

Aviation Fauna

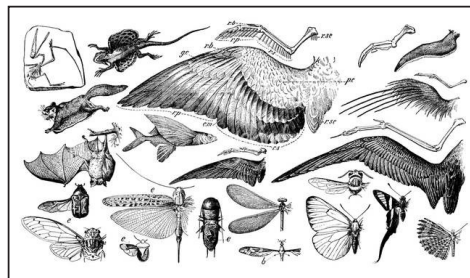
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Aviation fauna ranges from invertebrates to vertebrates comprising butterflies, insects, some fish, some reptiles, aves and mammals. It means that all these different groups of animals have different origins as flying objects, a phenomenon known as analogous. They use these capabilities to fly or glide. True flying animals have modified their fore limbs as wings which are strengthened by bones or membranes. All gliders do not have wings, but have their skin folded on the sides of the body and attached to the fore limbs and hind limbs, which expand when they need to glide from a high position to a low position. Gliding is rudimentary flight displayed by certain types of fish (Exocoetus), amphibians (Rhachophorus), lizards (Draco), and in the case of some mammals, by some phalangers, flying lemurs and squirrels. Soaring and flapping are more efficient mechanisms, but need more profound morphological and physiological adaptations. Soaring flight is attained by certain birds, while flapping flight is accomplished both by birds and bats. Here one can learn about the evolution of flight, and how animals were adapted to fly or glide.

Origin of flight

Flight is one of the most demanding adaptations found in nature because of the physical problems of moving in air. The common belief was that flight must have evolved from the trees down. Although most scientists agree that



birds have evolved or descended from reptiles, there is much controversy over from which group of reptiles' that birds evolved, and during which time period did they evolve. Two theories involved are

the Pseudosuchian Thecodont Hypothesis and the Dinosaur Theory.

According to Pseudosuchian Thecodont Hypothesis, it has been suggested that birds evolved roughly 230 million years ago from small arboreal thecodonts. On the other hand the Dinosaur Theory suggests that birds evolved about 150 million years ago from theropods, or bipedal carnivorous dinosaurs. The theropods are thought to have given rise to birds that existed in the Cretaceous period, 80 million years after *Archaeopteryx*.

Along with theories on evolution came theories for the evolution of flight. Scientists believe that feathers evolved from scales. There are several theories for the evolution of flight capabilities. These include Ground-up Theory, "Insect-net" Theory, and the Trees-

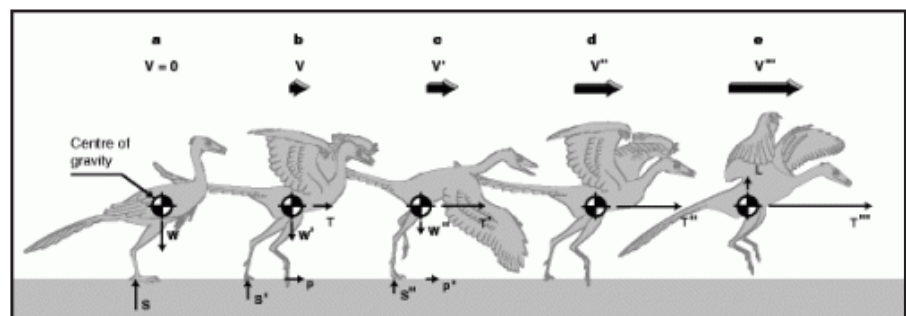


Fig 01 : Evolution of Flight from Cursorial Dinosaur like Reptile

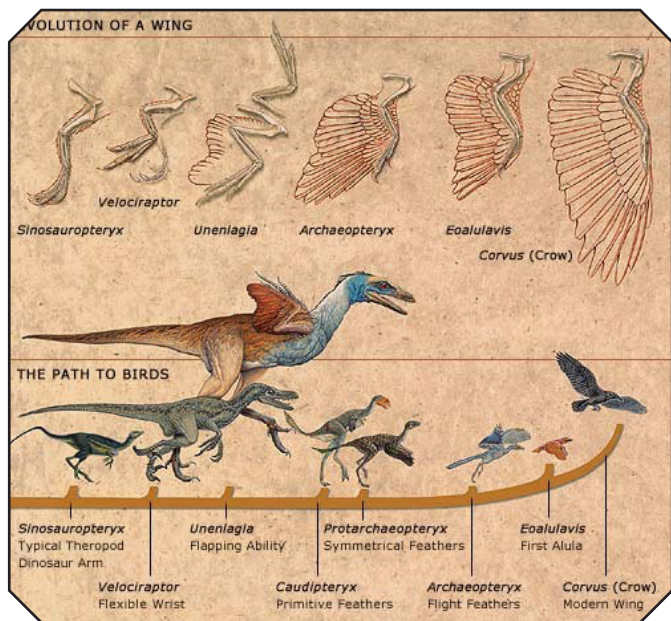


Fig 02: Evolution of a wing

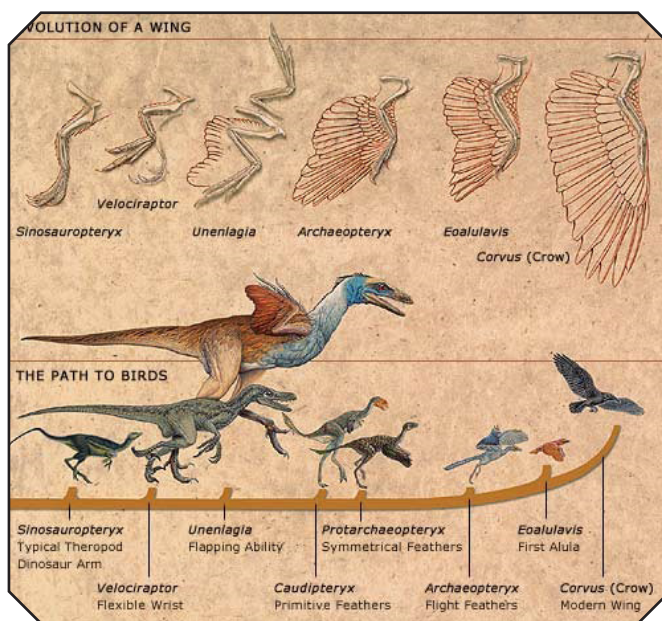


Fig 03: The evolutionary path towards birds

down Theory. Among these the Trees-Down Theory is the most widely accepted. According to this theory, the ancestors of birds were tree dwellers that jumped from branch to branch. Consequently, wings and feathers developed, allowing them to glide and fly.

This was the first animal that evolved with feathers and wings that showed moderate flight. *Archaeopteryx*, discovered in 1860, is the oldest known bird dating back to 150 million years. Its fossils were excavated out of Jurassic period limestone.

Archaeopteryx at first superficially resembled both a bird and a reptile. It was regarded as a primitive bird with feathers, but its fossilised skeleton looked more like that of a small dinosaur. It was amazing for a few reasons. It was about the size of a magpie. Unlike modern birds it had a full set of teeth, a long bony tail and three claws on its wings, which may have been used for grasping branches. It lacked the fully reversed toes which enable many modern birds to perch. In fact, except for the feathers, the bird-like feet, and the fact that it had a wishbone (*furcula*), it did not really look like a bird. It was likely

that though *Archaeopteryx* could fly, it probably did not have the full capacity to do so.

Pterosaurs

Pterosaurs (winged lizard) hold a special place in the history of life on earth. They were the first creatures, other than insects, to successfully populate the skies. The evolution of Pterosaurs roughly paralleled that of their terrestrial cousins, the dinosaurs, as the small, “basal” species of the late Triassic period which gradually gave way to bigger, more advanced forms in the Jurassic and Cretaceous periods. The first Pterosaurs for which fossil evidence is available, flourished during the middle to late Triassic period, that is about 230 to 200 million years ago. These flying reptiles were characterized by their small size, long tails and obscure anatomical features. The key trait that distinguished Pterosaurs from land-bound feathered dinosaurs that evolved into birds, was the nature of their “wings”, which consisted of wide flaps of skin



Fig 04: Fossil Archaeopteryx



Fig 05: Archaeopteryx- drawn by an artist

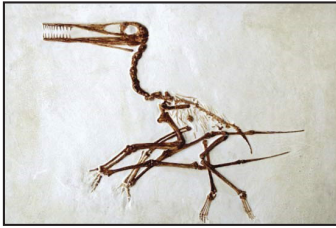


Fig 06: Pterosaurs – Flying Reptiles during Mesozoic Era

connected to an extended finger on each hand. Although these flat, broad structures provided enough lift, they may have been better suited to passive gliding than for powered, flapping flight.

Origin of birds

Birds constitute a very specialized group of vertebrates which had evolved from reptiles during Mesozoic era. Finally, three hypotheses appeared on the origin of birds.

1. Theropod Dinosaur Hypothesis: The first hypothesis assumed that they came from the theropod dinosaurs.
2. The second hypothesis assumed that they came from crocodiles because they had an endolymphatic duct.
3. The third hypothesis claimed that it was neither the dinosaur line nor the crocodile line, reasoning that several dinosaurs were already very specialized.

Evidences in Favor of Reptilian Origin of Birds

Reptiles and birds appear quite different from external appearance, but both these classes of vertebrates were basically similar. Birds are basically reptilian and the characters which distinguish a bird from a reptile were due to former's adaptation to aerial life.

Flight adaptations in birds

Unique avian characters

- Body contour-
- Stream lined body
- Presence of feathers
- Forelimb modified into wings
- Lack of teeth
- Many bones fused or reduced
- Bones pneumatized or air-filled
- Forelimbs specialized for flight
- Body Mass highly centralized
- Increased ability to withstand metabolic stress
- Unique respiratory system with air sacs
- Reproductive system comprise a single ovary which matured only during the reproductive season

Streamlined body. Since speed is a must for aerial life, it is necessary to minimize the resistance offered by air during flight. Hence the bodies of birds are fusiform or spindle-shaped, and lacks any extra projections which may offer resistance in the attainment of speed in air, like in the case of fish in water. During flight the air molecules must rapidly flow through the upper and lower surface of their body. If a bird has no streamlined body, air molecules will not be able to pass through its body smoothly, and hence will cause a considerable extent of

friction. Therefore a bird needs a streamlined body, because that is the only perfect shape that can effectively reduce the aerodynamic drag, and consequently save more energy during flight.

All birds have feathers and share a common structure. A feather is a unique adaptation. A feather is lightweight, durable structure which is made mostly of keratins. Adaptations of feathers allow them to be used for specialized roles. Feathers provide insulation, waterproofing, and a lightweight to become airborne. There are many different kinds of feathers. They are contour feathers, down feathers, semiplumes, filoplumes, and bristles.

Contour Feathers - Contour Feathers cover the body and wings. They are often asymmetrical and provide an aerodynamic shape to the wings. The smooth and streamlined surface is achieved because the feathers' barbules (branches on the barb). The contour feathers used for flight are known as remiges (wing feathers and rectrices tail feathers).

Down Feathers - Down Feathers are simple in structure, and have no hooks or barbules. Their primary function is insulation.

Semiplume - Semiplume looks like a cross between a contour feather and a down feather providing insulation. Therefore it

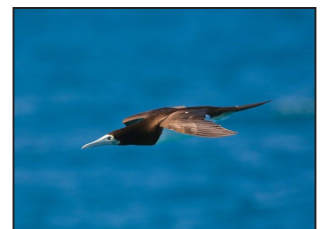




Fig 07: Wing of bird with contour Feathers



Fig 08: Structure of a contour feather



Fig 09: Down Feathers



Fig 10: Semiplume Feather and Filoplume Feather

makes the bird more aerodynamic. Filoplumes - Filoplumes are long and hair-like feathers, which are sensory in function. Sensory corpuscles at the base of each filoplume allows a bird in flight to know the position of each of its feathers.

Forelimbs modified into wings

The forelimbs have transformed into unique and powerful propelling organs, the wings. During rest they remain folded against the sides of the body, but during flight they become expanded. The surface area of the wings is increased by the development of elongated flight-feathers, the remiges. Infact the particular

shape of the wing causes reduction in air pressure above, and increase below, with minimum turbulence behind. This helps in driving the bird forwards and upwards during flight.

The wing feathers are made up of primary, secondary and tertiary feathers. Primary feathers are the largest of the flight feathers and propel the bird through the air. They are the farthest away from the body, attached to the skin of the wing on the 'hand' of the bird. In most bird species, there are 10 primary feathers on each wing. If these flight feathers are damaged

or lost, a bird cannot fly. Secondary feathers are those that run along the 'arm' of



the wing, and sustain the bird in the air, giving it lift. The number of secondary feathers vary with different species. Feathers on a bird's wings provide a lightweight, but at the same time provides a solid surface to push against the air. When the wing flaps downwards, the feathers mesh together, and then part to allow air through as it sweeps upward again. While allowing it to fly, a bird's feathers keep it warm and dry.

Lack of Teeth

Birds lack teeth because flight requires a highly centralized body mass with light extremities. Therefore a bird's head must be very light. Teeth of the jaws for

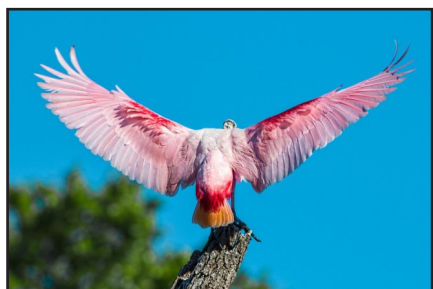


Fig 11: Wings of the Flying birds showing primaries, secondary and tertiary

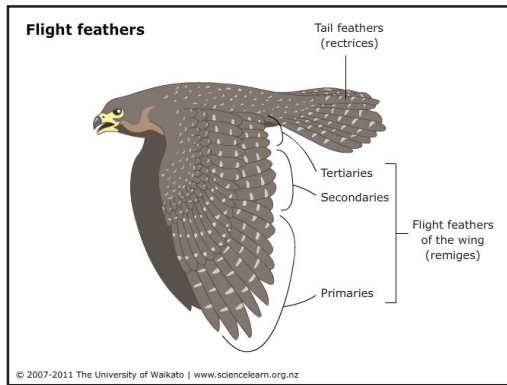


Fig 12: Flight Feathers

birds are no longer necessary. Instead of using teeth to tear food into pieces, birds use one of two strategies. They will either eat only food items of a size that they can swallow or they will have a beak which is adapted for tearing food.

Many Bones are fused or reduced

A bird's skeleton is designed for flight. For that purpose many bones are fused or reduced in size thereby reducing the mass of the skeleton, and redistributing mass towards the centre of the body. The main fused bone of the bird skeleton is known as synsacrum, which is made by fusing of the last thoracic vertebrae, lumbar vertebrae, sacral vertebrae and pelvic girdle.

Bones Pneumatized or Air-Filled

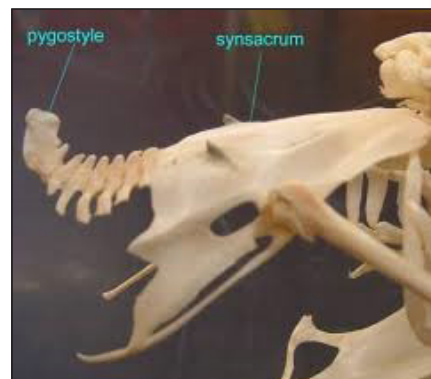


Fig 14 : Synsacrum of a Bird

Many bones in a bird's body are pneumatized. They contain large air pockets that are connected to the respiratory system. Therefore bird bones are very light. Small bone struts in the air pockets provide strength. Different species of birds show differing degrees of pneumatization. Small birds tend to show less pneumatization than large birds, and in birds adapted for diving, there is hardly any pneumatization at all.

Body Mass Highly Centralized

Apart from bones, the tissues and organs of birds have the same mass as mammalian size equivalents. But most of a bird's overall mass is found in its torso. The centre of mass in a bird is found between the wings. The limbs are far less muscled, compared with those of a typical mammal. Major flight muscles are located in the pectoral region rather than on the wings themselves. Birds also have very small heads and short, stubby tails. This also helps reducing the mass of the extremities.

Increased Ability to Withstand Metabolic Stress

Birds have the highest metabolic rate for their size of any vertebrate. A high metabolic rate allows them to fly efficiently. The fastest metabolic rates are found among the smallest birds like hummingbirds. Also, high metabolic rates allow some birds to fly at very high altitudes. Hence, they release fecal matter while they are flying which helps them to reduce their body weight.

Unique Respiratory System

The avian respiratory system is



Fig 13: Beak of the bird

unlike any other animal. It is composed of a sponge like lung, and a number of membranous air sacs. In the lung, the air channels, or bronchioles, run cross-current to the circulating blood. The transfer of oxygen from air to blood is extremely efficient, and because the lung does not expand when air passes through it, there is no change in the aerodynamics of a bird in flight. The air sacs fill and empty in a two-breath cycle, ensuring a constant flow of air through the lungs.

Reproductive system with a single ovary

In female birds, the presence of a single functional ovary on left side also leads to a reduction of body weight which is essential for flight. Thus, it is evident that birds are fully developed for terrestrial, arboreal and aerial environments.

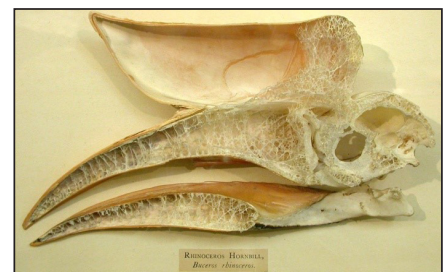


Fig 15 : Pneumatized Bones of Birds

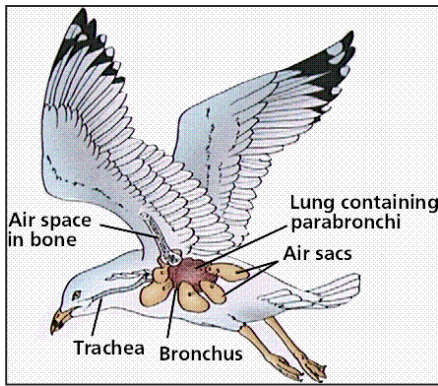


Fig 16 : Bird showing lungs and air sacs

modified to live on trees. Their mode of living is named as arboreal. Arboreal mammals are able to climb the trees and use their branches as the highways. There are three possible modes of aerial locomotion or flight namely, gliding, soaring and flapping. Gliding is the rudimentary flight, displayed among some mammals by some phalangers, flying lemurs

elongated, flattened and streamlined body. Their limbs are long and equal. Tail is long and gradually tapering. The double fold of furred skin, called patagium can be seen, or there is a parachute membrane that is stretched on either lateral side between neck, limbs, body and tail. It is sometimes also provided with a cartilaginous rod springing from the elbow or wrist. When the

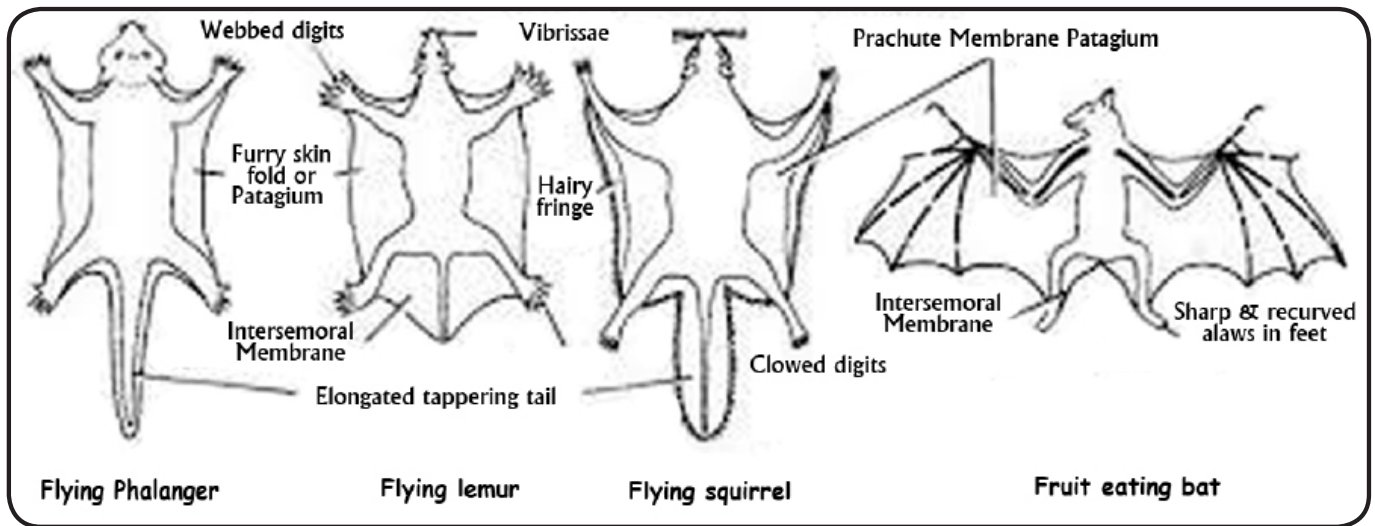


Fig 17 : Gliding and flying mammals

and squirrels. Soaring and flapping are more efficient, and need more profound morphological and physiological adaptations. Soaring flight is attained by certain birds, while flapping flight is accomplished by both birds and bats.

animal is at rest, the parachute is visible, as it remains folded close to the body by its own elasticity.



Fig 18 : Gliding Mammals

Gliding and flapping flight

Many mammals specially living in forest areas have become

Gliding Mammals

- Common examples are
- (i) Order Marsupialia: Flying phalangers (Petaurus) and feather tails (Acrobates).
 - (ii) Order Dermoptera: Flying lemurs
 - (iii) Order Rodentia: Flying squirrels

Gliding Adaptations

Gliding mammals have an

Nature of Gliding Flight

Gliding is not a true continuous flight, It is merely a prolonged aerial leap, covering 10 to 20 metres at the most. This type of movement involves no propulsion other than the initial force of jumping. Gliding is characterized by leaping or jumping from a high point, and holding up by some sustaining organs, and finally gliding to a lower level. Thus, there is no locomotive force other than gravity. The gliding mammals glide from one tree to another smoothly, and then swiftly downwards, supported by the outstretched parachute



Fig 19: Wings of Bats

and limbs. Aerial progress is in a straight line, rapidly losing height with little manoeuvrability. However, the flight can be guided to some degree by changing the position of the limbs, and by twisting the parachute membrane using the tail. Before alighting the animal raises the front body part to check speed and to soften its impact on the landing target.

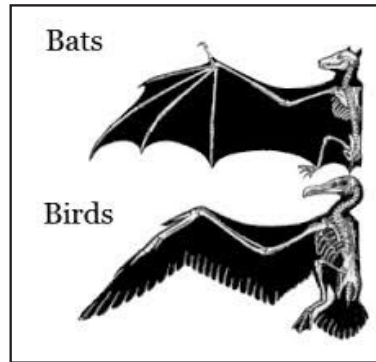
Flapping or Flying Mammals and Adaptations (Bats)

Bats belong to the order Chiroptera. Bats are the only mammals which have attained powered flapping flights. Though bats fly, their anatomy is more closely related to humans than to birds.

Flight Adaptations of Bats

Bats possess many adaptations which are infinitely more profound. The modifications are not so conspicuous in their external features. But radical changes have taken place internally in their skeleton and musculature.
 Wings - Wings or patagia of bats are thin like a paper and elastic membranes. Bat wings are highly articulated with independent joints and a thin flexible membrane covering them. Their wings are similar in structure to the human arm and hand.

Forearm is greatly elongated, carrying a hand with 5 fingers. In small insectivorous Micro-chiropterans, the first finger or pollex is short, free and sharply clawed. The other 4 fingers are clawless, enormously lengthened



and embedded in the web of wing to support it. In large fruit-eating bats or Mega-chiropterans, the 2nd finger also ends in a claw. The 3rd finger is the largest, corresponding to the leading edge of the wing membrane. The muscles and other body structures are specially designed in bats to support and operate the wings. The keeled sternum offers space for the attachment of great pectoral muscles which sustain the arms in flight.

Legs - In bats the hind legs are small, weak and with sharp curved claws on toes. Knee-joints are directed backwards which helps in maximum spread of wing membranes, but is of little help in other movements.

Tail - In bats, the tail is variable in size. It may be large, small or scarcely visible. When well developed, the tail supports the inter-femoral membrane which can act as a brake to flight.

Modern aviation

Aeroplanes

Aeroplanes owe much of their design to birds, and now it appears that man-made flying machines and birds have more in common than ever. People have looked up at birds for years, and they have inspired us to fly. Airplanes have wings like birds. They also have a light skeleton to decrease their weight, and they have a streamlined shape to decrease drag. The big difference is that airplanes do not flap their wings. Airplane wings are designed to create lift by changing the pressure, rather than by flapping them up and down.

Flight of the drones
 Scientists look to the natural world



Fig 20 : Comparison of Bird Wing and Bat Wing

for inspiration, investigating the adaptations that allow winged animals to efficiently navigate through the air, even under difficult conditions. Aerial drones are ever more sophisticated, and are likely to continue to improve in performance as scientists uncover more of the secrets and success of slying in insects', bats' and birds.



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