

## Respiratory System of Birds

### Transcript

Hello everybody, I am Siham Al-Bushaje', a biology teacher at Al-Kadeeh secondary school in Al-Katif province, Saudi Arabia.

There are over 10,000 different types of birds in the world. They are an example of an innocent, dreamy and peaceful life, exemplified by chirping bulbuls, hardworking crows, peaceful pigeons, beautiful peacocks, and fishing seagulls. Birds are gentle creatures, but they also have the pride of hawks and the glory of eagles.

This lesson focuses on the respiratory system in birds, and we will examine the structure of bird lungs and explore how respiration in birds differs from respiration in other creatures. Let's watch this scene and I will come back shortly."

When humans exert lots of effort while running a marathon for example, they sweat a lot, especially if it is summer and the temperature is high. Exertion makes them feel thirsty because they need to make up for the lost liquids by drinking enough water to make up for their need, and also to cool their bodies down.

Sweat glands are really important for thermal regulation of the human body, because it is the main method of cooling the body down when it heats up; water evaporates from the skin taking away with it some thermal energy. Humans have about 3 million sweat glands.

However, birds do not have sweat glands. We look at birds that fly long distances and exert lots of energy in the process, and their bodies don't get damaged.

Activity #1: I want you to discuss this question with your fellow students.

Without sweat glands, how can birds maintain their body temperature during short and especially long flights? Why don't their bodies burn up or get damaged by all the heat that their bodies are creating with that constant activity?"

**Second Segment:**

Welcome back. I hope you enjoyed discussing these questions and that you came up with some good ideas. We will come back to these questions later in the lesson

The human respiratory system consists of the following: the nose, the larynx, the trachea- which splits into two primary bronchi from the larynx-and two lungs- made of several air sacs.

The bird respiratory system consists of the following:

Bird lungs are relatively small and compose only about 12% of the volume of respiratory system in birds. Instead airflow is regulated by changing pressure in the air sacs. There are 9 air sacs in the system and they are: two cervical air sacs, one interclavicular air sac, two anterior thoracic air sacs, two posterior thoracic air sacs, and two abdominal air sacs.

Respiratory pathways lead air into lungs, and those pathways includes the nose, pharynx, trachea, and larynx. Bronchi are also considered respiratory pathways.

Respiratory bones are connected to the system and provide support to ensure that respiration takes place. They are hollow bones filled with air and it includes the bones of: skull, humerus, collarbone, and other bones.

Activity #2 As you have seen, the respiration system of a bird is built quite different than that of a human being. Take a few minutes with your fellow students to discuss why you think the bird respiration system is the way that it is and how that structure is beneficial to birds.

### **Third Segment:**

Welcome back. I hope you and your peers came up with some good ideas about why a bird's respiration system is built the way it is.

The anatomy of birds- especially when it comes to respiratory systems- is more complicated than that of mammals. For example, a bird's respiratory system is proportionately larger and much more efficient than ours -- as might be expected, since flight is a more demanding activity than walking or running. An average bird devotes about one-fifth of its body volume to its respiratory system, while an average mammal devotes only about one-twentieth.

Both respiratory systems contain expandable lungs, but birds have 9 thin-walled air sacs connected to their lungs and these air sacs occupy the majority of space

in the bird's body cavity. Most birds have nine air sacs, which are connected to bone cavities making it lighter especially during flight

Bird respiratory systems work differently from those of mammals for several reasons: first, birds need large amounts of Oxygen; for example, birds usually consume twenty times more oxygen than humans. Mammal lungs can't provide that much Oxygen, and thus bird lungs were designed differently.

If we follow the path of air through a mammal's respiratory system, we will find a bidirectional motion. When mammals inhale, air travels through a network of respiratory pathways to stop at small air sacs, where gaseous exchange of Oxygen and Carbon Dioxide takes place. When mammals exhale, air takes an opposite path leaving the lungs towards the trachea and out of the body.

The process is different in birds because it is unidirectional; it goes as follows: breathing cycle starts when birds inhale through their nasal cavities located above the beak at the front part of the head. In this stage, air flows through respiratory pathways just like in mammals, and then it passes to the trachea. However, before it goes through the trachea, air passes by the syrinx- the voice-box of a bird- which splits the flow into two streams so that each one goes to a different bronchus. Air doesn't get to the lungs immediately, but goes through the posterior thoracic air sac, which in turn passes some air to air sacs in the lungs

Air capillaries continue to split into smaller sizes, finally resulting in fine blood capillaries. There are two different types of flow in those capillaries which take place in opposite directions. Air flows from posterior air sacs to the skull for one, and from the skull to the posterior air sacs for the other. This mechanism is called "gaseous exchange" because Oxygen and Carbon Dioxide are exchanged through it.

When the bird inhales again, air moves to air capillaries closer to the skull, and the second stage happens when air moves out of air capillaries near the skull through the syrinx and trachea and then out. Air ultimately goes out through the nasal cavity.

As air flows through the air sac system and lungs, there is no mixing of oxygen-rich air and oxygen-poor, carbon dioxide-rich, air as in mammalian lungs. Thus, the partial pressure of oxygen in a bird's lungs is the same as the environment, and so birds have more efficient gas-exchange of both oxygen and carbon dioxide than do mammals.

To summarize, birds breathe air in and out at the same time - you could say they breathe two times in one breath - and this has proven necessary for long trips especially that it saves them lots of energy and effort.

Activity #3: As you can see, the air sacs of birds enable them to breathe much more efficiently than we do - which they need for the demands of flight. Take some time now to see if you can come up with some other ways in which these air sacs might help birds. Discuss this with you classmates.

#### **Fourth Segment :**

Welcome back. I hope you had a good discussion. Did you come up with an answer about how birds can cool themselves without sweat glands – the question we asked in Segment 1? The flow of air through the 9 air sacs plays an important role in preventing birds from overheating or burning up when they are extremely active, for example during long migrations. Air flowing through the sacs picks up most of the heat a bird's muscles generate during flight and is conducted outside when the bird exhales.

*Short video showing machines and cooling fans in factories, and another of birds migrating and traveling long distances.*

Humans have had to design a similar cooling system since the Industrial Revolution. Humans have built factories and machines that work continuously for long hours, and it was necessary to maintain them at certain temperatures to avoid their combustion, which led to installing cooling fans. We know that heat is generated from motion and physical work, which can lead to damaging those machines due to overheating.

The respiratory system – with the 9 air sacs - is generally in charge of cooling down the body of a bird, but there are other benefits to air sacs. Did you come up with some other benefits? Let's watch the following scenes to explore some additional benefits.

Air sacs provide cushioning to the birds' bodies especially while diving into water for obtaining food.

Air sacs provide birds with the ability of altering their buoyancy to help in floatation while swimming.

Air sacs also help birds in flying. When birds fly, the air sacs act like a bellows, pumping air through the entire respiratory system.

Flight is strenuous and requires a tremendous amount of energy, so it's no surprise birds must have adaptations for very active metabolisms. As we come to the end of our discussion about bird respiration, here are some other interesting facts:

- Bird hearts are five times as large as ours as a percentage of body weight, and can pump more than ten times faster than ours.
- Birds have many more oxygen-carrying red blood cells per ounce than non-flying animals.
- Birds maintain high body temperatures while active.
- Bird digestive tracts are adapted for rapid processing of large amounts of high-energy, fuel-providing foods.

Activity #4: Before concluding this lesson, I want to explore a topic about birds that fascinates me: migration. But first, I want you to think about the following question and to discuss it with your fellow classmates. Migrating birds often go back to the same place they left, and sometimes even to the same nest. How are they able to navigate themselves to go back again? Discuss this with your peers and I will come back afterwards.

### **Fifth Segment:**

Welcome back. I would now like to finalize our discussion about birds and their amazing ability to withstand the harsh circumstances they face in nature.

Birds usually migrate at the end of summer or fall, traveling long distances exceeding thousands of kilometers to spend winter in warmer areas, and they migrate back in the spring. Most birds migrate south, crossing the equator to spend winter in southern Africa, South America, or Southeast Asia. Note that some birds migrate alone or in small groups, while others migrate in extremely large groups.

Many birds return to the same exact place they have left during migration, and some even go back to the same nest they had left. How can birds navigate their way back again? There has been a lot of research done and many hypotheses have been made regarding this issue. One of the explanations is that birds rely on sunlight and stars for navigation. It also has been posited that birds rely on geographic terrain such as mountains, bays, rivers, etc. There also have been explanations about birds using their smell or sensing infrared radiation or ultrasonic waves to help guide it through its path; others think it is air pressure or

direction of wind. Some think that birds have strong memory and remember the path of travel, but none of these hypotheses have been proven as a theory yet. A German research team has recently announced that birds' eyes contain a magnetic compass that helps it identify its path and to fly east during sunset and vice versa. Birds have a protein in their retinas that allows them to sense blue light, and that helps in magnetic navigation.

Whatever reasons lead birds to migrate and return to the same exact spot, it is fascinating that they could cover such distances- which are impossible to travel by human standards considering physiological structure-. Birds have definitely excelled over humans in that respect.

While many species of fish, mammals, and even insects undertake amazing migratory journeys, birds as a group are the most mobile creatures on Earth. Even with our trains, planes, bikes, and many vehicles, humans can't equal the mobility of some birds. For example, no human population moves across distances as great as the Arctic Tern does, flying from the Arctic to the Antarctic and returns again each year.

Now as we conclude our discussion about this beautiful and amazing world of birds, I want to leave you with a few more remarkable facts about birds. I hope you will continue to do your own research about these fascinating creatures.

- Did you know that: - A bird's heart beats 400 times per minute while resting and up to 1000 beats per minute while flying?
- A bird's feathers weigh more than its skeleton does?
- The world's only wingless bird is the Kiwi of New Zealand?
- Crows have the largest cerebral hemispheres (brains), relative to body size, of any avian family?
- A Peregrine Falcon can dive at speeds of 200 mph?