

# Cute Animal Physics – Birds

## For Grade 3-6



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### **Description of Content**

The content here is suitable for grades 3-6. The physics descriptions presented here involve cute bird animals which kids love (ducks, owls, hummingbirds, and penguins). This is the motivation behind using cute animals to teach kids about science. Not only are there a lot of cute animals in the world, but there is also a lot of cool science explaining how their anatomy works. Two versions of this ebook are available, in Word and PDF format. The pictures in the Word version have slightly higher resolution, while the PDF version is more portable for viewing on a variety of devices.

The Next Generation Science Standards addressed here are:

3-LS4-3: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

4-LS1-1: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

## The Mallard Duck



[1]

Have you ever looked at cute animals and wondered how physics applies to them? I'm betting you haven't, but nevertheless there is some interesting physics that applies to many animals, and not just the cute ones. In this section I will talk about the physics of one such cute animal from the animal kingdom, the mallard. This is a species of duck found in many parts of the world. They are very common in North America.

The first thing you will probably notice about mallard ducks is their highly oval shape. All birds are oval shaped to some extent, but some are more so than others. The mallard is highly oval shaped which makes it helpful for floating in the water, either on the surface or submerged with its duck butt pointing in the air (as shown in the figure below). In order to float in water, ducks need to have lower density than water. This is explained by Archimedes' principle.



[2]

The oval shape of mallards is not necessary to float but it does help them "roll over" quite easily in the water, when they tip forward and submerge their front ends in order to get food underneath the water surface.

The other very noticeable part of a duck's anatomy is their webby feet. Such odd looking feet are ideal for swimming because they act as flippers in the water which the duck uses to push itself along, by way of gentle kicking motions. However, webby feet are not ideal for perching on tree branches, which many birds do. The webby feet lack the finger-like structure which birds, like Robins, have. This makes them unsuitable for wrapping around branches for support. Hence, ducks and other webby footed birds, can best perch on flat surfaces. A seagull is a great example of a webby footed bird that you often see perched on a flat surface, such as the top of a lamp post.





[3]

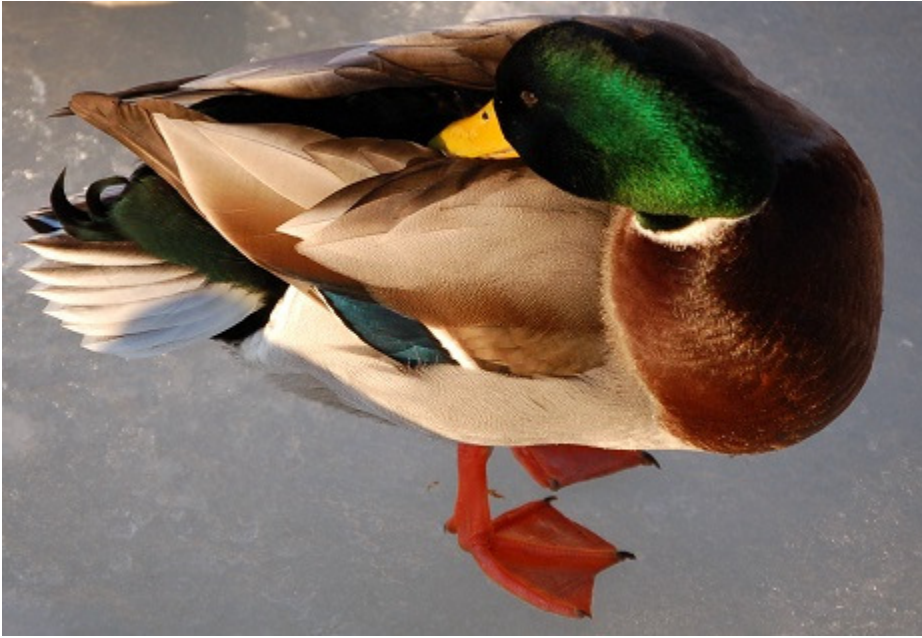
Moving up from the webby feet we encounter the body which is thick with feathers. The feathers have great insulation value to keep ducks warm, especially the down feathers underneath. These are the feathers you see on baby ducks (shown in the figure below), which upon growing up develop the full feathers as seen on adult ducks.



[4]

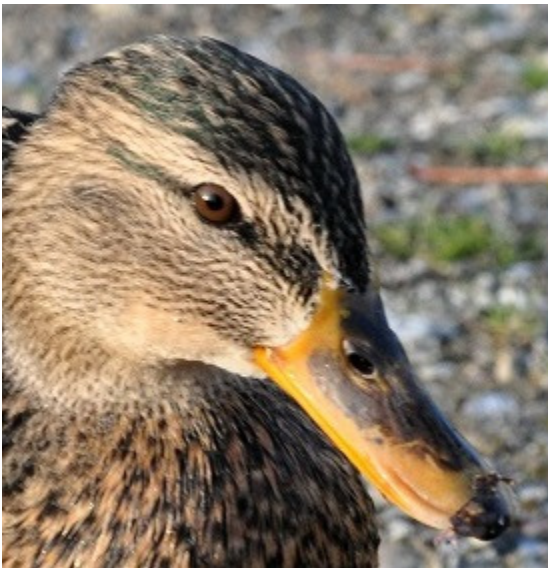
Duck feathers are also waterproof. Water doesn't make their feathers wet and instead beads on them. This is an important feature in all birds but is especially important in those that spend so much time in water, like ducks do. Keeping their feathers waterproof is very important because wet feathers lose their insulation ability which would spell disaster for the birds.

Ducks, like all birds, often preen as part of keeping their plumage clean and to distribute the oil from their sebaceous gland (located in their rump area), onto their feathers. The oil from this gland is what keeps their feathers waterproof.



[5]

The bills of ducks are useful for feeding. The flat shape and inner structure allows them to dabble and strain out bits of food from the water.



[6]

Ducks can move around in all environments, either by flying through the air, swimming in the water, or walking on land. In the first two environments they are graceful and very well adapted, but on land they exhibit a clumsy sort of gait which we call "waddling". Ducks waddle along in this comical fashion which is funny to watch. Without getting into a long biomechanical explanation, the funny way a duck walks is a consequence of their

short legs and body shape which forces them to sway their hips in order to move along on the ground; hence the characteristic waddle. It seems that their anatomy is best suited to swimming and flying. Nature found a way to give ducks the ability to do these two things really well but compromised a bit on the walking part. So in terms of walking ability they are so-so. But they can nevertheless walk fast if they have to, run even, especially when an angry goose is chasing after them.

When ducks, or any other bird, stand on one leg they must do so in such a way that their center of gravity is directly above their foot. This prevents them from falling over.

The reason birds stand on one leg is to reduce heat loss. Their legs are unfeathered which causes a lot of body heat to be lost through them. By standing on one leg, and tucking the other one underneath their feathers, they reduce heat loss which helps them stay warm. When they tuck their long bills into their feathers they are also reducing heat loss in the same way.





[7]

Last but not least, we have the wings of a duck. The wings are obviously essential for flying. The structure of the wings, as well as the streamlined body shape ducks make when flying, both satisfy aerodynamic principles of flight.



[8]

To slow down when landing, ducks keep their wings open. This creates aerodynamic drag which helps slow them down. This is similar to how a skydiver uses a parachute to slow down when landing.



[9]

## The Owl

Snowy owl feathers (shown below) are very good insulators which is ideal for very cold temperatures.



[10]

Its white color camouflages it by blending it in with its snowy surroundings, helping it to avoid detection as it sneaks up on prey. This ability to blend in with its surroundings also helps prevent it from being preyed upon by other animals.





[11]

Being able to turn their heads 270 degrees in both directions mean that they can see all the way around them with minimal movement, and therefore be as silent as possible without having to shift body position the way we would have to in order to see all the way around us.



This guy looks sleepy.



[12]

The feet of an owl are very strong with sharp talons ideal for seizing and killing prey. The picture below shows the talons of a barn owl.



[13]

The beak of an owl is as sharp as its talons and is well suited for slicing through flesh and bone, like a pair of scissors. The curved tip of an owl's beak acts like a grappling hook for holding onto and tearing into a carcass. The picture below shows the beak of a great horned owl.



[14]

The barn owl (shown below) is a night predator that relies on stealth. Its wings are specially designed to minimize noise when flying due to how the feathers at the edges are designed. They break up the air and create small pockets of turbulence in the air which almost entirely eliminates the flapping noise the wings make when flying. Owl's bodies are light compared to their wing area, which means they can get plenty of lift.





[15]

Owls have excellent vision and hearing to detect and lock onto their prey. Their large eyes provide binocular vision and can judge distances in a similar way to humans. Their eyes are also excellent for seeing at night, due to the large size of their eyes which allows them to gather a large amount of light (in order to better see in the darkness), as well as specific structures inside their eyes helping them to see at night.

An owl's ears are located on the left and right side of its head. An owl can tell which direction a sound is coming by the minute time difference it takes for sound waves to reach the left and right ears. The owl turns its head until it detects that the sound is reaching both ears at the same time. At this point the owl is directly facing the source of the sound. The feathers surrounding an owl's ears are structured so as to focus the sound into the ears, and the shape of the facial disk can be adjusted by the owl to focus sounds into their ears more effectively.



## The Hummingbird

This is one of the world's smallest birds and it is very distinct in the way it flies just by its hovering ability. The wings beat very fast, up to 4800 beats per minute, and it can tilt its wings at the joint to enable it to hover, fly forward, or fly backwards. Studies show that it's 20% more efficient at hovering than a helicopter drone (reference: <http://www.bbc.com/news/28563737>).



[16]

Its beak is long in order to reach into flowers and obtain the sweet nectar that it feeds on.

It's called a hummingbird because of the humming sound it makes when flying. Its rapidly beating wings produce this sound.

During heavy rain hummingbirds experience much greater relative impact forces due to the raindrops impacting their bodies than does a much larger animal. Consequently they have developed a unique strategy to cope with this. They adopt a more horizontal body and tail position, and increase the frequency of their wingbeat. As well they reduce the stroke amplitude of their wings. With their bodies in a more horizontal position they can better control their wing orientation to minimize the amount of water that strikes their wings. In addition their feathers absorb up to 50% of the raindrop impact forces on their bodies. All this combined allows them to maintain flight control as they do in normal (no rain) conditions (reference: <http://www.huffingtonpost.com/2012/07/19/hummingbird->

rain-video\_n\_1685752.html). However, it takes more energy for them to maintain this more controlled flight during heavy rain.

In many species of hummingbird, the coloring does not come from pigmentation in the feather structure, but instead comes from the diffraction of light. As light strikes the top layers of the feathers, the prism-like structure of the cells in these feathers causes the light to split into its constituent colors, which are then seen by us with varying degrees of intensity. Hence, the hummingbird feather structure acts as a diffraction grating. A hummingbird, just by shifting body position, can change its apparent color from a dull color to a bright red or green.

Check out the coloration of this male ruby throated hummingbird. A real cutie! The red coloration on the neck helps the males attract females, which therefore is a favorable trait for reproduction. However, by shifting its body position a hummingbird can make its neck appear darker in color which will help avoid attracting predators. This is a favorable trait for survival.



[17]

Hummingbirds need to beat their wings very rapidly in order to have the precise movements required when feeding on the nectar from flowers. With their wings beating so rapidly they can produce almost a perfectly constant lifting force on their body, and with small wing adjustments they can redirect this force to smoothly propel their bodies sideways, forward, backwards, or up and down. Regular birds with their typical wing speed cannot do this because the force produced by their wings is not nearly as continuous as a hummingbirds, and as such, finer movements while airborne are not possible.

# The Penguin

Penguins' dense feathers and layer of fat (blubber) serve as a good insulator, both inside the water and out. Insulation in cold water is even more critical since the convection coefficient in water is much higher than in air, meaning they lose heat much faster in water than in air. The picture below shows an emperor penguin.



[18]

The blubber surrounding the bodies of penguins also serves as energy storage to help them survive long periods without food.

The blubber is also a good shock absorber, as in the case of rockhopper penguins (shown below) who often fall down when climbing rocks but don't injure themselves.





[19]

Penguins, in particular emperor penguins, can dive very deep (more than 1800 feet) and hold their breath for a long time underwater, up to 20 minutes (reference: <http://www.antarctica.gov.au/about-antarctica/wildlife/animals/penguins/emperor-penguins/how-deep-can-they-dive>). Their bodies are well suited to withstand the high pressures of deep dives, and are highly efficient at utilizing stored oxygen in their bodies, even at low levels.

Penguins are excellent underwater swimmers using their flippers as underwater wings, propelling themselves through the water the same way that the typical bird propels itself through the air using its wings. The bodies of penguins are highly streamlined and efficiently move through the water with minimal drag.

The picture below shows a gentoo penguin swimming underwater.



[20]

Penguins are so perfectly suited to swimming in water that their locomotion ability on land seems to be compromised as a result. As a result, their body structures are very specialized for swimming. This is not to say that penguins cannot walk. They can, but it's a very clumsy and comical sort of gait reminiscent of the waddle that ducks do.

Penguins have a funny way of walking, similar to ducks, but even more comical. They have short legs and have to rock their bodies back and forth in order to walk. In the case of emperor penguins, they can save energy and glide quickly across the ice and snow (shown below) using their round and smooth bodies which acts like a toboggan.





[21]

To prevent freezing during very cold winter temperatures, emperor penguins huddle together. This concentrates their body heat by minimizing the exposed surface area on their bodies. The most exposed penguins are on the outside, and they gradually get rotated into the warmer center as the huddle moves along. And the penguins in the center, which can overheat, get rotated towards the outside. This process occurs continuously.



[22]

All penguins have white fronts and dark backs and wings. The white plumage on their fronts helps prevent them from being seen by underwater predators beneath them due to the difficulty in distinguishing their white front from the reflective water surface.

Similarly, the dark plumage on their backs and wings helps prevent them from being seen by predators above.

Here is a picture of two adult emperor penguins with their juvenile youngster between them. This is just too cute to not include here!



[23]



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