Wingspan Curriculum Activities

1. *Wingspan Banner* Activities

   Objectives:

   Students will be able to

   1. measure and compare the shapes and sizes of bird wings.
   2. explain the differences in wingtips.
   3. compare bird wings to different types of airplanes.
   4. design bird wings.

2. *Wingspan Flight School.*

   Objectives:

   Students will be able to

   1. explain the forces involved in creating lift.
   2. demonstrate the physics of bird flight using Bernoulli's Principle.

3. *Wingspan On the Wing*

   Objectives:

   Students will be able to

   1. explain how thermals help birds travel.
   2. compare and discuss aspect ratios, wing shapes and flight styles.
   3. explain the concept of wing loading and calculate it for various birds.

4. *Wingspan Winging It.*

   Objectives:

   Students will be able to

   1. calculate the distances and duration of migratory birds.
   2. determine and map the pathways of various migratory species as they travel specific routes in the Western Hemisphere.

Wingspan Winging It.

Objectives:

Students will be able to

1. calculate the distances and duration of migratory birds.
2. determine and map the pathways of various migratory species as they travel specific routes in the Western Hemisphere.

Materials:

Winging It Worksheet
Map of the Western Hemisphere
Winging It Destination Routes
Colored Pins
Colored Ribbon
Calculator
Pencils

Preparation:

Make copies of the map of the Western Hemisphere; one for each student. Cut apart *Winging It Destination Routes*; one route for each student.
Prepare a large map of the Western Hemisphere on a large piece of foam core.
Cut small lengths of colored ribbon.

Procedures:

1. Explain to the class that this activity examines the migratory pathways, distances and duration of these yearly migrations. Ask students what they know about bird migration. Being able to fly enables birds to move about for food, water, shelter and breeding habitats. Birds can fly long distances in search of these basic needs. Some of them cover thousands of miles every year during spring and fall migration. Neotropical migratory birds breed in North America and fly south either across the Gulf of Mexico or through Mexico to over winter in Mexico, the Caribbean, or Central and South America. Other birds, called temperate migrants, may migrate only from Canada or the northern United States to southern Gulf Coast states. Each spring, these migrants return to their breeding grounds.

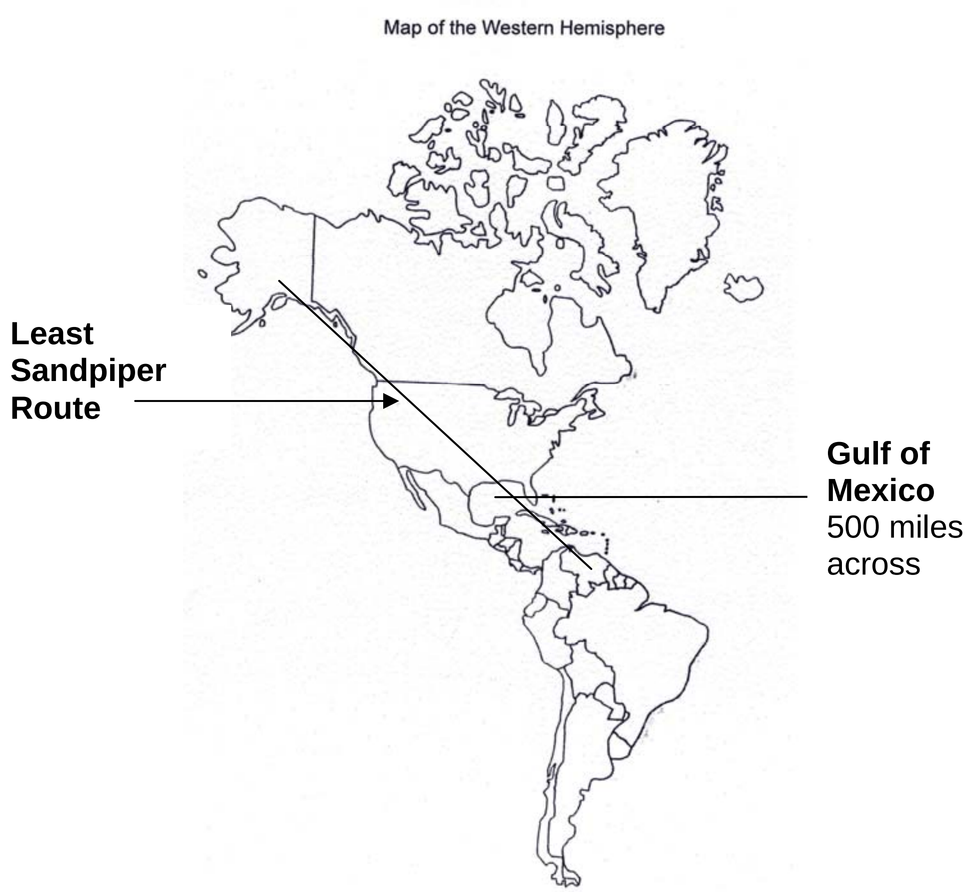
   Distribute a *Winging It Destination Route* and a map of the Western Hemisphere to each student. Tell the class to read their bird's destination and put an 'X' on their map where their birds have been. Remind them that some of the birds do not migrate, but if they have a migratory bird, they should connect the 'X's with a line. After they have finished marking their maps, ask students to use pins to mark their bird's locations on the large foam core map of the Western Hemisphere. For the birds that migrate, ask students to connect the pins with ribbon to see the entire route. Using different colored ribbon for each bird's route will make it easier to see different migratory pathways.

2. After there are a number of migratory pathways on the foam core map, ask students:
   a. Which birds do not appear to migrate, but instead remain in the same area all year?
   b. Which birds migrated the longest distances?

c. Which birds migrate within North America only?
d. Which birds migrate between North America and Mexico?
e. Which birds migrate to Central and South America?
f. Which birds migrate around the Gulf of Mexico?
g. Can you describe the wings of the birds that do not fly across the Gulf of Mexico? (Birds with large, broad wings need thermals when migrating. They cannot get the extra lift of thermals when flying over the water.)
h. Which birds migrated across the Gulf of Mexico?
i. Can you compare and describe the wing shapes of the bird wings that fly over the Gulf and those that do not?

3. Tell students that migratory birds fly non-stop approximately 500 miles across the Gulf coast of the United States to the northern coast of Mexico and Yucatan Peninsula. Ask them:

   a. How long do you think it takes a bird to fly 500 miles across the Gulf of Mexico? (About twenty hours).
   b. How fast do you think a bird can fly when flapping? (About 25 mph)
   c. If a Least Sandpiper begins fall migration from southern Alaska, how many miles is it to Venezuela? (Ask students to determine this distance by comparing the distance from Alaska to Venezuela with the distance from the Gulf coast of the United States to the Yucatan Peninsula.)
   d. How many hours does it take the Sandpiper to travel that distance?



Winging It Destination Routes

A California Condor was released from a breeding program in southern California and again seen soaring above the Grand Canyon in northern Arizona.

Bald Eagles nested in Alaska and migrated south to spend the winter in Washington.

Bald Eagles nested in southern Wisconsin near Lake Michigan and spent the winter in northern Alabama.

A Turkey Vulture was seen soaring Oregon in June, seen in central California in August, seen northern Mexico in September, and last seen in central Mexico in November.

An American Crow was seen at a bird feeder in eastern Oklahoma and later in southern Illinois.

American Robins nested in central Alaska, migrated to Florida for the winter, and returned to central Alaska in the spring.

A Tufted Titmouse was seen gathering nesting material in western North Carolina in April and in January flew to eastern Tennessee.

A Peregrine Falcon migrated from western New York to southern New Jersey in August. In September, it flew from New Jersey, along the coast of Georgia and across Alabama, Mississippi and Louisiana to Texas. It spent the winter in Costa Rica.

An Osprey nested in the Grand Teton National Park in northern Wyoming in summer and migrated to spend the winter on the coast of southern California.

A Great Blue Heron spent the winter in northern Mexico and migrated to southern Minnesota in the summer.

A Wandering Albatross was seen off the coast of Chile and seen again following a ship 200 miles farther west towards Australia.

A flock of Brown Pelicans was seen on the coast of Louisiana, then the coast of Mississippi and, finally, the coast of Alabama in December.

Wood Ducks nested in hole in a tree in New Hampshire and spent the winter in Georgia.

A Least Sandpiper nested in central Alaska, migrated through Oregon and California, flew through central Mexico and spent the winter in western Venezuela.

Great Horned Owls were seen in Kansas, New Mexico, Rhode Island, Guatemala, and Panama.

A Killdeer nested in a parking lot in North Dakota and spent the winter in southern Florida.

Chimney Swifts nested in a chimney in Pennsylvania, roosted during migration in a chimney on the coast of Georgia, flew over the Gulf of Mexico, and spent the winter in western Brazil.

A Red-tailed Hawk nested in Ohio in summer and spent the winter in South Carolina.

A flock of Broad-winged Hawks was seen migrating along the coast of Texas to eastern Mexico. They spent the winter in Ecuador.

Two Merlins were seen chasing prey in central Alaska. They migrated in August; one spent the winter on the coast of Oregon, but the other went to Colombia.

Wingspan Flight School.
Objectives:
Students will be able to

1. explain the forces involved in creating lift.
2. demonstrate the physics of bird flight using Bernoulli's Principle.

Materials: paper (8.5 x 11 inches)

Procedures:

1. With birds and airplanes flying all around us everyday, we often lose our sense of wonder and curiosity about flying. But such a simple behavior can raise many questions: Why are wings shaped as they are? How does a bird overcome the force of gravity? How is lift generated? Tell students that they are going to explore the mechanics of flight and answer many questions. Review Bernoulli's Principle with the class.

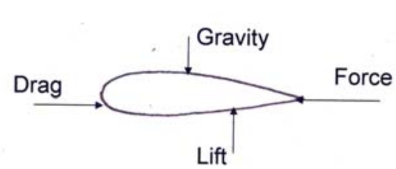
   Bernoulli's Principle states that as the speed of a moving fluid increases, the pressure within the fluid decreases. Wings, shaped like airfoils, are curved on the top. If one assumes that the air that is divided at the leading edge of the wing must rejoin at the trailing edge, the air following the upper surface of the wing has longer to travel and, therefore, must flow faster over the upper surface. According to Bernoulli's Principle this faster airflow creates lower pressure above and relatively higher pressure below the wing. This pressure difference generates lift as the higher pressure moves into the lower pressure region. Keep in mind, however, that lift is also generated because of Newton's Third Law that states that for every action there is an equal and opposite reaction. Wings are forced upwards because they are tilted and they deflect air.

1. Draw a large side view of a wing (an airfoil) on the board.

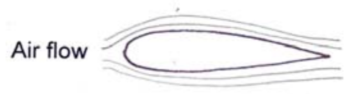
Airfoil

2. Explain to the class that in order for a bird to fly, the wing must overcome gravity and drag. Ask the students:

   a. How does a bird overcome drag in order to move forward? (Energy or thrust)
   b. How does a bird overcome gravity? (lift)



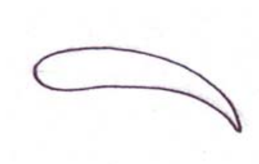
3. Explain to the students that the wing that is drawn on the board cannot generate lift because it is symmetrical and the air flows equally over the top surface of the wing and under the wing:



Wing showing equal airflow above and below wing's surfaces.

4. Explain to the students that in order for the wing to generate lift, the airflow above the wing must be different from the airflow below the wing. Ask the students:

    a. How can you change the wing's shape and, therefore, change the airflow above and below the wing? (Curve the top of the wing).



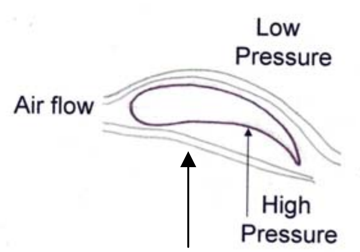
Curved Wing

    b. What does the airflow on top of the curved wing need to do to get to the trailing edge of the wing at the same time as the airflow under the wing? (The top airflow must move faster).

Airflow

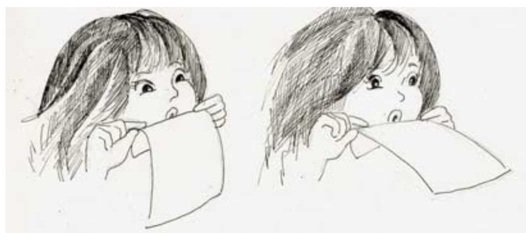
Trailing edge of wing

    c. Since Bernoulli's Principle states that as air moves faster, pressure decreases, where is the lower pressure? (Low pressure develops on top of the wing).
    d. Where is the higher pressure? (High pressure develops under the wing).
    e. Bernoulli's Principle states that air moves from high to low pressure. Therefore, how does the wing move? (The high pressure under the wing pushes the wing up into the low pressure, causing lift).



Lift

5. Tell students to take their piece of paper and hold it with their fingertips at the corners placing it under their lower lip. Tell them to gently blow across the top of the paper as it loosely hangs down below their lip. An even, steady blowing is best. If done correctly, the paper will move up.



Ask students:

a. Why did your paper move upwards? (Faster air over the top of the paper caused low pressure. The high pressure under the wing pushes the wing up into the low pressure, causing lift).

6. Tell students to fold their piece of paper in half, making a small tent. Tell them to think about what happened with their first experiment. Then tell them to put their paper tent on the table in front of them, hold onto the corners so it stays in place and blow through the middle of the tent.

Ask them:

a. Did the sides of your tent move in or move out?
b. Did your paper tent sides do what you thought they would?
c. Why or why not? (Faster air going through the tunnel of the paper caused low pressure. The high pressure outside of the wing pushes the wing inwards into the low pressure, causing the sides of tunnel to move inwards).

Wingspan On the Wing
Materials: Wingspan banner
Objectives:
Students will be able to
1. explain how thermals help birds travel.
2. compare and discuss aspect ratios, wing shapes and flight styles.
3. explain the concept of wing loading and calculate it for various birds.

Procedures:
1. Display the *Wingspan* banner in front of the class. Tell the class that they are going to explore birds' wings and flight. Ask them to name different ways that they have seen birds flying. They should include flapping, gliding, soaring, diving, swimming underwater (as in penguins and some ducks), and hovering. Tell the class that birds need certain types of wings for these flight patterns.

2. Ask them to stand and hold their arms out horizontally. Tell them to pretend their arms are wings and to flap like a bird. After a few seconds, stop them. Chances are, they have been flapping up and down, vertically. Inform the class that birds do not flap up and down, but instead move their wings in a figure '8'. Using your own arm as a guide, trace a figure eight for them to see and ask them to slowly imitate your flapping pattern.

   Tell the class to sit down and ask them:

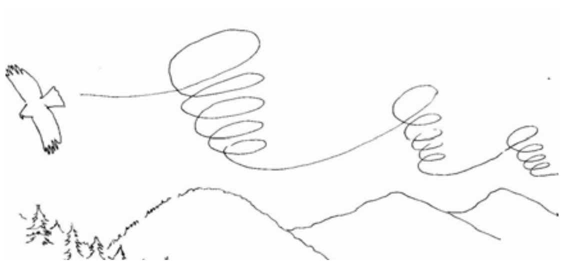
   a. What types of birds fly by constantly flapping their wings?
   b. Can you find these birds on the *Wingspan* banner?
   c. What can you say about their wingspan, wing shape and wing tips? (They have short, fat 'elliptical' wings in proportion to their body. Their wing tips are rounded.)
   d. If you were a bird with short, rounded wings that needs to turn quickly around obstacles, where would you live? (They live in habitats such as forests, fields, or shrubby areas where being able to maneuver is important).
   e. If an American Robin flaps its wings 25 times a second, how often do you think a Wood Duck flaps its wings in one second? (15) A Great Blue Heron? (1) A Bee Hummingbird? (70)
   f. Why do bigger birds usually flap slower than smaller birds? (Large birds often have a larger wing area in proportion to their body, therefore, their wings generate greater lift and require less flapping than smaller wings.)

3. Tell the class to stand again and to hold their 'wings' out and soar without flapping. Ask them:

   a. What types of birds would you be if you could fly this way?
   b. Can you find these birds on the *Wingspan* banner?
   c. How do they keep aloft without flapping? (They use thermals)

   Explain to the class that thermals are rising columns of warm air resulting from the sun's heat (Diagram 1). As the air is warmed by sunlight, it expands and becomes lighter than the surrounding air. Thermals are used by birds to gain altitude without much effort and to stay aloft, soaring with very few wing beats. This is an efficient way to hunt for food and to travel, moving from one thermal to another.

Diagram 1



   a. What can you say about the wingspan, wing shapes, and wing tips of birds that use thermals and soar? (Soaring birds often have long, broad wings and slotted wing tips)

ASPECT RATIO ACTIVITY

1. Tell students that they are going to study the 'aspect ratio' of the wings which is the ratio of the length of a wing to its width. Tell them that this aspect ratio determines how a bird flies. Ask students to measure the width and length of one wing on each of these birds: Wandering Albatross, Tufted Titmouse, and Red-tailed Hawk from the *Wingspan* banner.
   Ask them:

   a. What is the length of one wing of the Wandering Albatross? (72 inches)
   b. What is the width of one wing of the Wandering Albatross? (10.5 inches)
   c. What is the ratio of this wing's length to width? (72:10.5 or 7:1)
   d. What is the length of one wing of the Tufted Titmouse? (4.5 inches)

e. What is the width of one wing of the Tufted Titmouse?
 (2 inches)
f. What is the ratio of this wing's length to width?
 (4.5:2 or 2:1)
g. What is the length of one wing of the Red-tailed Hawk?
 (22 inches)
h. What is the width of one wing of the Red-tailed Hawk?
 (9.5 inches)
i. What is the ratio of this wing's length to width?
 (22:9.5 or 2:1)

a. Compare and discuss the aspect ratios, wing shapes and flight styles of all three birds.

The **Wandering Albatross** has a 'high' aspect ratio wing (72:10.5 or 7:1) because it has a high proportion of wing length to wing width, i.e., very long thin wings.

These wings cannot not soar like the Red-tailed Hawk or make tight turns Like the Tufted Titmouse, but instead glide over the ocean using the extreme length of the wing for needed lift. The wing tips are pointed and very far away from the bird's body thus reducing the effects of turbulence around the wing tips. Ask students:

a. Can you find other birds with high aspect ratios on the *Wingspan* banner? (Peregrine Falcon, Chimney Swift, Bee Hummingbird, Least Sandpiper, Merlin, Killdeer.)
b. How do these bird fly compared to other birds on the banner? (The Wandering Albatross is able to glide without flapping their wings often. The others have very fast wing beats and are fast effortless fliers often migrating long distances.)

The **Tufted Titmouse** has a ‘low’ aspect ratio wing (4.5:2 or 2:1) that has a small ratio of wingspan length to wind width, i.e., short and very broad with rounded wing tips.

These wings are not efficient for soaring like the Red-tailed Hawk or gliding like the Albatross, but are well suited for quick turns in tight places. Ask students:

a. Can you find all the birds on the *Wingspan* banner that have low aspect ratio wings that are short and broad? (Wood Duck, Killdeer, American Crow, American Robin, and Great Horned Owl.)
b. How do these birds fly compared to other birds on the banner? (They flap more often and make tight turns need to escape from predators or catch their prey.)

The **Red-tailed Hawk** also has low aspect ratio wing (22:9.5 or 2:1) but has a much heavier body than the Tufted Titmouse.

In order to overcome this weight difference, the hawk has wing tips that are ‘slotted’, reducing the effect of drag or turbulence on the wing and increasing lift while soaring. Ask students:

a. Can you find all the birds on the *Wingspan* Banner that have a moderate aspect ratio with long, broad wings and slotted wing tips? (California Condor, Bald Eagle, Turkey Vulture, Red-tailed Hawk, Osprey, Broad-winged Hawk, Brown Pelican, Great Blue Heron.)

b. How do these birds fly in relation to the Tufted Titmouse? (They have a more difficult time taking off and have a strong flapping flight, soaring often without flapping.)

WING LOADING ACTIVITY

1. Explain to the class the concept of 'wing loading' which is the amount of weight or 'load' that each square inch of wing surface must carry. In general, smaller birds have lighter wing loadings than larger birds. They have large wings in relation to their small body mass. Therefore, each square inch of their wings' surface carries a small or light amount of weight. Heavier bodied birds, or birds that carry heavy objects, usually have a high wing load. Their wings are small in relation to their heavy bodies. Therefore, each square inch of their wings' surface carries a high amount of weight.

The **Ruby-throated Hummingbird** weighs .11 oz (3 grams) and has a wing area of 1.9 square inches (12.4 square cm). Its wing load is calculated at

.11 oz/1.9 square inches (3 gms/12.4 square cm) or .057 oz/square inch (.24 grams/square cm).

$$\frac{.11 \text{ oz weight}}{1.9 \text{ square inch wing surface}} = .057 \text{ oz/square inch}$$

Light

In other words, each square inch of wing area supports only .057 ounces of weight for a '**light'** wing load.

The **American Crow** weighs 19.47 oz (552 grams) and has a wing area of 208 square inches (1344 square cm).

$$\frac{19.47 \text{ oz weight}}{208 \text{ square inch wing surface}} = .093 \text{ oz/square inch}$$

Moderate

Its wing load is **'moderate' since** every square inch of wing area supports .093 ounces which is nearly twice the wing load of a hummingbird. Therefore, a crow is a slower flyer and uses wing tip slotting to stay aloft. It cannot hover or fly as fast as a hummingbird.

A **Great Blue Heron** has a weight of 67.2 oz (1905 grams) and a wing area of 687 square inches (4436 square cm).

$$\frac{67.2 \text{ oz weight}}{687 \text{ square inch wing surface}} = .097 \text{ oz/square inch}$$

Moderate

Its wing loading is a **moderate** .097 nearly the same as the American Crow. Every square inch of wing area supports .097 ounces.

Even though the Great Blue Heron weighs nearly four times more than the American Crow, their wing loading is about the same because the Great Blue Heron has larger wings in proportion to its body size than the American Crow. Its wing beat is much slower and more powerful than that of a Crow. It cannot turn and maneuver as well as a Crow, but it is a better glider.

The **Peregrine Falcon** has a weight of 43.12 oz (1222.5 grams) with a wing area of 208.06 square inches (1342 square cm.) for a **'high'** wing loading of .207ounces/square inch (0.91 grams/square cm.)

$$\frac{43.12 \text{ oz weight}}{208.06 \text{ square inch wing surface}} = .207 \text{ oz/square inch}$$

High

Despite that fact that the Peregrine Falcon has a heavy body mass and small wing surface, it is a fast flyer for such a high wing loading because it has powerful muscles and tapered, pointed wings.

Birds with a high wing loading use more effort in taking off and need a strong wing beat to stay aloft. An extremely high wing load of a Boeing 747 is approximately 12.88 ounces per square inch. Like the Peregrine Falcon, its wings are very small in proportion to its body and would glide like a rock. It can fly only because of the extreme amount of thrust or power generated by the engines.

The Wandering Albatross also has a high wing load, but compensates for this by having a high aspect ratio; long, thin wings that can maintain lift while gliding over the ocean.

Turkey Vultures, Red-tailed and Broad-winged Hawks, Wood Ducks and Bald Eagles have high wing loading and have a hard time taking off, generating lift, and staying aloft. They compensate for this with wing tip slotting.

2. Using the *Wingspan* banner, students should decide which birds have light, moderate, or high wing loading by looking at their wing sizes in relation to their body size. Remind them that, in general, a light wing load is usually large wings in relation to the bird's smaller body size, a moderate wing load is usually medium sized wings in relation to a medium sized body, and a high wing load is usually small wings in relation to a large body. Use the examples from the Ruby-throated Hummingbird, American Crow, Great Blue Heron and Peregrine Falcon to help them make educated guesses on the banner.

   Ask them to calculate the wing loading for the birds in the table below. Have them to find the square inches of each bird's wings on the banner by measuring each wing length and width, then multiplying to find the square area. Remind them to add together **both** wings' square area to calculate the total square area.

Bird on Banner	Weight (Oz)	Wing Area (Sq. In)	Wing Loading Oz/sq. inch	Wing Load
Ruby-throated Hummingbird	.11	1.9	.11/1.9 = **.057**	Low
American Crow	19.47	208	19.47/208 = **.093**	Moderate
Great Blue Heron	67.2	687	67.2/687 = **.097**	Moderate
Peregrine Falcon	43.12	208.06	43.12/208.06 = **.207**	High
Chimney Swift	.61	16.12	.61/16.12 = **.038**	Low
Wandering Albatross	320.00	821.00	320/821 = **.389**	High
Wood Duck	24.00			
American Robin	3.00			
Red-tailed Hawk	40.00			
Brown Pelican	160.00			
Tufted Titmouse	.92			
Broad-winged Hawk	15.00			
Great Horned Owl	60.00			
Merlin	7.00			
Killdeer	3.30			
Least Sandpiper	.80			
Bald Eagle	160.00			
California Condor	400.00			
Turkey Vulture	104.00			
Osprey	56.00			

WINGSPAN ACTIVITY

1. Ask students to calculate what their own wingspan would need to be in order for them to fly. Tell them that the ancient Teratorn had a wingspan of 16 feet and weighed 44 lbs. With this information, they should be able to use the formula for their wing span:

$$\frac{\text{Their weight}}{\text{X (Their wingspan)}} = \frac{\text{44 lbs (Teratorn weight)}}{\text{16 feet (Teratorn wingspan)}}$$

44 lbs X = their weight x 16 feet

X = their weight x 16 feet/ 44 lbs

X = their wingspan in feet

Example for a 100 lb. person would need a 36 foot wingspan to fly:

44 X = 100 lbs x 16
X = 1600 / 44
X = 36 foot wingspan

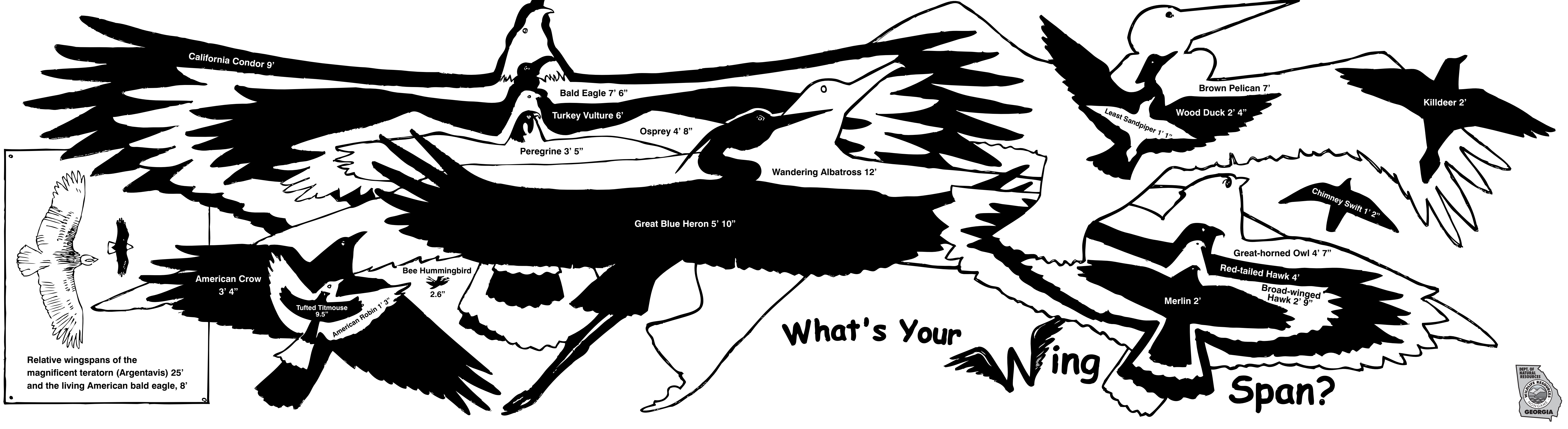
Ask students if they could lift their wings if they had a 36 foot wingspan. This is one reason that birds do not weigh a lot—their wings would need to be bigger, too.

2. Tell students to imagine that they could change wings from one bird to another. Ask them:

    a. How would the flight pattern and behavior of the Chimney Swift change if you put the Brown Pelican wings were put on it?
    b. What would happen if the wings of the Broad-winged were put on Hawk Peregrine Falcon? Could it dive for food that same way? Why or why not?
    c. What would happen if the Tufted Titmouse wings were put on the Bald Eagle? Could it soar?
    d. If you put the Albatross wings on the American Robin, would it need to change its habitat and food?
    e. Can you make any other changes that would affect the flight patterns, behaviors, or habitats of the birds?

3. Ask students to design the most practical wing (and body) for a bird that:

    a. Needs to glide over the ocean for weeks at a time without landing.
    b. Dives for fish in the water but needs to soar sometimes.
    c. Swims underwater.
    d. Lives in small caves and tunnels.
    e. Only climbs up and down tree trunks.


California Condor 9'
Bald Eagle 7' 6"
Turkey Vulture 6'
Osprey 4' 8"
Peregrine 3' 5"
Wandering Albatross 12'
Great Blue Heron 5' 10"
American Crow 3' 4"
Tufted Titmouse 9.5"
American Robin 1' 3"
Bee Hummingbird 2.6"
Brown Pelican 7'
Wood Duck 2' 4"
Least Sandpiper 1' 1"
Killdeer 2'
Chimney Swift 1' 2"
Great-horned Owl 4' 7"
Red-tailed Hawk 4'
Broad-winged Hawk 2' 9"
Merlin 2'
Relative wingspans of the magnificent teratorn (Argentavis) 25' and the living American bald eagle, 8'
What's Your Wing Span?
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