly, you might never be able to move your arms and legs again. No wonder God placed it inside the bones in your spine. This cord must be protected!

This ant does not have a backbone. Is it a vertebrate or an invertebrate?

Animals that have backbones are also called **vertebrates**. That's because the backbone is made up of bones called vertebrae. Animals without backbones, such as insects, are called **invertebrates**. The prefix *in-* before the word *vertebrate* means "not." Basically, all animals either have a backbone or they do not have a backbone. There's a big difference between animals with a backbone and those without one. We'll study both kinds of animals in this book. Interestingly, there are a *lot* more invertebrates than vertebrates in the animal kingdom. Because of this, they must be grouped in several phyla (the plural of *phylum*), unlike vertebrates that can all be placed into the phylum Chordata.

This tiger does have a backbone. Is it a vertebrate or an invertebrate?

Look at the diagram below. **Arthropoda** is one phylum made up of animals without a backbone. Crabs, lobsters, spiders, and insects are in this phylum. Another phylum that contains animals without a backbone is phylum **Annelida**. Earthworms are put here. There are other phyla of invertebrates, but we won't discuss them now.



This diagram illustrates part of the classification process. The creatures in the upper box are in the animal kingdom. They are then grouped into different phyla based on their similarities. Next, they are grouped into classes. This is only a partial illustration. The classes will be subdivided into smaller and smaller groupings.

Based on the *Kingdom Animalia* diagram, which phylum would your newly discovered creature go into? If you said the phylum Arthropoda, you are correct! Why? Because your new creature is obviously some type of butterfly.

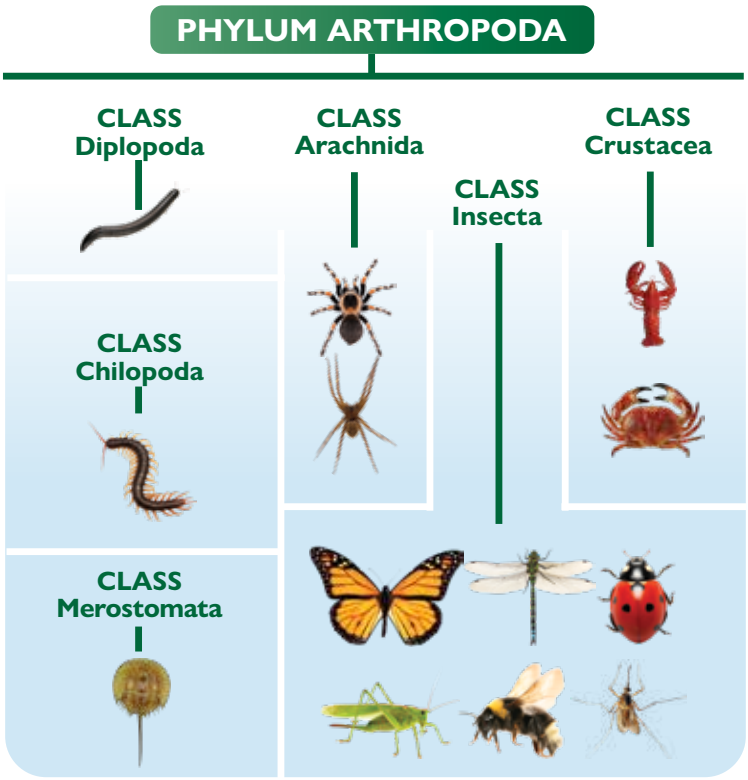
Explain what you have learned so far about how animals are grouped.

Class

As I mentioned before, animals in each phylum are further divided into groups called **classes**. For example, look back to the previous page. Birds are placed in their own class, called **Aves**. Animals that have fur or hair, give birth to live babies (not eggs), and nurse their babies with mother's milk are put into a class called **Mammalia**.

The creatures in phylum arthropoda are further divided into classes like **Insecta** (mostly arthropods with 6 legs) and **Arachnida** (mostly arthropods with 8 legs). Some people think spiders are insects, but they are not. Why? Because spiders have 8 legs.

Look at the image to the right showing the different classes within Arthropoda. Some people don't think of butterflies as insects because they are so lovely. But they are, indeed, insects.



As you know already, your creatures is in class Insecta. Now it's time to figure out just what kind of insect it is.

Order

Now it's time to put your animal in the right **order**. That's what comes after class: order. One kind of flying creature will study this year is birds. Birds in class Aves are divided into orders based on the special characteristics of each bird. Birds of prey that have a hooked beak, like falcons, are grouped in the order **Falconiformes**; birds that perch on branches with 3 toes in the front and one flexible toe in the back that keeps them anchored to the perch are called **Passeriformes**; and birds that look like pelicans are in the order **Pelecaniformes**. You can see examples of these here.

Class Insecta includes more than 30 orders, but I'll just show you a few. See if you can place your insect in the right order within class Insecta. Notice how many of the orders are grouped and named based on how the creatures' wings look.

CLASS INSECTA

ORDER Lepidoptera
(scaly wings)
Example:
Butterfly

ORDER Odonata
(toothed flies)
Example:
Dragonfly

ORDER Coleoptera
(hard wings)
Example:
Ladybug

ORDER Orthoptera
(straight wings)
Example:
Cricket

ORDER Diptera
(two wings)
Example:
Mosquito

ORDER Hymenoptera
(membrane wings)
Example:
Ant/Bee

ORDER Blattodea
(insect avoiding light)
Example:
Cockroach

ORDER Trichoptera
(hairy wings)
Example:
Caddisfly

ORDER Mantodea
(like a prophet)
Example:
Praying Mantis

ORDER Siphonaptera
(tube without wings)
Example:
Flea

ORDER Phasmantodea
(like a ghost)
Example:
Walking Stick

ORDER Hemiptera
(half wings)
Example:
Cicada

Hopefully, you figured out that your butterfly-looking insect belongs in the order **Lepidoptera**. This word comes to us from Ancient Greek words meaning "scale wing." Scientists who study butterflies and moths are called lepidopterists.

Family

Scientists divide the orders into smaller groups called **families**. For example, if a butterfly has tiny front legs, it's put into a special group of butterflies with tiny front legs. There are 135 families in the order Lepidoptera.

Some of the major families of actual butterflies (not moths) are shown here:

ORDER LEPIDOPTERA

FAMILY Danaidae
(milkweed butterflies)
The adults are reddish-orange with black and white markings. The larvae feed on various species of milkweed. This family includes the monarch *(Danaus plexippus)*.

FAMILY Pieridae
(whites and sulfurs)
The adults are predominantly white or yellow with black markings. The imported cabbage-worm *(Pieris rapae)* is a pest throughout the world.

FAMILY Papilionidae
(swallowtails)
The hind wings have a tail-like extension. The tiger swallowtail *(Papilio glaucus)* is a cosmopolitan species.

FAMILY Nymphalidae
(brushfooted butterflies)
The front legs are reduced in size. This is the largest butterfly family. It includes the fritillaries, admirals, emperors, and tortoiseshells.

FAMILY Lycaenidae
(blues, coppers, and hairstreaks)
The hind wings are fluted. Some species are extinct or nearing extinction; others are very common. These butterflies are small.

FAMILY Hesperiidae
(skippers)
The antennal club is hooked at the tip. The silver spotted skipper, *Epargyreus clarus*, is a common species.

Take a look at your discovery again. Which family do you think it belongs in? Look carefully at the wing shape. Did you select family **Papilionidae**? If so, great job! All the butterflies in this group are called swallowtail butterflies. This is because they have a tail on the end of each of their wings. If you compare swallowtails, you'll see that some tails are longer and some are shorter.

So here's what we have so far: Your animal is in the kingdom Animalia, phylum Arthropoda, class Insecta, order Lepidoptera, and family Papilionidae.

Why do you think there are so many levels of groups in taxonomy?

Activity 1.3
COUNT THE SWALLOWTAILS

How many butterflies in the family Papilionidae (swallowtails) can you find in this collection? The answer can be found in the back of the book in the Activity Answer Key.

Genus

After family comes the group called **genus**. At this level, all the animals in a group share a lot of the same features. As you learned from the last activity, there are many different kinds of swallowtails. To group a swallowtail in the correct genus, scientists look for very specific features like the shape of the eggs it lays, whether its wing has an "eyespot" marking on its wing, or where the eyespot is located.

Black swallowtail or *Papilio maackii*

Unfortunately, it would be difficult for us to figure out the right genus for your new discovery unless we were to study the animal for a long time. Let's assume that because your newly discovered butterfly has some unique qualities, it belongs in genus *Papilio*. This brings us to an interesting fact: Once we have put the animal in a genus, we now know the first name of the animal. Your animal's first name is *Papilio*.

Notice that, like your first name, the animal's genus is always capitalized. But unlike your name, it must be italicized too.

Species

Now for the final group, the **species**. This is the most specific grouping used when scientists classify animals. The important thing to remember about animals in the same species is that a male and female can mate and have babies.

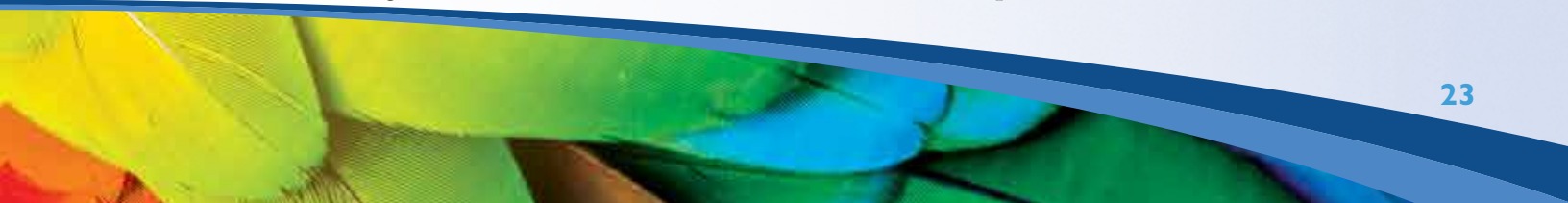
When a living thing is placed within a species group, that species becomes the creature's last name. Oftentimes, the person who discovered the creature will use his or her own name for the species. So if I were naming the new butterfly after myself, I would name it *Papilio fulbright* and write it like that. When writing the species name, it should be italicized, but it's never capitalized.

Activity 1.4
NAME YOUR BUTTERFLY

Now it's time to draw your butterfly and write out its scientific name. If you have a Zoology 1 Notebooking Journal, you will find a page with the outline of the butterfly. Color it and then write out its name under the image. Be sure to italicize it! Capitalize its genus but not its species.

Activity 1.5
MAKE A MNEMONIC

To help you remember the system of classification that scientists use, you can think of this sentence: **K**ings **P**lay **C**hess **O**n **F**ine **G**lass **S**ets. This is a mnemonic phrase. It helps you remember the order of classification groups because the first letter in each word is the same as the first letter of each classification group from the largest to the smallest: **K**ingdom, **P**hylum, **C**lass, **O**rder, **F**amily, **G**enus, and **S**pecies.



Sometimes it's easier to remember a mnemonic if you've created it yourself. Create a sentence that makes sense to you and will help you remember the order of classification groups used in taxonomy. The sentence must have 7 words that start with the letters shown in the diagram:

Kingdom	Phylum	Class	Order	Family	Genus	Species
K	P	C	O	F	G	S

Now that you know the sentence "Kings play chess on fine glass sets" and you've created your own mnemonic, you understand that the first letter of each word corresponds with the name of a classification group. Let's see if you can recite the groups in order. Practice for a while and then say it for a parent. Could you do it without looking? That's awesome!

Binomial Nomenclature

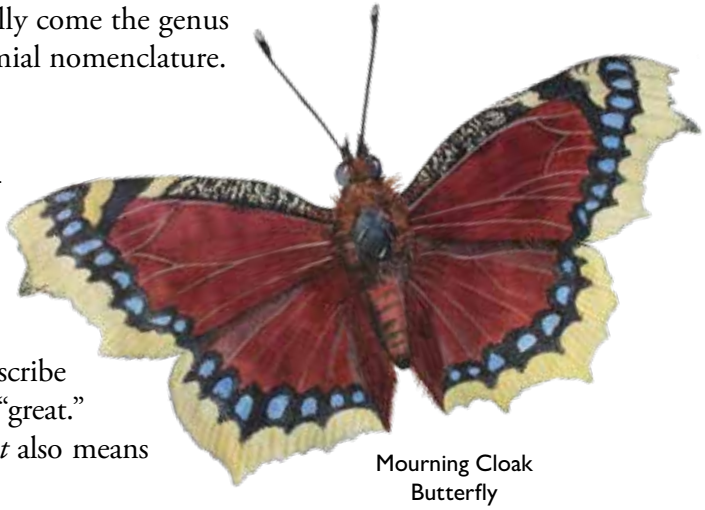
You have learned a lot in zoology so far. Not only did you learn all about the classification system that scientists use, you classified your own animal. That's amazing. Another amazing thing you did is you used a system called binomial nomenclature to name your animal. That's a big word that goes along with the big work you did.

Let's talk about this system of using 2 words to name an animal. As we have seen, an animal's first name is its genus, and its last name is its species. We call this 2-name system **binomial nomenclature**. In addition to its scientific name, each animal is usually given a common name, but common names are often different in each country. That's one reason why scientists use Latin to name animals officially. We'll explore the reason for this further, but first, let's take a minute to review what we've learned.

As you know, the process for naming and classifying animals is called taxonomy. The largest taxonomic group is called a kingdom. The next group is called a phylum. And then comes the class. After that, we have orders. This is followed by family. And finally come the genus and species, which give us an animal's name according to binomial nomenclature.

Why Latin?

So far, you have read a lot of Latin words. And that's very common when studying science. Scientists all over the world use Latin to name plants and animals. Why? Because it's a language that many people learn yet no one speaks in their everyday lives. Therefore, it never changes. English, on the other hand, changes all the time. Several years ago the word *cool* was used only to describe the temperature. Later, *cool* also came to mean "fashionable" or "great." The word *neat* once meant "tidy and clean." Now the word *neat* also means "enjoyable" or "excellent."



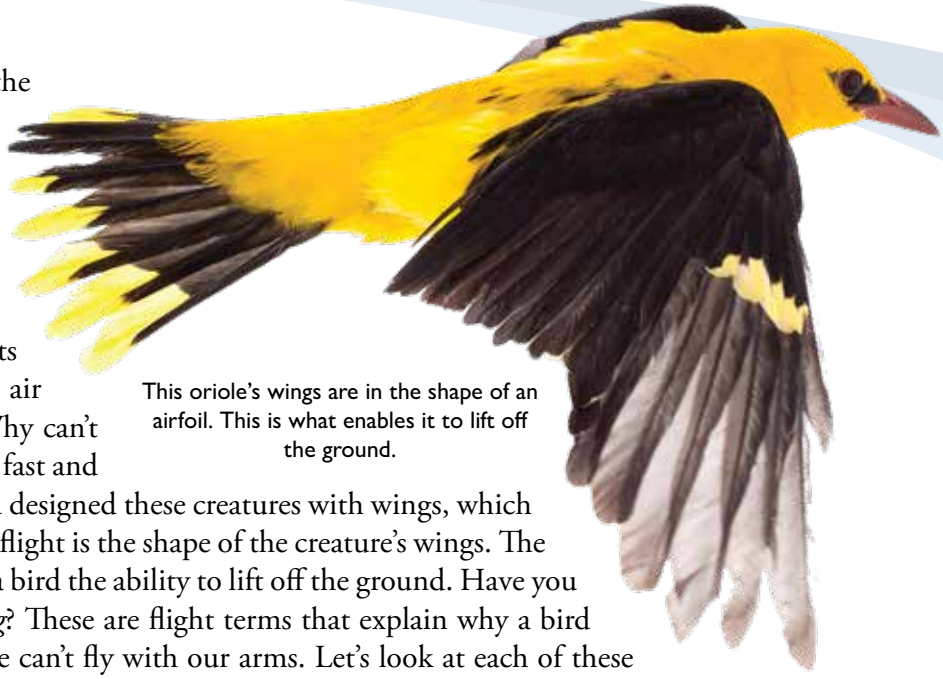
Mourning Cloak Butterfly

Latin is helpful to scientists because the meanings of Latin words do not change. Therefore, scientists all over the world can work together to understand nature, even though they don't all speak the same language. For example, a butterfly that we call the "mourning cloak" in the United States is called a "Camberwell beauty" in England, while in Germany it is called a "Trauermantel." Its scientific name, however, is *Nymphalis antiopa*. Since this name comes from Latin, it doesn't change from country to country. Scientists from every country will know which butterfly is being discussed when it is called by its scientific name.

Tell someone why Latin is used for classifying animals.

FLIGHT

Handsome creatures speckle the sky and declare the glory of God with their unique ability to fly. These creatures remind us how wonderful God is to have made such beautiful, astonishing animals.



This oriole's wings are in the shape of an airfoil. This is what enables it to lift off the ground.

Birds, bats, and many insects glide, soar, and sail through the air with ease. How do they do it? Why can't you and I just flap our arms really fast and join them in the air? Because God designed these creatures with wings, which we don't have. A key structure for flight is the shape of the creature's wings. The wings' **airfoil** shape is what gives a bird the ability to lift off the ground. Have you ever heard the words *lift* and *drag*? These are flight terms that explain why a bird can fly with its wings and why we can't fly with our arms. Let's look at each of these terms in a way that will help you understand what they mean.

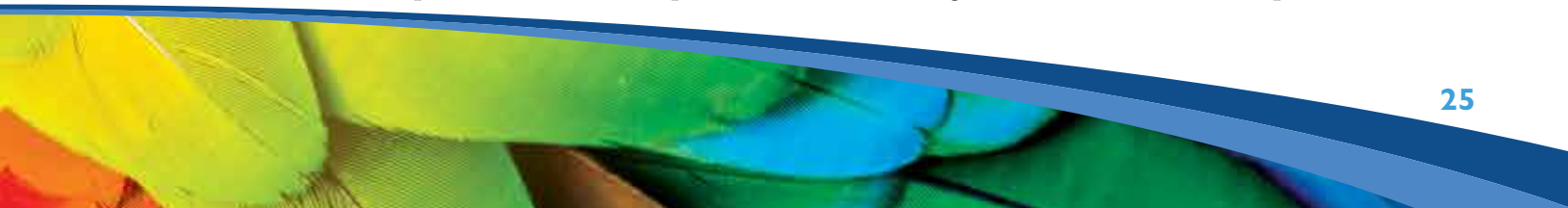
Long ago, in the 1700s, a man named **Daniel Bernoulli** did some experiments with objects under water. These experiments actually help us understand how things fly. You might be asking yourself what water has to do with lifting things up into the air. Well, we're going to learn about one of God's invisible creations and how He made the air so that birds can fly.

Air, just like water, applies pressure on everything it touches. You see, air may not be visible, but it's not just empty space. Air actually weighs something, just like water. Air has a lot of stuff in it—colorless, odorless gasses that are all around you. So when you walk through air, all that stuff is actually pressing against you. Of course, it's a lot easier to walk through air than to walk through water, because water is much denser than the stuff in the air. Nevertheless, walking through air is just like walking through a swimming pool, only much easier.

Walking through water

Walking through air

Let's do an experiment that will help us see that air has weight, or mass, and is made up of matter.



Activity 1.6
EXPERIMENT WITH AIR

You will need:

- Balloons (2 the same size)
- String (3 pieces, each 7 inches long)
- Ruler
- Tape
- Needle

You will do:

1. Inflate the 2 balloons until they are the same size and tie them shut.
2. Tie a piece of string to each balloon.
3. Tape the other end of each string to opposite ends of the ruler, ensuring they are exactly the same length. The balloons will dangle below the ruler.
4. Tie the third string to the center of the ruler.
5. Hang the middle string from the edge of a table using tape. Find the balance point so that the ruler is parallel to the floor. The balloons should be evenly balanced at the same height above the floor.
6. Puncture one of the balloons with the needle.

What happened when you popped one of the balloons? How does this show that air is a substance with weight and matter?

In the "Experiment with Air" activity, the reason popping a balloon caused the ruler to tip upward on that side is because the balloon on the other end of the ruler still had air in it and so was heavier than the popped balloon. When the empty balloon's air escaped into the room, the air that remained compressed inside the full balloon weighed the balloon down.

Now let's talk about air pressure.

Uplifting Pressure

The air around you is pressing on you all the time, even though you don't notice or feel it. That's because your body was created to push back. This pressing of air against you is called **air pressure**. Air pressure changes depending on such things as weather conditions and elevation. When air pressure is high, it means lots of air is pressing hard against you. If air pressure is low, there's less air and it isn't pressing as hard.

Up on the highest mountains, air pressure is less because the air is thinner. That means there's not as much air, so your body needs to work harder just to get enough air to breathe. At the bottom of the mountain, it will be easier for you to breathe. There, air pressure is greater because there is more air and more matter in that air.

Airfoil

Bernoulli, the scientist I mentioned before, discovered that when he made water move quickly against objects that were in the airfoil shape of a bird's wing, the water moved differently on top of the wing compared to the

bottom of the wing. As the water moved along the top of the wing, it actually sped up, which caused it to push down with less pressure. The water that moved along the bottom of the wing did not speed up, so it pushed on the wing with the same pressure as always. So the water below the wing pushed up more strongly than the water above wing pushed down. What happens if you push *up* on something more strongly than you push *down* on it? It rises, doesn't it?

When air flows across a bird's wing, the air that travels above the wing moves more quickly than the air that travels below the wing. This causes more pressure on the bottom of the wing than on the top, which lifts the wing, making the bird fly.

The same thing happens with air and a bird's wing. Faster-moving air on top of the bird's wing pushes down on the wing with lower pressure, while the slower-moving air pushes up on the underside of the wing with higher pressure. As a result, the air pushes the wing up harder than it pushes the wing down. This causes the wing and bird to rise. In other words, the air lifts the wing. Because of this, scientists say that the difference in air pressure above and below a wing provides **lift**.

Activity 1.7
EXPERIMENT WITH AIR PRESSURE

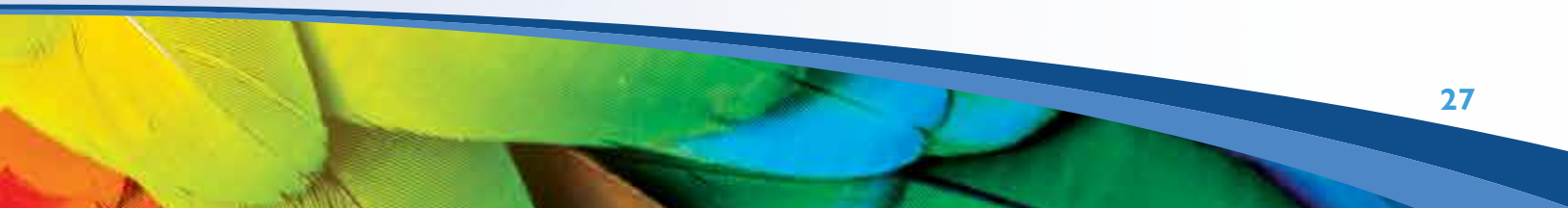
You will need:

- Water (a cup full)
- Straws (2)
- Scissors

You will do:

1. Place one straw in the water and cut it so that it sticks out of the water only about a half inch.
2. Put the cup with the straw in it next to the edge of a counter or table and squat down so your eyes are level with the cup.
3. Use your fingers to hold the cut straw against the edge of the cup.
4. Point the other straw at an angle toward the top of the straw in the cup and blow through it. Angle the straw upward so that the air coming out of it passes right over the top of the straw in the cup.
4. Keep blowing and blowing. This will make the air move faster over the top of the straw in the water. As a result, the air pressure above the straw in the water will decrease. With less air pressure above the straw, what do you think will happen? Try it and see!

Did a stream of water squirt out the straw that was in the cup? It should have, if you blew at the right angle. Be sure not to blow on the water in the cup; blow only at the tip of the straw. Keep trying until it works, then read on to discover why this happened.

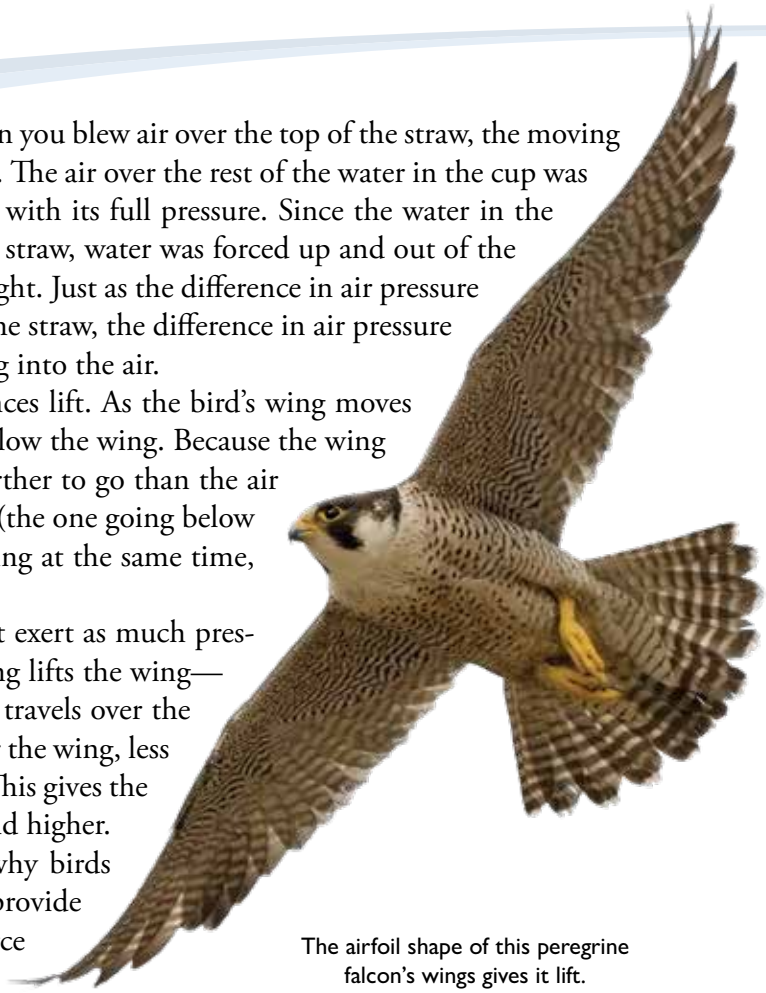


So what happened in the last experiment? Well, when you blew air over the top of the straw, the moving air could not press down as hard on the water in the straw. The air over the rest of the water in the cup was not moving, so it continued to press down on the water with its full pressure. Since the water in the cup was being pressed down harder than the water in the straw, water was forced up and out of the straw! This is a lot like what happens to a bird's wing in flight. Just as the difference in air pressure over the straw and the rest of the cup lifted water out of the straw, the difference in air pressure between the top and bottom of a bird's wing lifts the wing into the air.

The airfoil shape of a bird's wing is why it experiences lift. As the bird's wing moves through the air, some air goes above and some air goes below the wing. Because the wing is curved, the air moving over the top of the wing has farther to go than the air moving underneath the wing. In order for the 2 air flows (the one going below and the one going above) to make it to the end of the wing at the same time, the air on top of the wing must move faster.

As your experiment showed, fast-moving air cannot exert as much pressure as slow-moving air. That pressure difference on a wing lifts the wing—and the bird—into the air. As the bird speeds up, the air travels over the wing even faster, and as the air travels faster and faster over the wing, less and less pressure is placed upon the top part of the wing. This gives the wing more and more lift, causing the bird to go higher and higher.

Speed is very important for creating lift. This is why birds flap their wings. When a bird flaps its wings, the wings provide a force that makes the bird go faster. Scientists call this force **thrust**. The more thrust, the faster the bird goes—and the greater the lift on its wings!



The airfoil shape of this peregrine falcon's wings gives it lift.

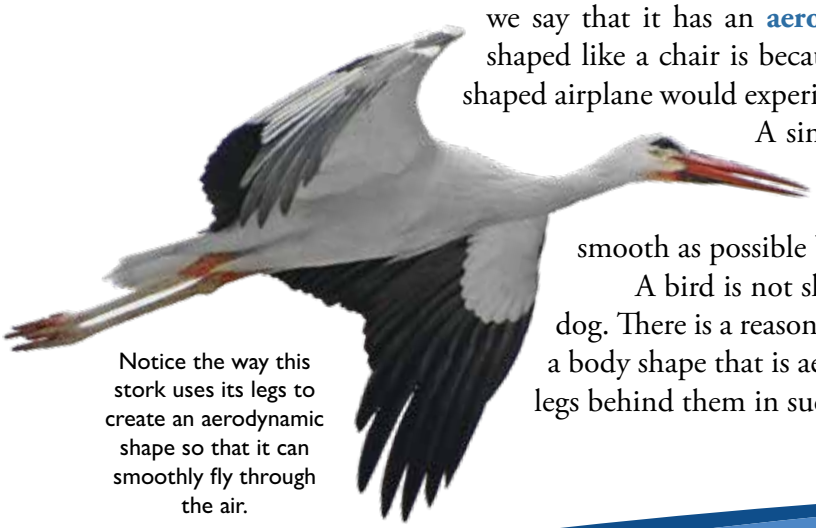
Explain to someone what you have learned so far.

Dragging You Down

Although the speed of the air over an airfoil gives lift, staying in the air is difficult because there is another force that tends to slow an object in flight. This force is called **drag**. Drag resists, or pushes against, an object as it travels through the air. You may have felt this drag when you ran against the wind on a windy day. If you were shaped like a knife, it would be easier for you to run through the windy air, because the air would not drag against you as strongly. When an animal or object can travel through the air without experiencing a lot of drag, we say that it has an **aerodynamic** shape. The reason an airplane isn't shaped like a chair is because it wouldn't be very aerodynamic. A chair-shaped airplane would experience a lot of drag as it traveled through the air.

A similar principle is at work for objects traveling through water. Competitive swimmers want to reduce drag, so they make themselves as smooth as possible by wearing swim caps and shaving their legs.

A bird is not shaped like a pig, and a bat is not shaped like a dog. There is a reason for this. God created each flying creature with a body shape that is aerodynamic. Even long-legged storks trail their legs behind them in such a way as to make themselves aerodynamic.



Notice the way this stork uses its legs to create an aerodynamic shape so that it can smoothly fly through the air.

Activity 1.8
MAKE A PAPER AIRPLANE

Let's make a couple of airplanes and conduct an experiment with them.

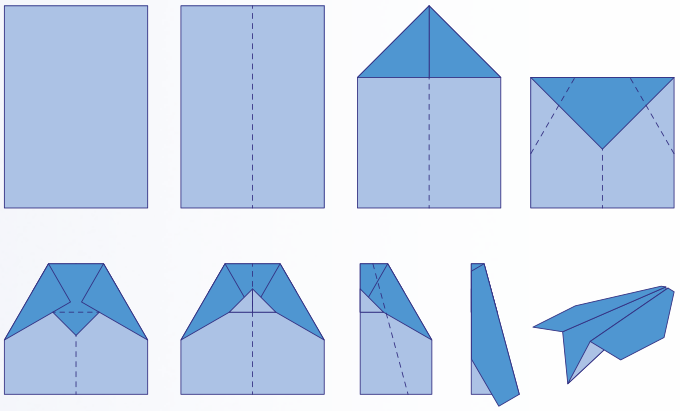
You will need:

- Two sheets of paper
- A tape measure

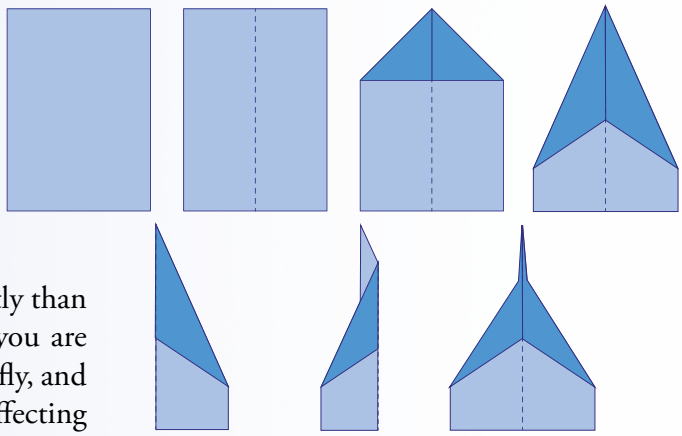
You will do:

1. Follow the visual instructions on the right for folding your airplanes.
2. Once you have folded your 2 airplanes, guess which one will fly the farthest. Which one will stay in the air longest? This kind of guess is called a **hypothesis**. Don't fly your planes until you have formed a hypothesis about how the planes will fly.
3. Write down your hypothesis in your Notebooking Journal. Also, write down why you made that guess.
4. Practice tossing your paper airplanes into the air to get a feel for how to best launch your aircraft.
5. Choose a starting place to launch your planes for the test. Toss each plane from that place.
6. With your measuring tape, measure how far each flew.
7. Record the results in your Notebooking Journal.
8. Repeat the test 2 more times.

AIRPLANE 1



AIRPLANE 2

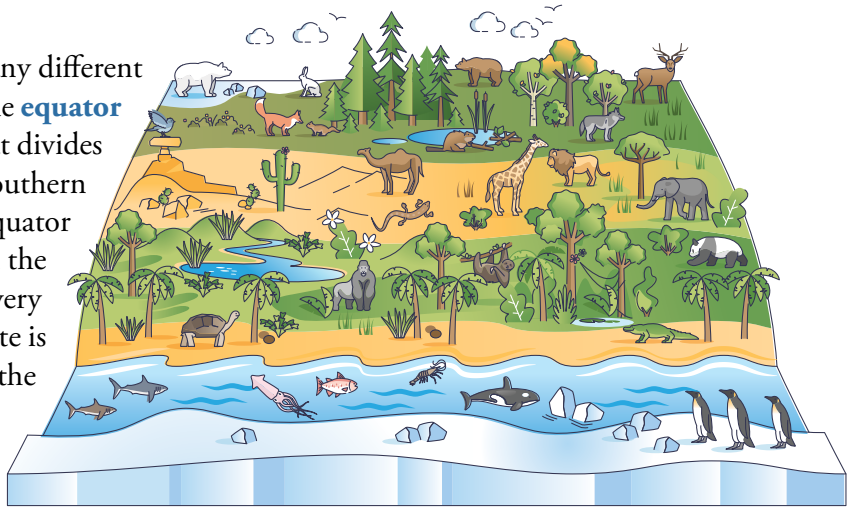


Was your hypothesis correct? Why do you think it was or was not correct? What happened? Ponder this until you have come up with a conclusion. Now you are learning to think like a scientist!

As you could see, wing shape is very important in flight. Every animal with wings flies differently than other animals with different wing shapes. When you are out in nature, take a look at how different creatures fly, and consider the shape of their wings and how it is affecting that creature's flight pattern.

Now let's take a look at where animals live and examine some interesting features and behaviors God gave animals to help them survive. We will also look at some animals that did not survive and became extinct.

HABITATS



God created the world and filled it with many different and interesting places for animals to live. The **equator** is an imaginary circle around our planet that divides Earth into the northern hemisphere and southern hemisphere. Places that are close to the equator stay warm all year. The farther you get from the equator, the cooler the winters are. At the very top and very bottom of the globe, the climate is cold most of the time. We call these places the North and South Poles.

As you probably already know, some kinds of animals prefer a certain part of the Earth over other areas. We call the places where animals live habitats, or biomes. There are many different kinds of habitats including hot, dry deserts; icy polar regions; hot, humid rainforests, or jungles; temperate forests that are warm in the summer and cold in the winter; mountain habitats; and urban areas in and around a city. There are also wet habitats, like the ocean. You probably already know more about habitats than you think. Let's do a fun activity to find out how much you know.

Activity 1.9

MATCH ANIMALS TO THEIR HABITAT

See if you can guess which habitat is home to each of these animals. Each of these animals lives in either a polar, temperate forest, rainforest, or desert habitat. Can you place the animals in the right locations? The answers can be found in the back of your book in the Activity Answer Key.

a. parrot

b. woodpecker

c. penguin

d. ostrich

e. bat

CREATURE FEATURES

God gave survival skills to all of His creatures. In fact, He has given every animal special qualities to help them survive in their particular habitat. Take, for example, a bird that lives near the ocean and eats creatures found underwater. This kind of bird has feet that can both walk on sand and swim in the sea. There is webbing between their toes. We say they have webbed feet.

Some animals actually blend in so well with their environment that they are amazingly difficult to see. This helps them hide from other animals that might want to eat them. We call this survival quality **camouflage**. For example, parrots are brightly colored, matching the fruit that grows on trees in the rainforest where they live. Bats are usually darkly colored and difficult to see in the caves where they dwell, in trees, or in the sky at night when they come out to hunt.

Activity 1.10

SPOT THE CAMOUFLAGE

Can you spot the camouflaged animals in the images below? They are hard to find. Look for a screech owl, a praying mantis, a leaf insect, a common Quaker moth, and bats. You will find the correct answers at the back of the book in the Activity Answer Key.

Instinct

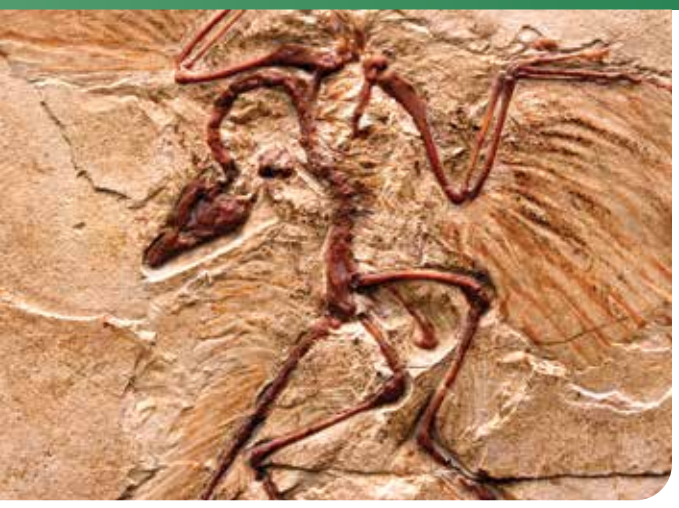
One of the amazing features God has given the creatures we will study is their remarkable **instinct**. An instinct is a built-in behavior that plays an important role in the animal's survival. It's not something a creature thinks about or has to learn; it's a behavior the animal does automatically. For example, a baby bird naturally throws its head back, opens its mouth wide, and hollers for food. It's his instinct to do so.

All of God's creatures have been given this special gift. Mother cats instinctively wrestle and bite their kittens, teaching them how to fight. Baby bats automatically cling to their cave wall. Birds begin building nests in the spring, even before there are eggs to put in them, and many birds instinctively fly to a special place each year where birds of their kind go to have their young. Grasshoppers just "know" to spit out the contents of their stomach on predators that try to eat them, the way emerald moths know to chew bits of flowers and stick them to their bodies to camouflage themselves. Likewise, butterflies naturally know which plant their young need to eat, and that's where they lay their eggs.

Isn't it amazing that God gave animals these important behaviors so that the species will survive to reproduce young? Many scientists believe animal instincts are evidence of the God who created the world around us. They say these instincts point to a Creator who built certain behaviors into animals to help them survive. Animals have limited intelligence and yet do some very intelligent things without even thinking about it.

think about this

The Bible says that God's law is written on the hearts of mankind (Romans 2:15). Because we are made in the image of God, we have the ability to choose to do what is right or what is wrong. This is a gift God gives to no other creature—the ability to choose how to behave. When we choose to follow God and live for Him, He promises to lead us and guide us, helping us to make the right decisions for our lives (Psalm 32). Animals don't have this option because they aren't made in God's image. Therefore, animals are given instincts, automatic "instructions" they follow to survive. This gift demonstrates that God takes care of all His creation, including the animals!



These are the fossilized remains of a bird that lived long ago.

EXTINCTION

Perhaps you have heard that some animals have become **extinct**. Sadly, this is true. An animal species becomes extinct when every single one of its kind dies and there are no longer any living on the Earth. How do we know these animals existed at one time? Some were described in books written long ago, and some were even photographed before becoming extinct. Some were discovered when scientists dug up bones, shells, and other traces of life that were preserved in rock. These preserved remains of animals that were once alive are

called **fossils**. Many animals have become extinct throughout the history of the world. We have recorded a few, but it's likely there are many more that have not been recorded.

Passenger Pigeon

How does a species become extinct? There are many ways this can happen. Sometimes, a change in the animals' habitat will cause them to die off. This change could be caused by an environmental shift, like a drought (a long time with no rain) or an ice age (a long period of cold weather). Or it could also be the result of a worldwide catastrophe, like the Great Flood described in Genesis 6–8.

Can you guess who created this painting of passenger pigeons? John James Audubon!

Some animals have died out because people hunted them or destroyed their habitats. The **passenger pigeon**, for example, was a common bird. In fact, scientists believe that at one time there were more passenger pigeons than any other type of bird on Earth. They estimate that in the 1800s, there were more than 2 billion of these birds. When traveling from one place to another, passenger pigeons flew in huge flocks up to a mile wide and 300 miles long! When these flocks passed over an area, the sky would be full of birds, to the point of blotting out the Sun.

So what happened to them all? Well, passenger pigeons ate a *lot* of food. They would noisily descend on orchards and fields, causing trees to topple as they gobbled up all the seeds in sight. Sometimes they destroyed the food supply of entire communities. So each year, people shot and killed millions of the birds. In fact, pigeon hunting was very profitable. Back then, people ate pigeons as often as we eat chicken today. Because a female passenger pigeon laid only one egg per year, they soon began to die out. The last wild passenger pigeon was shot in 1900 by a 14-year-old boy who had it stuffed. It is now in a museum.

think about this

All animals were created for God's glory, so perhaps animals that were once extinct will roam the new earth that God promises us in the Bible. One day, Jesus will create a "new heavens and a new Earth (2 Peter 3:13) and make "everything new" (Revelation 21:5). Now that would be an awesome sight!

Dodo Bird

The **dodo bird** is another bird that went extinct. When sailors found this flightless bird on an island in the Indian Ocean, they wrote about how strange and ungainly it was. It would waddle right up to the sailors, as friendly and fearless as could be, which the sailors didn't think was very smart. These men were hungry. After living on the open sea for months, they were starving for meat. Sailors often killed the fat, round-bottomed birds to fill their bellies.

Another problem was that the dodo bird laid its eggs on the ground. When pigs, monkeys, dogs, and rats were brought to the island, the dodo eggs were easily crushed or eaten. Within 80 years of its discovery, the dodo bird was extinct.

Model of a dodo bird from the 19th century.

Pterosaurs

Have you read about flying reptiles like the **pterosaurs**? We know they lived on Earth at one time because we have found their fossilized remains. However, scientists have not found any dinosaurs or pterosaurs living in the world today. We believe they are extinct.

think about this

Have you ever wondered what happened to the dinosaurs and pterosaurs that once roamed the Earth? I know I have. There are many different ideas about what caused dinosaurs to die out, but we have only a fossil record, not written documents, to tell us exactly what happened. What can we do? We can speculate based on what we do know. It's fun when you get to consider your own ideas to solve a science mystery. Most of the explanations for the dinosaurs' extinction involve some kind of worldwide disaster that dramatically changed the environment so that it no longer supported this type of animal life. Was it caused by a giant asteroid from the far reaches of outer space that collided with the Earth in such a violent way that most life didn't survive? Maybe there were volcanic eruptions that were so huge that the skies were filled with ash clouds that dramatically changed the environment. Perhaps the worldwide Flood recorded in Genesis 6–8 played a part in their eventual extinction. This is what I have come to believe based on my own research. But you'll have to do your own research and come to your own conclusion. You can explore this question further by visiting a museum that contains fossils and discussing with your family what you think happened. And maybe one day you will choose to become a paleontologist to help us solve this mystery!

Trumpeter swans were saved from extinction.

ENDANGERED

Animals whose populations are dying out and might become extinct are called **endangered species**. These days, people try to protect endangered species so that they won't go extinct.

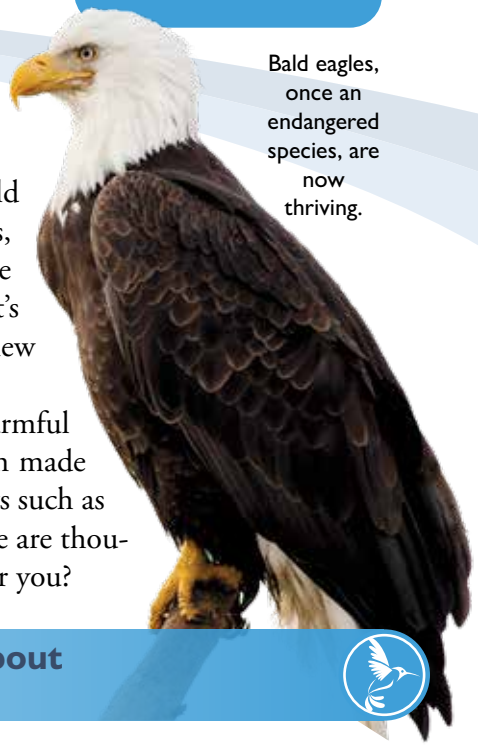
Trumpeter Swan

At one time, the **trumpeter swan** was an endangered species. There were once millions throughout North America, but Native Americans and European settlers hunted them for their meat, eggs, skin, and beautiful feathers. By the 1900s, so few trumpeter swans were known to remain that the United States passed the Migratory Bird Treaty Act of 1918, which made it illegal to kill the swans and many other birds. Caring people helped them survive by breeding and relocating the swans to protected areas in the wild. Soon, the population began to grow again, and today the trumpeter swan is no longer endangered.

Bald Eagle

The **bald eagle** has a similar story. There were once bald eagles all over North America, and they were selected by the U.S. Congress as the nation's symbol. Then in the 1800s, the landscape of America began to change, and the bald eagles began to die out. Their decline was likely caused by a number of factors, including the clearing of forests as settlers moved westward and hunting of the eagles' food supply (smaller birds and rodents). In the twentieth century, it's believed that bald eagle populations were further decreased by the use of new pesticides by farmers to protect their crops from insect damage.

To protect the eagles, Congress eventually banned some of the most harmful pesticides. They also passed the Bald and Golden Eagle Protection Act, which made it a criminal offense to hunt, capture, or even disturb the nest of an eagle. Laws such as these have helped the bald eagle population to recover and increase. Now there are thousands of bald eagles in North America once again. Do you have any living near you?



Bald eagles, once an endangered species, are now thriving.

Tell someone what you have learned about extinct and endangered animals.

EXTINCTION ERRORS

Usually, scientists say they believe an animal is extinct when no one has seen it for a long while. When this happens, scientists may even mount an expedition to try to find the animal in its natural habitat or where the last living one was seen. If they are unable to find the animal after years of searching, they consider it extinct. Sometimes, however, a supposedly extinct animal will turn up again in a different place.

Once thought to be extinct, Blackburn's sphinx moth was rediscovered on Maui.

Blackburn's Sphinx Moth

One example of an extinction error is **Blackburn's sphinx moth**. It was thought to be extinct because it could not be found in any of its normal habitats. However, in 1984, a small population of the moths was found on a Hawaiian island.

Miami Blue Butterfly

The **Miami blue butterfly** is another example of an extinction error. Everyone thought this butterfly became extinct after Hurricane Andrew wiped out the last known members of the species in 1992. Several years later, however, a person interested in butterflies found a whole colony of them in the Florida Keys.

Miami Blue Butterfly

Takahe

The **takahe** was also once thought to be extinct. This flightless bird once thrived in New Zealand. However, in the 1800s,

settlers brought red deer to New Zealand, and the deer began eating the grass that was the takahes' main food source. When weasels were brought in to control the rat population, the weasels began eating takahe eggs. By 1900, it was thought that the takahe population had been wiped out. However, nearly 50 years later, a group of the birds was discovered living in the valleys of the Murchison Mountains in New Zealand.

Takahes are beautiful blue-and-green birds.

This honeybee is collecting pollen.

Honeybees

This isn't a story of an extinction error, but an extinction misunderstanding. Not long ago, a rumor went around that the **honeybee** was on its way to becoming extinct. Many became fearful because honeybees were believed to pollinate many of our plants and crops that make up our food supply. People reasoned that if the bees were to die out, humans would not be far behind them in becoming extinct.

As it turned out, the rumor was not true. Recent studies have shown that honeybee populations are not, in fact, decreasing at an alarming rate. Also, most of the food we need to survive is not pollinated by honeybees. As you can see, it's important to research the scientific evidence before believing a scary rumor.

Activity 1.11
MOBILE MENAGERIE

Throughout this course, we will use our hands to create animals for a special zoo called a mobile menagerie. Mobile means "capable of moving or being moved." Of course, all the animals we craft will be animals that move, but you can also move this zoo around your home.

In each lesson, I will suggest an option for crafting an animal you've learned about. But you can also visit Pinterest, look in craft books, or use your imagination for making other animals. You can also find instructions for crafting an origami animal. Origami is a Japanese art form in which paper is cleverly folded into the shape of animal.

Usually, we will discuss only one type of animal in each lesson. But in this lesson, we have discussed a great many flying creatures. So you have many options available to you. My suggestion, however, is to craft a pterosaur. Below are instructions for crafting a small pterosaur called a Rhamphorhynchus.

You will need:

- Packet of air-dry modeling clay
- 2 paper clips
- 3 chenille stems (pipe cleaners)
- Tissue paper
- Glue
- Googly eyes

You will do:

1. Form an egg shape with ¾ of clay.
2. Pinch a smaller neck to define the head and form a beak at the end of the head.
3. Shape the body and insert a paper clip where the tail would go.

4. Attach chenille stems to create the arms and legs.

5. Roll a small piece of clay into a ball and form it into a diamond shape for the tail vane. Insert a paper clip into a tip of the diamond.

6. Let both the Rhamphorhynchus and the tail vane dry. Then, place your Rhamphorhynchus on a sheet of tissue paper. Draw wings in the shape of a crescent beginning from the middle of the torso, stretching out and around the arms, and ending at bottom of the neck as shown in the picture.

7. Cut out the wings and attach them with glue to the arms and the sides of your pterosaur.

8. Attach a chenille stem between the 2 paper clips to form the tail. Add 2 googly eyes to complete your creation.

WHAT DO YOU REMEMBER?

On what day of Creation did God create flying creatures? What is the order of the groups used in taxonomy? Which of these 2 groups give an animal its scientific name? What is air pressure? What is an airfoil? What does the word aerodynamic mean? What is lift? What is drag? How many habitats can you name? What is camouflage? What is instinct? What is extinction? What is one reason the dinosaurs may have become extinct? Name a bird that became extinct. What does it mean when we say an animal is endangered? Name a flying creature that was endangered but is not anymore. What is an extinction error?