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Secrets of Silent Flight

A great horned owl in flight over a meadow in Ontario, Canada.

Credit: Peter K. Burian, CC BY 4.0, via Wikimedia Commons

Anyone who's been in an airplane has heard that constant roar of flight. That's partly the engines—but the noise comes more from air rushing over the wings.

Anyone who's *seen* an owl fly… hasn't *heard* anything. Because unlike an airplane, owls fly almost silently.

How do they do this? Aeronautical engineers have examined owl wings and found several features working together:

The leading edge of the wing, called the *comb*, is finely serrated, to break up the air flowing over it.

The middle of the wing is covered in soft feathers called *velvet*, which dampen the high pitch of rushing air that would be audible to rodents and other prey.

The trailing edge has a wispy *fringe* which further silences the moving air.

In a technique called biomimicry, engineers design products inspired by successful plant and animal features. We've covered several in prior *EarthDate* episodes.

Now they're looking to adapt the owl's silent flight to our technology.

New designs have shown that adding a sound-absorbing middle section and a porous, flexible trailing edge to an airplane wing can cut its noise by 25%.

Adding plastic finlets to the leading edge of a wind turbine blade can cut *its* noise in half!

Owls have other remarkable features: Their eyes are up to 100 times better than ours. And their ears are the most sensitive of any animal ever tested.

What else might engineers learn from this wise old bird?

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Background: Secrets of Silent Flight

Synopsis: Of the thousands of types of birds in the world, owls are known to have the most hushed sound during flight. This feature is due to three unique adaptations that all species of owl have in common. By studying and understanding owl motion, humans can apply similar principles of engineering to decrease the sound of airplane wings and wind turbines.

- Apart from the polar ice caps and a few remote islands, owls are found all over the world. The over 250 species of owls (*Strigiformes*) have many likenesses and distinctions.
  - Owls live from 5-12 years and vary greatly in size with some as small as 5 in (13 cm) while other species grow as large as 28 in (71 cm) tall. They range in weight from 1.5 oz (42 g) to 9 lb (4 kg).
  - Owls tend to be solitary but when they do form a group, it is called a parliament.
  - Known for their keen eyesight, an owl's eyes can contribute 3% of their body weight. The human eye is just 0.0003% of its body weight.
  - Owls excel at tracking their prey, twisting their heads a whopping 270 degrees.

The elf owl (*Micrathene whitneyi*) is the world's smallest owl, averaging just 4 to 6 inches (10–15 centimeters) in height and are the mass of a small strawberry. It can be found in the deserts of the United States and Mexico.

Credit: Dominic Sherony, CC BY-SA 2.0, via Wikimedia Commons

The endangered Blakiston's fish owl (*Bubo blakistoni*) is the world's largest owl, weighing 8 to 10 pounds and having a wingspan of 6 to 7 feet. If you're lucky, you might get to see this very rare species in Russia, China or Japan.

Credit: Tokumi, public domain, via Wikimedia Commons

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References: Secrets of Silent Flight

Owls | National Geographic
Features of Owl Wings that Promote Silent Flight | Royal Society
To Silence Airfoils, Engineers Study Owl Wings | Smithsonian
Specialized Feathers Enable Owl's Silent Flight | AskNature
Low-Noise Wind Turbine Inspired by Owl Wings | AskNature

Contributors: Lynn Kistler, Juli Hennings, Harry Lynch

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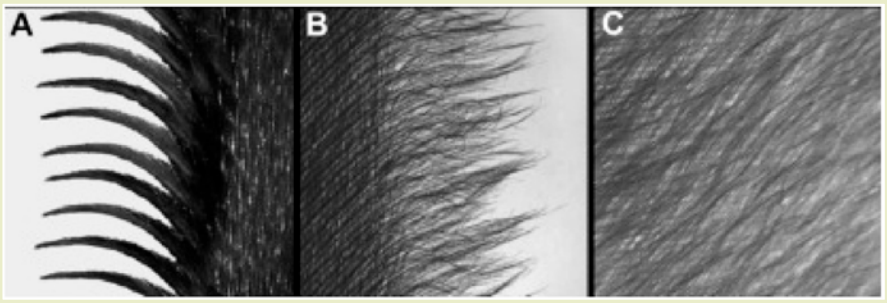
- Owls are carnivores and mostly eat small rodents but will also eat fish, insects, and even other birds. Sometimes, they even capture larger prey such as foxes or small deer.
- Most are nocturnal, preferring to hunt during the night. Their excellent night vision, sensitive hearing, and quiet flight all contribute to their success.
- An owl in flight is extremely quiet, so quiet that the sound is below the threshold of human hearing until the owl is just 3 feet away!
- Owls can mute their flight at frequencies higher than 1600 Hz. It is not surprising that this is the threshold of hearing for rodents. It's no wonder owls are successful predators.



A close-up view of barn owl wing sections showing (A) the leading edge or comb, (B) the finer feathers of the fringe, and (C) the sleek and soft feathers of the velvet.

Credit: Bachmann et al. (2007), CC BY 4.0, via Springer Nature

- Throughout history, humans have often looked to nature for inspiration in developing new technologies. This approach, known as biomimicry, involves studying the designs and processes found in the natural world to solve human challenges. By observing and mimicking nature, we have been able to create innovations that improve our lives, advance our technologies, and address environmental issues.
  - Scientists looked to the mosquito to decrease the pain of needle injections. (ED-221 Mosquito-Inspired Injections)
  - Plants, animals and now humans collect water from fog in arid and desert areas. (ED-43 Water from Thin Air)
  - Reflective, structural color paints have changed the way we look at color. These paints mimic the color properties on butterfly wings. (ED-339 When Paints Don't Need Pigment)
  - The sticky toes of the gecko serve as an inspiration for a range of adhesive materials. (ED-181 Hanging with Geckos)
  - After removing burrs from his dog, a Swiss engineer designed Velcro after close examination of the small hooks on the ends of burr needles.
- As researchers continue to explore biomimicry, they turn their attention to creatures that have mastered specific challenges in nature. By studying the unique features that allow owls to glide almost noiselessly through the air, scientists are developing ways to reduce noise in human-engineered systems, such as airplanes and wind turbines.
  - In 1934, British aeronautical engineer and bird expert, Robert Rule Graham, described three important structures of owls that may account for their silent flight: the comb, the velvet and the fringe.
  - The *comb* forms the leading or front edge of an owl's wing. This toothed edge breaks up the air mass, allowing it to be more stable and quieter. Steep angles, which would occur when attacking prey, produce even better results.
  - As the air moves across the owls' feathers or the region called the *velvet*, these soft feathers on the wing and legs absorb high frequency sounds that would be audible to prey and humans.
  - The *fringe*, or trailing edge of the wing has even finer wispy edges that results in an especially larger reduction in aerodynamic noise.

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Owls | National Geographic
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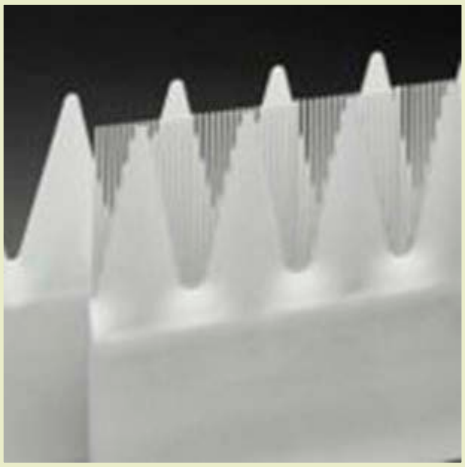
- When the owls flap their wings during flight, the velvet and fringe dampen the frictional noise between the feathers as well as the aerodynamic noise.
- While these factors account for some of the reduced noise of owls, scientists and engineers know there is still much to learn. The role of each individual feather appears to create minute changes in the owl motion versus other birds and this is an area of continued research.

- These insights are now being applied to modify the shape and structure of airplane wings and wind turbine blades, leading to quieter, more efficient designs.
  - Most of the noise in an airplane is a result of airflow over the wings and not the engines, as many would assume. Much of this noise is generated at the rear of the wing, like the fringe area of the owl.
  - Making the trailing edge of wings more porous and flexible would help to decrease this noise.
  - Experiments in wind tunnels have shown that having a porous material on the trailing edge of an airplane wing reduced noise by 2-5 decibels.
  - To simulate the smooth velvet of the owl wing, researchers covered wings with various materials and tested them in the wind tunnel. Unfortunately, the best material was a wedding veil which wouldn't hold up well during an actual flight.
  - Researcher did find that when plastic "finlets" were attached to a wind turbine blade, there was a 10 dB reduction in the noise. (Note that the decibel scale is logarithmic, therefore, a 10 dB reduction means the sound is reduced by half!)
  - On-shore wind farms are required to stay within maximum noise levels which often means they must limit energy production. Using a windmill blade with fringes like an owl, the Siemens DinoTail reduced wind noise by as much as 10% without a loss of power.
- The study of owls and their silent flight exemplifies how biomimicry can lead to significant advancements in technology, improving both functionality and environmental impact. As we continue to draw inspiration from nature, the possibilities for innovation are boundless, offering sustainable solutions to complex challenges. This ongoing exploration of the natural world promises to inspire even more breakthroughs in the future.



Wind turbine design continues to evolve with smaller and smaller finlets to reduce noise.

Credit: Anonymous via Greensolver

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