Newton, Bernoulli and Birds

Student-Led ACTIVITY

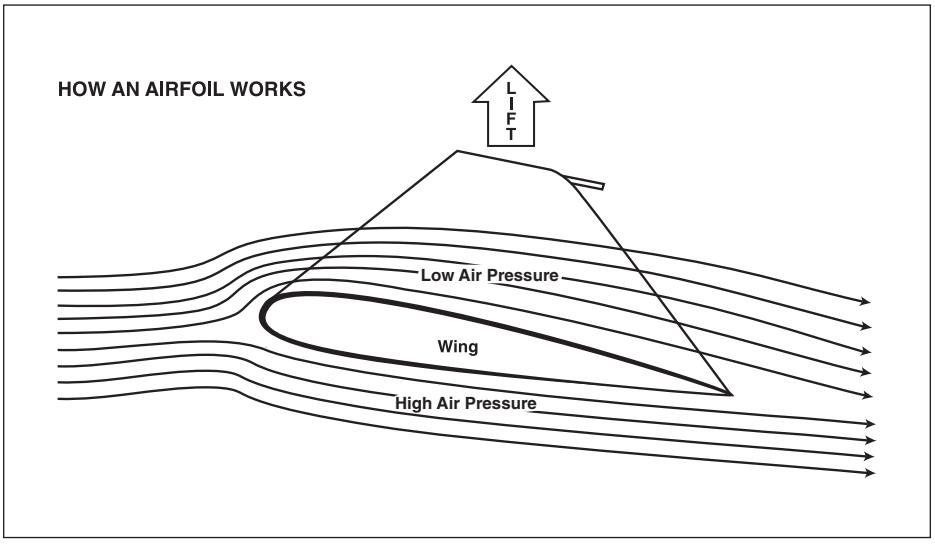
Participants learn how the shape of a bird's wing enables it to fly—by making models and observing the effects of air pressure.

Need to Know

Have you ever wondered how wings on a bird make flight possible? Many factors contribute to a bird's ability to fly, including wing size, the weight of the bird, wing shape and the rate at which wings flap. In simple terms, flight can be understood by the amount of air a bird needs to push down with its wings in order to lift into the air.

Newton's Third Law, established by the English scientist Sir Isaac Newton in the 17th century, states that for every action, there is an equal and opposite reaction. As a wing moving over air pushes the air down (the action), the wing carrying the bird is pushed up by that air (the reaction). We refer to this upward force on a wing as ***lift***. However, the air moving over the wing is also pushed slightly forward, creating a force called ***drag*** that pushes the bird back. Larger wings create more lift and more drag, but lift increases more than drag. Thus, animals with large wings tend to fly more efficiently but also more slowly.

In addition to Newton's discoveries, the work of Daniel Bernoulli, a Swiss scientist who lived in the 18th century, also helps us understand flight. ***Bernoulli's Principle*** says that when air speeds up, its pressure drops. That is, fast-moving air has less pressure, or force, than slower moving air. So what does this have to do with flight? Airplanes and birds use airfoil shaped wings with a curved upper surface to create



NEED TO GET

- ❏ Copy, preferably enlarged, of How an Airfoil Works (included here)
- ❏ Poster board

PROCEDURE I

- ❏ Sheets of notebook paper or paper from the recycling bin cut into strips

PROCEDURE II

- ❏ Copies of Flying Eagle Airplane, one for each participant
- ❏ Scissors
- ❏ Stapler

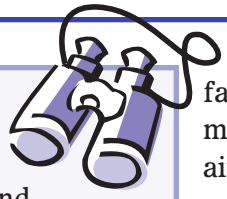
TIME

Preparation: 30 minutes
Activity: 20 minutes

TERMS TO KNOW

Bernoulli's Principle, lift

ZOOM IN, ZOOM OUT!



Practice making and flying the Flying Eagle Airplane ahead of time. The more you practice, the better you will be at helping participants. Here are tips for a successful flight:

- Hold the eagle from behind using your thumb underneath and forefinger above the airplane by the staple.
- Keep the wings level and nose pointed slightly downwards.
- Make adjustments to the wings, nose, and tail of the eagle to experiment with different flight patterns.
- Try flying your eagle under different conditions:
  - At different heights above a fan blowing upwards
  - Across the path of the fan wind (i.e. into a crosswind)
  - Above the surface of a large object where the wind is hitting the opposite side (this can show lift produced by winds hitting a mountainside and help explain why hawks migrate along mountain ridges)
  - Over a black top parking lot on a sunny, still day to see if your eagle can catch thermals
- Have competitions among festival participants to see who can keep their eagle up in the air the longest, who can fly their eagle the fastest, and who can make their eagle perform the greatest number of aerobatics.

faster airflow over the top of the wing than the bottom. The faster moving air on the top of the wing has lower pressure than the slower air below, creating lift and pushing some air downward. Compared to pushing air downward with a flat wing positioned at an angle, airfoils create more lift with less drag.

Wings vary greatly among species and enable birds to do many things in addition to basic flight. Have you ever noticed a hummingbird hover in mid-air, or a falcon dive at great speeds, or a loon swimming under water? What do you think the design of an Arctic tern wing looks like? This bird migrates several thousands of miles each year in its pole-to-pole journey, so it needs a lot of long-term lift!

Getting Ready

1. Copy the diagram of How an Airfoil Works. If possible, enlarge the copy so that it's easier to see. Mount the diagram onto poster board to display it at the festival booth.
2. If possible, precut the paper strips for the first part of the activity. If not, make sure you have scissors on-hand and give specific instructions about how to cut the paper properly. *Note: Make sure students handle scissors carefully.*
3. Have some sample Flying Eagle Airplanes constructed before the festival.

Taking Flight!

In this demonstration participants learn how Newton's Third Law and the Bernoulli's Principle work and understand how they create lift for birds in flight.

Procedure I: Demonstrating Bernoulli's Principle

1. Cut a one-inch-wide strip along the long (11-inch) side of a piece of notebook paper.
2. Hold the front end of the paper between your index finger and thumb.
3. Put your hand above your mouth, just above your upper lip.
4. Now blow. What happens? As Newton's Third Law helps us predict, the paper is lifted due to the force from the air you blew out.
5. Now, hold the paper with your fingers the same way, but this time with your hand below your mouth so your thumb and finger rest just below your lower lip and just above your chin.
6. Blow again. What happens? You might think the paper should be pushed down, but not so. Because of Bernoulli's Principle, it flaps in the air current, being lifted due to the lower pressure above the strip.

In both instances of blowing above and below the paper, the pressure below is greater and creates lift by pushing up.

Procedure II: Ready for Flight?

1. Copy the Flying Eagle Airplane template and instructions.
2. Follow the instructions to create a flying eagle.
3. Try making adjustments to the wings in order to compare how wing shape affects speed and the length of time the airplane glides before touching the ground. This helps you demonstrate the relationship between maximizing lift and minimizing drag (the amount of pull, or friction, that air exerts against the wing). Just like the bird's wing, the pressure below is greater and creates lift by pushing up on the wing.

Compared to flat wings, airfoil shaped wings with a curved upper surface create more lift with less drag.

Ready for Further Investigation?

Visit *www.flyingwild.org/resources.htm* for a step-by-step demonstration of the Bernoulli Principle.

Quiz Your Guests

1. Discuss how the design of the Flying Eagle Airplane wings compares to a bird's wings. A bird's wing is shaped like an airfoil, so in addition to pushing some of the air down, the air moving across the top of the wing moves faster than the air moving below the wing. How does the faster moving air above the wing help a bird fly?
2. Point out that the size and shape of different birds' wings vary greatly. In addition to flight, birds use their wings for many different and specialized purposes. Consider a hawk, a duck, and a hummingbird: The shapes of their wings vary as greatly as the purposes they serve. Do you think insects and flying or gliding mammals have wing designs similar to birds'?

IN STEP WITH SCIENCE STANDARDS

STANDARD A: SCIENCE AS INQUIRY

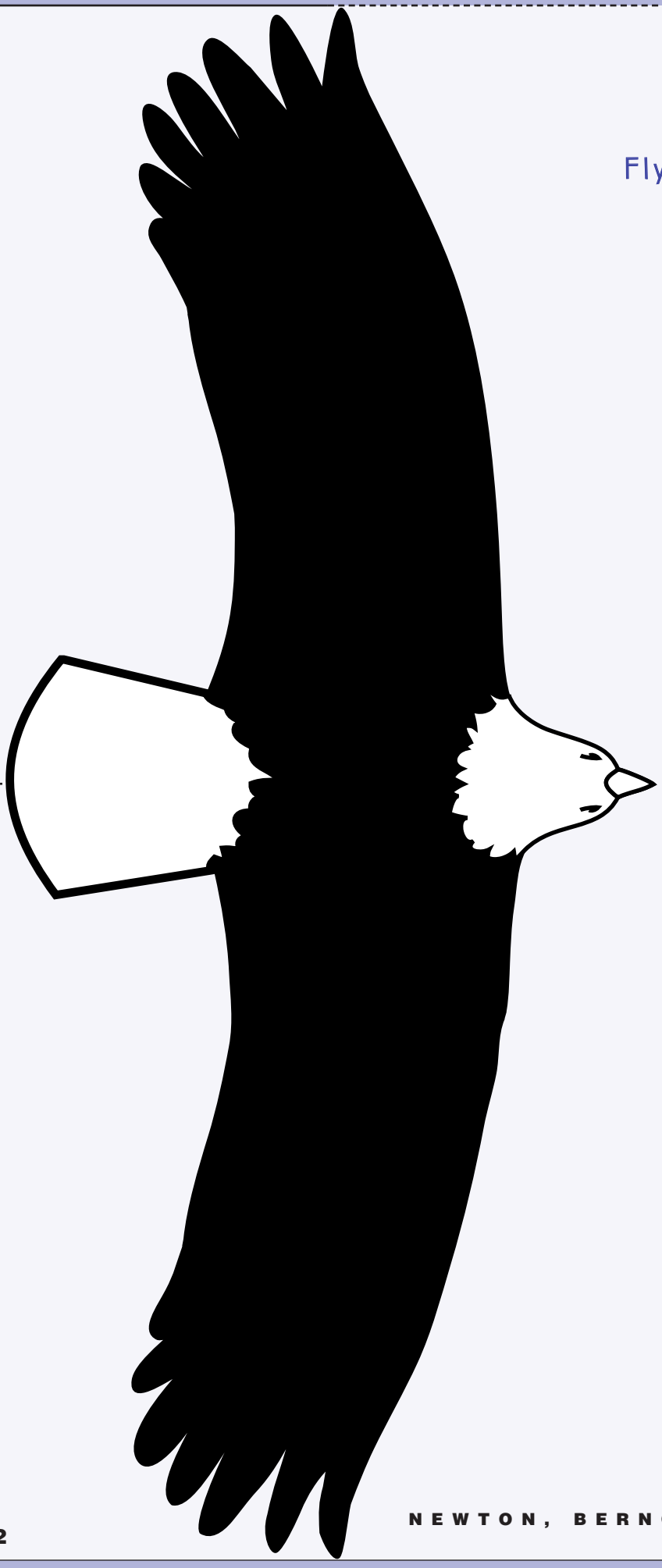
- Understandings about scientific inquiry

STANDARD B: PHYSICAL SCIENCE

- Understanding of motion and forces

STANDARD C: LIFE SCIENCE

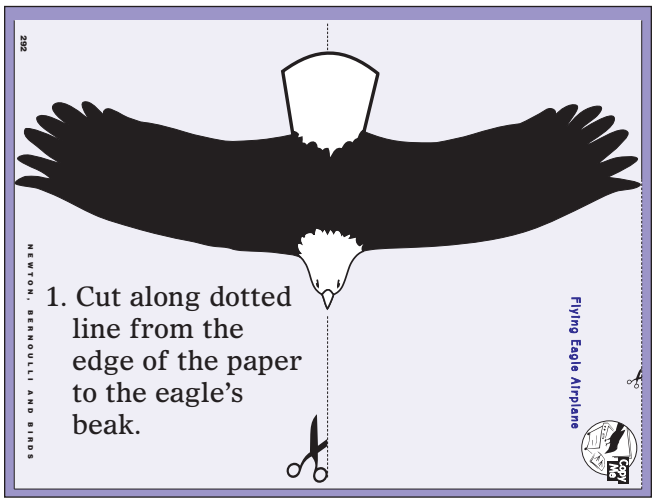
- Structure and function in living systems



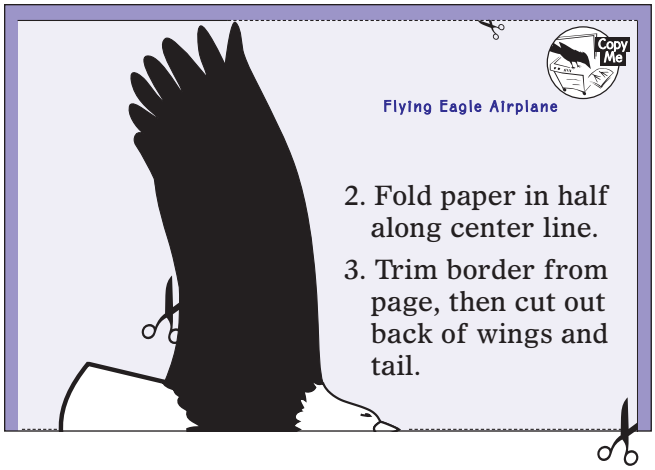
Copy Me

Flying Eagle Airplane

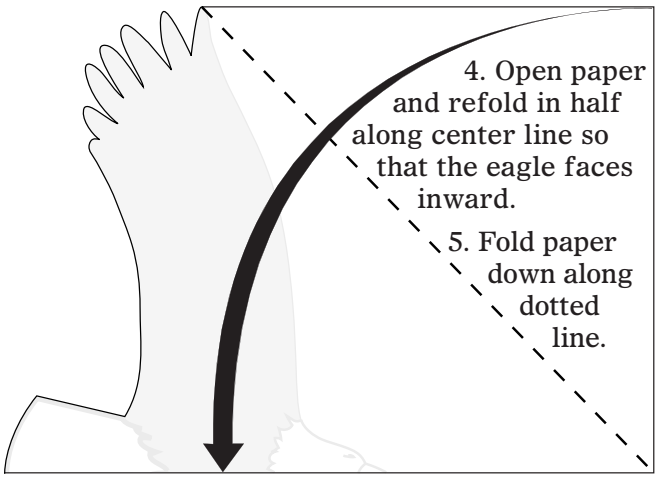
Flying Eagle Airplane Instructions



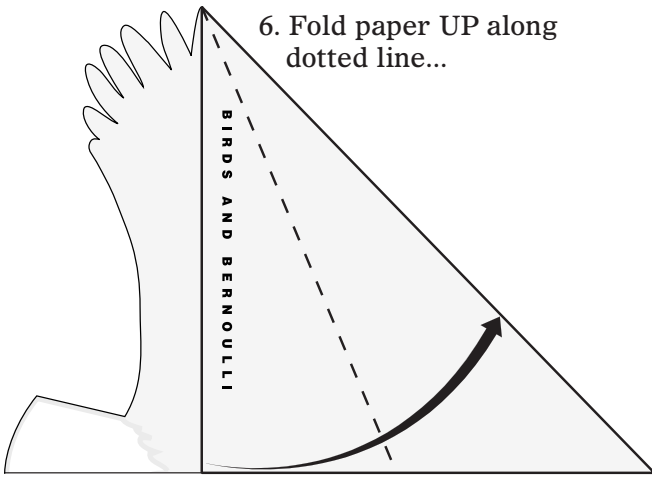
1. Cut along dotted line from the edge of the paper to the eagle's beak.



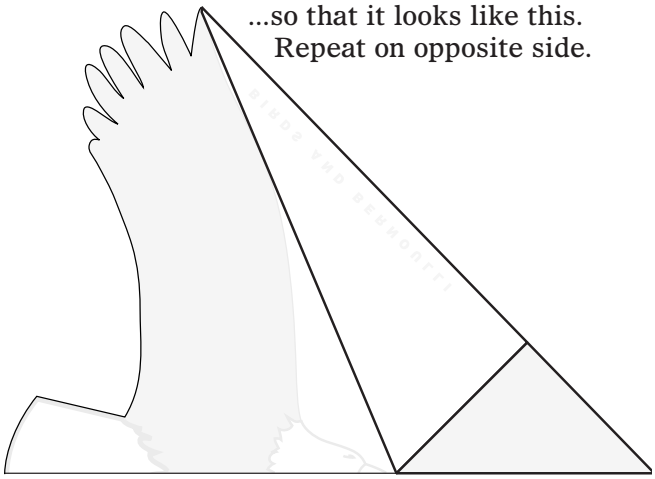
2. Fold paper in half along center line.
3. Trim border from page, then cut out back of wings and tail.



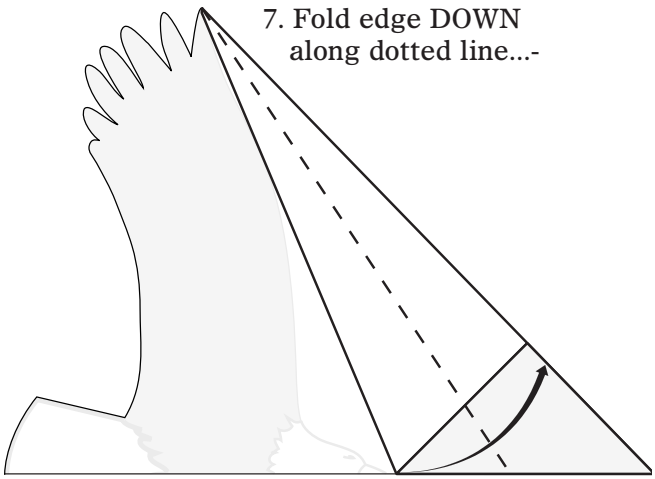
4. Open paper and refold in half along center line so that the eagle faces inward.
5. Fold paper down along dotted line.



6. Fold paper UP along dotted line...

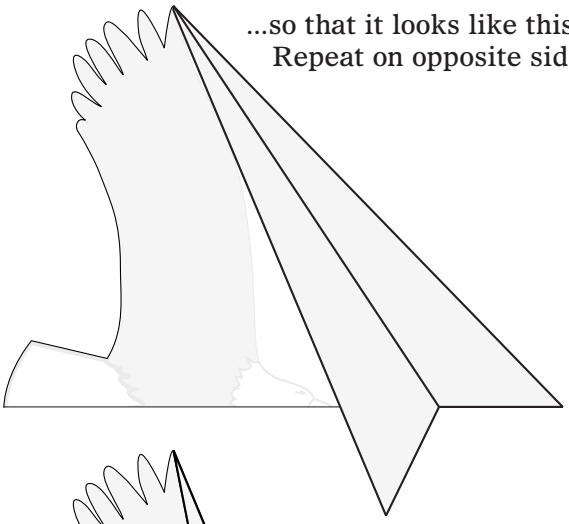


...so that it looks like this. Repeat on opposite side.



7. Fold edge DOWN along dotted line...-

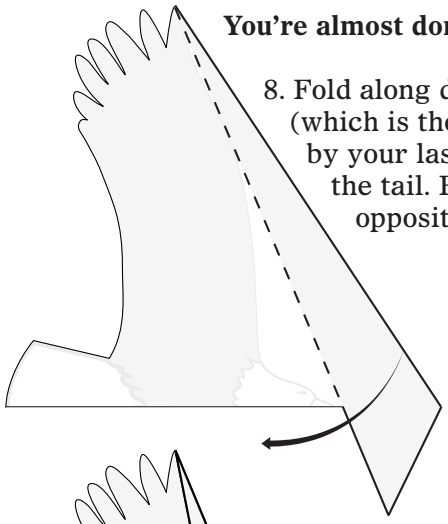
Flying Eagle Airplane Instructions

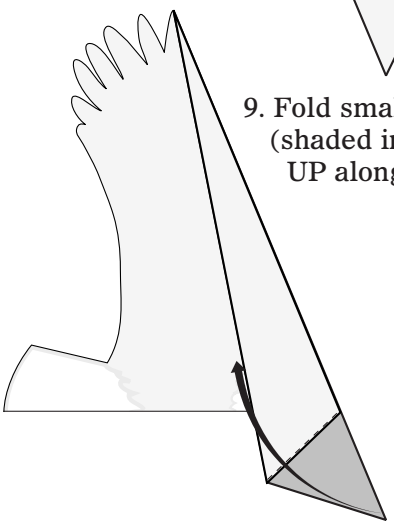


...so that it looks like this. Repeat on opposite side.

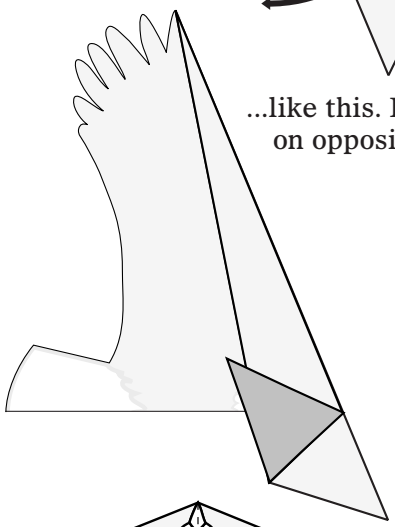
You're almost done!

8. Fold along dotted line (which is the edge created by your last fold), toward the tail. Repeat on opposite side.



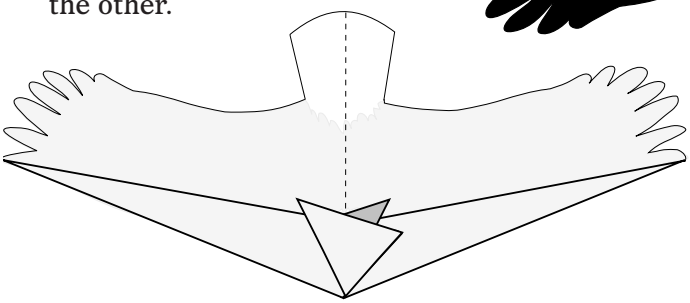


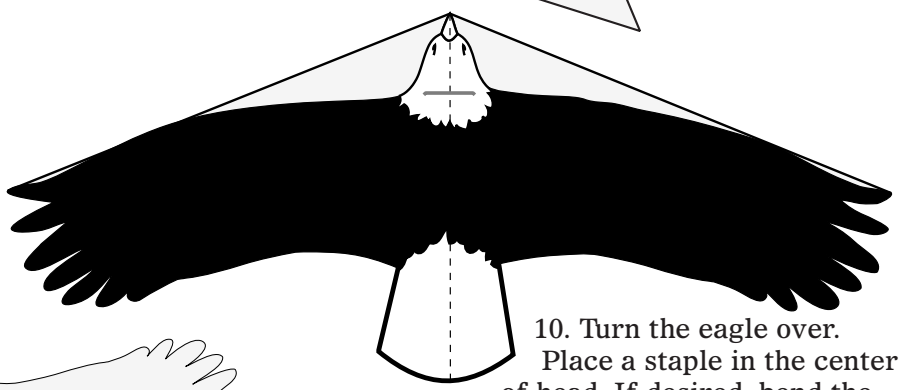
9. Fold small tab (shaded in diagram) UP along dotted line.



...like this. Repeat on opposite side.

10. Turn eagle upside down and open along center line. One folded tab should naturally lie underneath the other.





10. Turn the eagle over. Place a staple in the center of head. If desired, bend the staple slightly at the center fold (this will give the eagle a slight "v" shape when viewed head on).

11. Adjust wings; hold tail between thumb and forefinger; give a gentle push and watch the eagle fly!

This procedure has been developed from "Eagle Airbirds" an activity by Al Parker of the Indiana Department of Natural Resources, adapted with permission from Dr. Edmond Hui's "Paperang" design. Visit Dr. Hui's website *www.paperang.com* for more information on the Paperang.

Newton, Bernoulli and Birds

What Did You Learn?

1. What does Newton's Third Law state? What is Bernoulli's Principle?

2. Explain how adjustments made to the wings of the Flying Eagle Airplane affected the speed and gliding time.

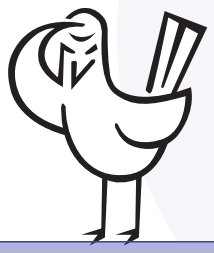
3. The size and shape of different birds' wings vary greatly. In addition to creating lift, for what specialized purposes do birds use their wings when they fly?

Wanted: Your Feedback

1. How effective was the How an Airfoil Works diagram? Was this effective in helping participants understand Newton's Third Law and Bernoulli's Principle?

2. What would you change about this activity?

3. What new information did participants learn?



Question for Reflection

1. The size and shape of different birds' wings vary greatly. In addition to flight, for what specialized purposes do birds use their wings?
2. Compare a hawk and a hummingbird. How do the shapes of their wings vary according to the purposes they serve?
3. Do you think insects and flying mammals have wing designs similar to birds'?